15213 C Primer

17 September 2002

Outline

- Overview comparison of C and Java
- Good evening
- Preprocessor
- Command line arguments
- Arrays and structures
- Pointers and dynamic memory

What we will cover

- A crash course in the basics of C
- You should read the K&R C book for lots more details

Like Java, like C

- **Operators same as Java:**
  - **Arithmetic**
    - `i = i+1; i++; i--; i *= 2;`
    - `+, -, *, /, %,`
  - **Relational and Logical**
    - `<, >, <=, >=, ==, !=`
    - `&&, ||, &, |, !`
- **Syntax same as in Java:**
  - `if ( ) { } else { }`
  - `while ( ) { }`
  - `do { } while ( );`
  - `for(i=1; i <= 100; i++) { }`
  - `switch ( ) {case 1: … }`
  - `continue; break;`

Simple Data Types

datatype	size	values
char	1	–128 to 127
short	2	–32,768 to 32,767
int	4	–2,147,483,648 to 2,147,483,647
long	4	–2,147,483,648 to 2,147,483,647
float	4	3.4E+/–38 (7 digits)
double	8	1.7E+/–308 (15 digits long)

Java programmer gotchas (1)

```
{
  int i
  for(i = 0; i < 10; i++)
    …
```

NOT

```
{
  for(int i = 0; i < 10; i++)
    …
```

Java programmer gotchas (2)

- Uninitialized variables
  - catch with `-Wall` compiler option

```
#include <stdio.h>

int main(int argc, char* argv[])
{
  int i;
  factorial(i);
  return 0;
}
```

Java programmer gotchas (3)

- Error handling
  - No exceptions
  - Must look at return values

“Good evening”

```
#include <stdio.h>
int main(int argc, char* argv[])
{
  /* print a greeting */
  printf("Good evening!\n");
  return 0;
}
```

```
$ ./goodevening
Good evening!
$
```

Breaking down the code

- `#include <stdio.h>`
  - Include the contents of the file stdio.h
    - Case sensitive – lower case only
  - No semicolon at the end of line
- `int main(…)`
  - The OS calls this function when the program starts running.
- `printf(format_string, arg1, …)`
  - Prints out a string, specified by the format string and the arguments.

format_string

- Composed of ordinary characters (not %)
  - Copied unchanged into the output
- Conversion specifications (start with %)
  - Fetches one or more arguments
  - For example
    - `char` `%c`
    - `char*` `%s`
    - `int` `%d`
    - `float` `%f`
- For more details: `man 3 printf`

C Preprocessor

```
#define FIFTEEN_TWO_THIRTEEN \
  "The Class That Gives CMU Its Zip\n"

int main(int argc, char* argv[])
{
  printf(FIFTEEN_TWO_THIRTEEN);
  return 0;
}
```

After the preprocessor (gcc -E)

```
int main(int argc, char* argv)
{
  printf("The Class That Gives CMU Its Zip\n");
  return 0;
}
```

Conditional Compilation

```
#define CS213

int main(int argc, char* argv)
{
  #ifdef CS213
  printf("The Class That Gives CMU Its Zip\n");
  #else
  printf("Some other class\n");
  #endif
  return 0;
}
```

After the preprocessor (gcc -E)

```
int main(int argc, char* argv)
{
  printf("The Class That Gives CMU Its Zip\n");
  return 0;
}
```

Command Line Arguments (1)

- `int main(int argc, char* argv[])`
- `argc`
  - Number of arguments (including program name)
- `argv`
  - Array of char*s (that is, an array of 'c' strings)
  - `argv[0]` := program name
  - `argv[1]` := first argument
  - ...
  - `argv[argc-1]`: last argument

Command Line Arguments (2)

```
#include <stdio.h>

int main(int argc, char* argv[])
{
  int i;
  printf("%d arguments\n", argc);
  for(i = 0; i < argc; i++)
    printf("  %d: %s\n", i, argv[i]);
  return 0;
}
```

Command Line Arguments (3)

```
$ ./cmdline The Class That Gives CMU Its Zip
8 arguments
  0: ./cmdline
  1: The
  2: Class
  3: That
  4: Gives
  5: CMU
  6: Its
  7: Zip
$
```

Arrays

- `char foo[80];`
  - An array of 80 characters
  - `sizeof(foo)`
    = 80 _ `sizeof(char)`
    = 80 _ 1 = 80 bytes
- `int bar[40];`
  - An array of 40 integers
  - `sizeof(bar)`
    = 40 _ `sizeof(int)`
    = 40 _ 4 = 160 bytes

Structures

- **Aggregate data**

```
#include <stdio.h>

struct name
{
  char*     name;
  int       age;
}; /* <== DO NOT FORGET the semicolon */

int main(int argc, char* argv[])
{
  struct name bovik;
  bovik.name = "Harry Bovik";
  bovik.age = 25;

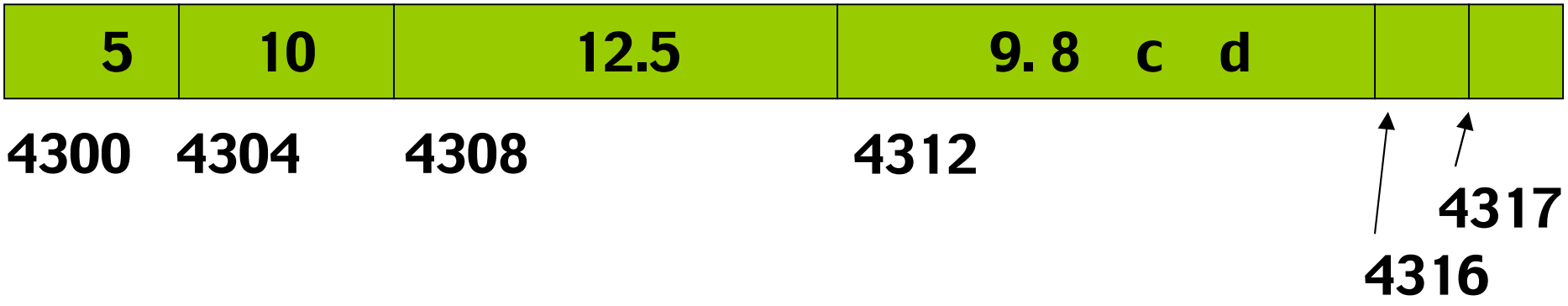
  printf("%s is %d years old\n", bovik.name, bovik.age);
  return 0;
}
```

Pointers

- Pointers are variables that hold an address in memory.
- That address contains another variable.

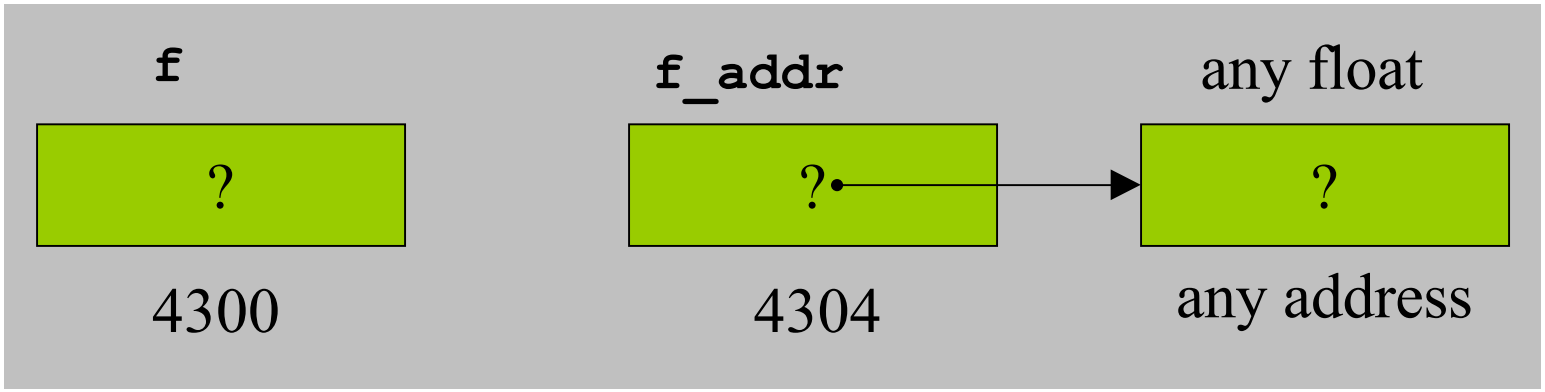
Memory layout and addresses

```
int x = 5, y = 10;
float f = 12.5, g = 9.8;
char c = 'c', d = 'd';
```

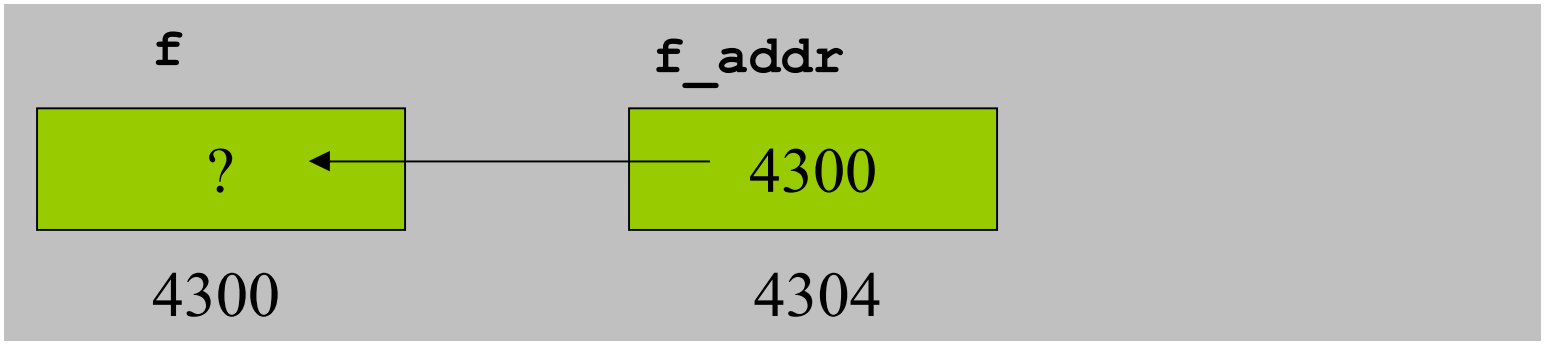


Using Pointers (1)

```
float f;          /* data variable */
float *f_addr;    /* pointer variable */
```

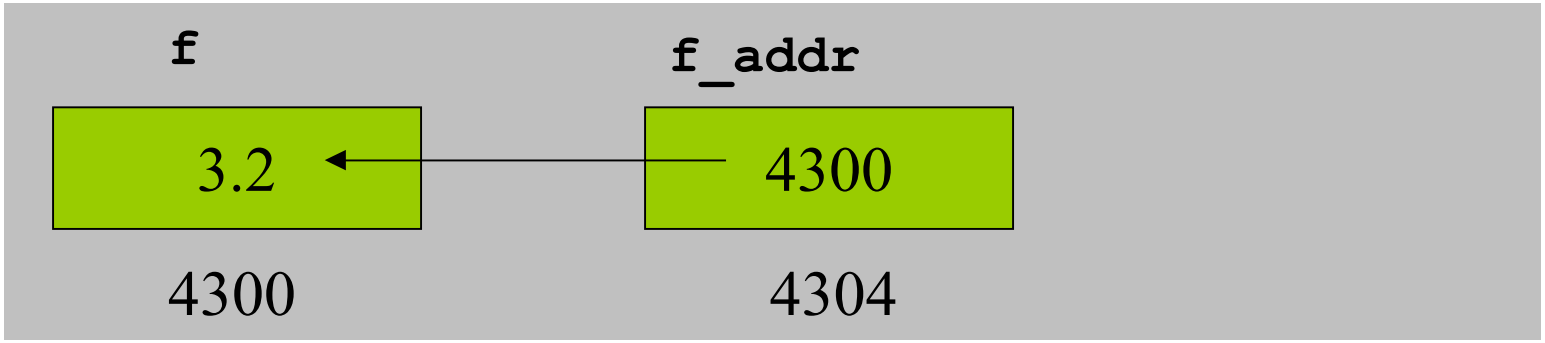



```
f_addr = &f;      /* & = address operator */
```

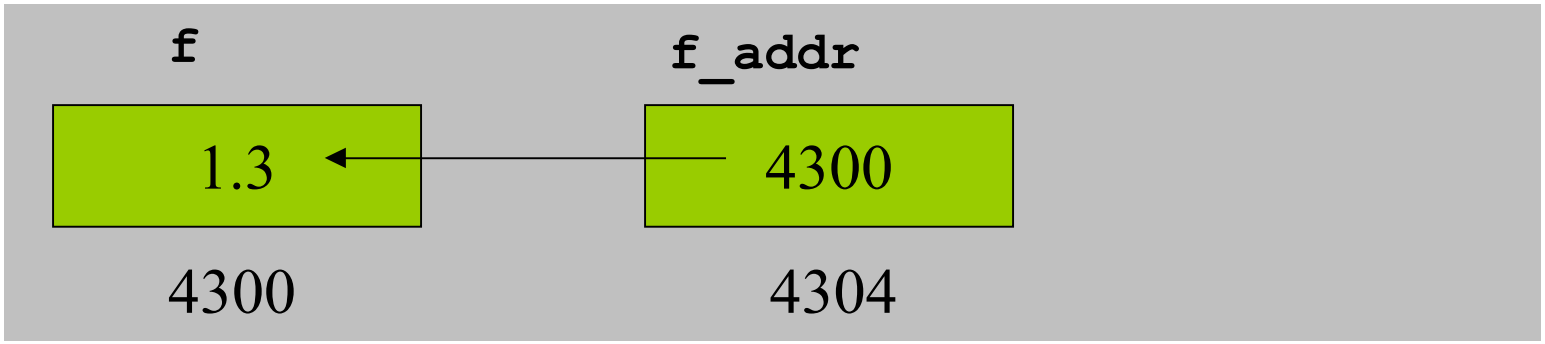


Pointers made easy (2)

```
*f_addr = 3.2;     /* indirection operator */
```




```
float g = *f_addr;/* indirection: g is now 3.2 */
f = 1.3;          /* but g is still 3.2 */
```



Function Parameters

- Function arguments are passed “by value”.
- What is “pass by value”?
  - The called function is given a copy of the arguments.
- What does this imply?
  - The called function can’t alter a variable in the caller function, but its private copy.
- Three examples

Example 1: swap_1

```
void swap_1(int a, int b)
{
   int temp;
   temp = a;
   a = b;
   b = temp;
}
```

Q: Let x=3, y=4,
after swap_1(x,y);
x =? y=?

~~A1: x=4; y=3;~~

A2: x=3; y=4;

Example 2: swap_2

```
void swap_2(int *a, int *b)
{
   int temp;
   temp = *a;
   *a = *b;
   *b = temp;
}
```

Q: Let x=3, y=4,
after
swap_2(&x,&y);
x =? y=?

~~A1: x=3; y=4;~~

A2: x=4; y=3;

Example 3: scanf

```
#include <stdio.h>

int main()
{
   int  x;
   scanf("%d\n", &x);
   printf("%d\n", x);
}
```

Q: Why using pointers in scanf?

A: We need to assign the value to x.

Dynamic Memory

- Java manages memory for you, C does not
  - C requires the programmer to *explicitly* allocate and deallocate memory
  - Unknown amounts of memory can be allocated dynamically during run-time with `malloc()` and deallocated using `free()`

Not like Java

- No `new`
- No garbage collection
- You ask for *n* bytes
  - Not a high-level request such as "I'd like an instance of class `String`"

malloc

- Allocates memory in the heap
  - Lives between function invocations
- Example
  - Allocate an integer
    - ```
      int* iptr =
            (int*) malloc(sizeof(int));
      ```
  - Allocate a structure
    - ```
      struct name* nameptr = (struct name*)
            malloc(sizeof(struct name));
      ```

free

- Deallocates memory in heap.
- Pass in a pointer that was returned by `malloc`.
- Example
  - ```
    int* iptr =
      (int*) malloc(sizeof(int));
    free(iptr);
    ```
- Caveat: don't free the same memory block twice!
    ```