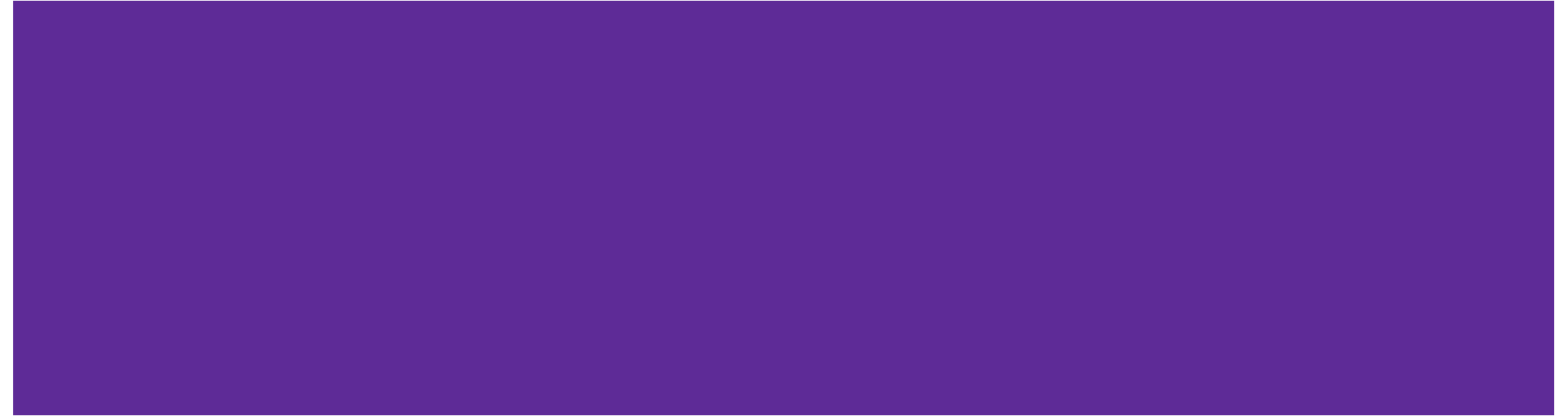


CSE 374 Lecture 8

Introduction to C



C v. Java

C

- Lower level (closer to assembly)
- No guaranteed memory safety
- Procedural
- Compiled (not interpreted like bash)
- Conditional controls (if, while)
- Modern syntax (human readable)
- Small standard library

Java

- Higher level (lots of compilation)
- Safe (sand-boxed in jvm, compiled limits)
- Object Oriented
- Compiled
- Conditional controls (if, while)
- Modern syntax (human readable)
- Large standard library, huge extended libraries

C v. Scripting

C

- Compiled
- Highly structured, data-typed
- Strings have library processing
- Data structures and libraries
- Good for large complex programs
 - Java, with object-oriented programming, is every better for complex programs

Scripting

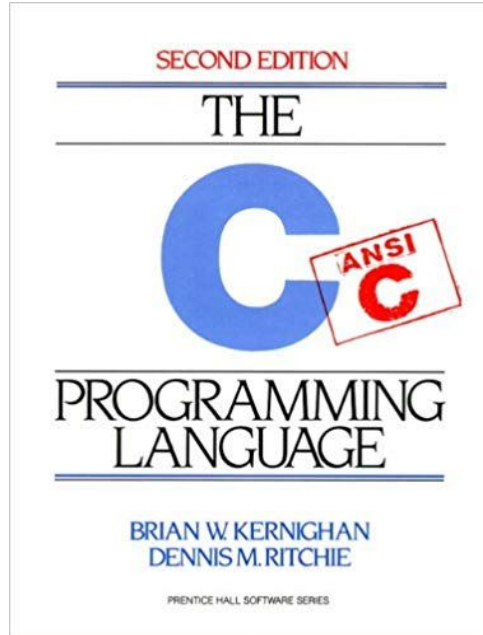
- Interpreted
- Esoteric variable access
- Everything is a string
- Easy access to files and program
- Good for quick & interactive programs
 - Do one thing and do it well

Why C?

- C is a fairly compact language - fewer features than Java, but easier to implement efficiently
- Provides lower level (closer to assembly) language
- Understanding C can give insight into how computers (and memory) work
- Still used for
 - ◆ Embedded programming
 - ◆ Systems programming
 - ◆ High-performance code
 - ◆ GPU Programming

C reference books

The standard reference. Available on Kindle and in the UW library.



Essential C - Stanford pdf
<http://cslibrary.stanford.edu/101/EssentialC.pdf>
<http://www.cplusplus.com/>

- O'Reilly books (C in a Nutshell, etc.), also through UW library

Hello World in C

```
#include <stdio.h>

/**
 * Compile this file with:
 *     gcc -o hello hello.c
 */
int main(int argc, char **argv)
{
    printf("Hello, World!\n");
    return 0;
}
```

- Compile: `gcc hello.c`
 - ◆ creates executable `a.out`
- Or: `gcc -Wall -std=c11 -o hello hello.c`
 - ◆ `Wall` - turns all warnings on
 - ◆ `C11` - specifies using C11 standard libraries
 - ◆ Creates executable `hello`
- Run: `./a.out` or `./hello`
 - ◆ Exits with '0' (`return 0;`)

```
// includes for functions & types
defined elsewhere
#include <stdio.h>
#include "localstuff.h"
// symbolic constants
#define MAGIC 42
// global variables (if any)
static int days_per_month[ ] = { 31,
28, 31, 30, ...};
// function prototypes
// (to handle "declare before use")
void some_later_function(char, int);
// function definitions
void do_this( ) { ... }
char *return_that(char s[ ], int n)
{ ... }
int main(int argc, char ** argv) { ... }
```

Source File Structures

Hello World in C

```
#include <stdio.h>

/**
 * Compile this file with:
 *     gcc -o hello hello.c
 */
int main(int argc, char **argv)
{
    printf("Hello, World!\n");
    return 0;
}
```

- Include the stdio library (printf, stdout, etc)
- Other standard libraries
 - ◆ Stdlib, math, assert, etc
- Also include developer files
 - ◆ #include "myFile.h"

Hello World in C

```
#include <stdio.h>

/**
 * Compile this file with:
 * gcc -o hello hello.c
 */
int main(int argc, char **argv)
{
    printf("Hello, World!\n");
    return 0;
}
```

→ Comment block

- ◆ /* long form comments */
- ◆ // shorter comments

Hello World in C

```
#include <stdio.h>

/**
 * Compile this file with:
 *     gcc -o hello hello.c
 */
int main(int argc, char **argv)
{
    printf("Hello, World!\n");
    return 0;
}
```

- C functions look a lot like Java methods.
 - ◆ Have return type, arguments
 - ◆ Code block set off with '{' and '}'
- Program runs through 'main'
 - ◆ But not part of class!!
- Return value - program exit
 - ◆ >> echo "\$?"

What is `char **argv` ??

- Char - datatype
- `char*` - pointer to a place in memory that stores a char
- `char**` - pointer to a place in memory that stores pointers to chars
- The variables `argv` hold `argc` points to `char*` ptrs
 - In c array lengths must be sent as separate arguments, as is done here
- Also access values with `argv[0], argv[1], ..., argv[argc-1]`

Okay, so, argv[i] ?

- Any argv[i] points to a char* (pointer to characters)
- char* - pointer to a place in memory that stores a char or multiple chars
- If char* points to an array of characters ending in \0 (a zero byte)
- Aka a string!!
- Argv are usually has arguments coded into strings

“Hello, World!\n”

Is a string of length 15 (\n is one character, but contains \0)

In this case, is a ‘string literal’ - evaluates to a global, immutable array.

“printf”

Prints to stdout, which is defined in `stdio.h`

Computers & Memory

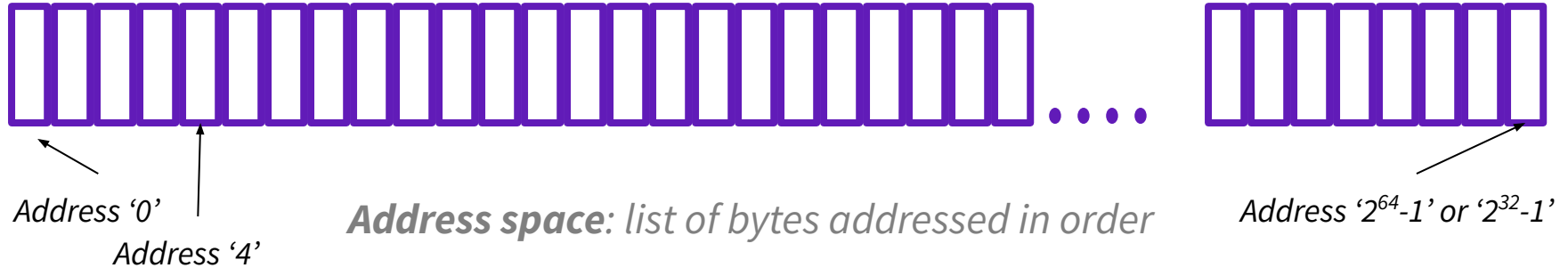
CPU - the 'central processing unit':
computer circuitry that follows computer
instructions with simple logic, arithmetic,
and I/O

Hard disc storage (modernly often solid
state memory instead of traditional drive):
holds long-term memory which can
persist across re-starts

RAM (memory) : where data is stored
during operation - short term memory

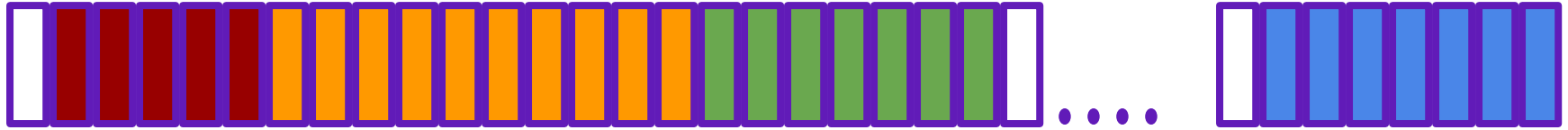


Working memory.



- Programs are said to have access to this 2^{64} byte space
 - '64 bit' system refers to needing 64 bits to index the space
 - But really don't - many other things are also using this space
- Location in array is the 'address' of a byte
- Programs keep track of addresses of each of their pieces of memory
- Accessing unused address causes a 'segmentation fault'

Working memory, cont.



code

globals

heap ->

<- stack

- Lowest memory stores program instructions, then global variables (static constants, string literals)
- ‘Heap’ holds dynamically allocated variables (‘new’ or ‘malloc’ variables)
- ‘Stack’ holds current instructions, each function in a frame
 - ‘Stack’ memory implies that a frame is added, and then the last frame added is removed first
- The heap and stack grow dynamically. Meet in the middle? = ‘out of memory’ error

Program address space

Pointers

“Point to memory location”



```
int x = 4;
```

Variable called 'x' of type 'int' given value of '4'

```
int *xPtr = &x;
```

Variable called 'xPtr' of type 'pointer to an integer', given value of the location of 'x'

```
int xCopy = *xPtr;
```

Variable called xCopy given the value stored at the location pointed to by xPtr

```
int* noPtr = NULL;
```

Variable 'noPtr' correctly set when location is not yet known

Arrays

Contiguous blocks in memory

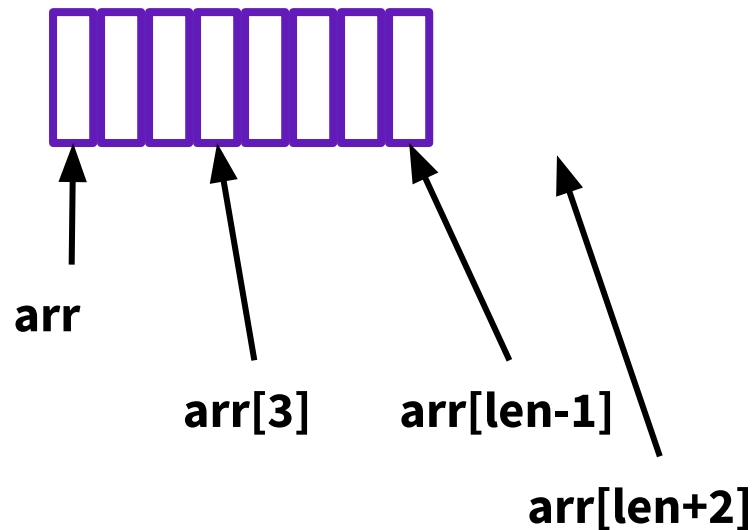
Declare as

```
Datatype arr[len]
```

Has type

```
Datatype*
```

Stores the location in memory of the first value; when arrays are passed passes this memory location



Danger, Will Robinson!!

Strings

No real strings - just arrays of characters.

```
[ "h", "e", "l", "l", "o", " ", "w", "o", "r", "l", "d", "!", \0 ]
```

Strings terminate with `\0` so their length can be determined

```
char str[] = "hello"; // array syntax
char *str2 = "hello"; // pointer syntax
char *arrStr[] = {"ant", "bee"}; // array containing char*'s
char **arrStrPtr = arrStr; // pointer to an array containing char*'s
arrStr[0] = "cat";
```