C for Java Programmers
CS 316

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Why use C instead of Java

- Intermediate-level language:
  - Low-level features like raw memory tweaking
  - High-level features like complex data-structures
- Access to all the details of the implementation
  - Explicit memory management
  - Explicit error detection
- More power than Java (so may be made faster)
- All this make C a far better choice for system programming.

Goals of Tutorial

- Introduce basic C concepts:
  - need to do more reading on your own
- Warn you about common mistakes:
  - more power means more room for mistakes
  - C programming requires strict discipline
- Provide additional information to get you started
  - compilation and execution
  - simple debugging

Common Syntax with Java

- Basic types are similar (**`int`**, **`short`**, **`double`**…)
- Operators:
  - Arithmetic:

    `+ - * / %`

    `++ -- *= += ...`
  - Relational: **`<,>,<=,>=,==,!=`**
  - Logical: **`&&, ||, !, ? :`**
  - Bit: **`&,|,^,!,<<,>>`**

Common Syntax with Java (cont.)

- Language constructs:

```
if( ) {...} else {...}
while( ) {...}
do {...} while( );
for (i=0; i<100; i++) {...}
switch( ) { case 0: ... break; ... }
break, continue, return
```

- No exception handling statements

  most functions return errors as special values (e.g., a negative number). Check for these!

Hello World Example

hello.c

```c
/* Hello World program */
#include <stdio.h>
#include <stdlib.h>

int main(int ac, char **av) {
    printf("Hello World.");
}
```

bash or cmd.exe

```
$ ./hello
Hello World.
```

Primitive Types

- Integer types:
  - **`char`** : used to represent ASCII characters or one byte of data (not 16 bit like in Java)
  - **`int`**, **`short`** and **`long`** : versions of integer (architecture dependent, usually 4, 2, and 4 bytes)
  - **`signed char/short/int/long`**
  - **`unsigned char/short/int/long`**

  conversion between signed/unsigned often does unexpected things
- Floating point types: **`float`** and **`double`** like in Java.
- No boolean type, int usually used instead.
  - 0 == false
  - everything else == true

Primitive Types Examples

```
char c='A';
char c=100;
int i=-2343234;
unsigned int ui=100000000;

float pi=3.14;
double long_pi=0.31415e+1;
```

Arrays and Strings

- Arrays:

```
/* declare and allocate space for array A */
int A[10];
for (int i=0; i<10; i++)
     A[i]=0;
```

- Strings: arrays of char terminated by ‘\0’ char

```
char name[] ="CS415"; //{'C','S','4','1','5','\0'}

name[2] = '3';
name[4]++;
```

  – Strings are mutable ("just data")
  – Common functions strcpy, strcmp, strcat, strstr, strchr, strdup. Use **`#include <string.h>`**

printf function

- **`printf(formating_string, param1, ...)`**
- Formating string: text to be displayed containing special markers where values of parameters will be filled:
  - %d for **`int`**
  - %c for **`char`**
  - %f for **`float`**
  - %g for **`double`**
  - %s for null-terminated strings
- Example:

```
int numstudents = 39;
printf("The number of students in %s is %d.", name,
  numstudents);
```

printf will not complain about wrong types, number of params, etc.

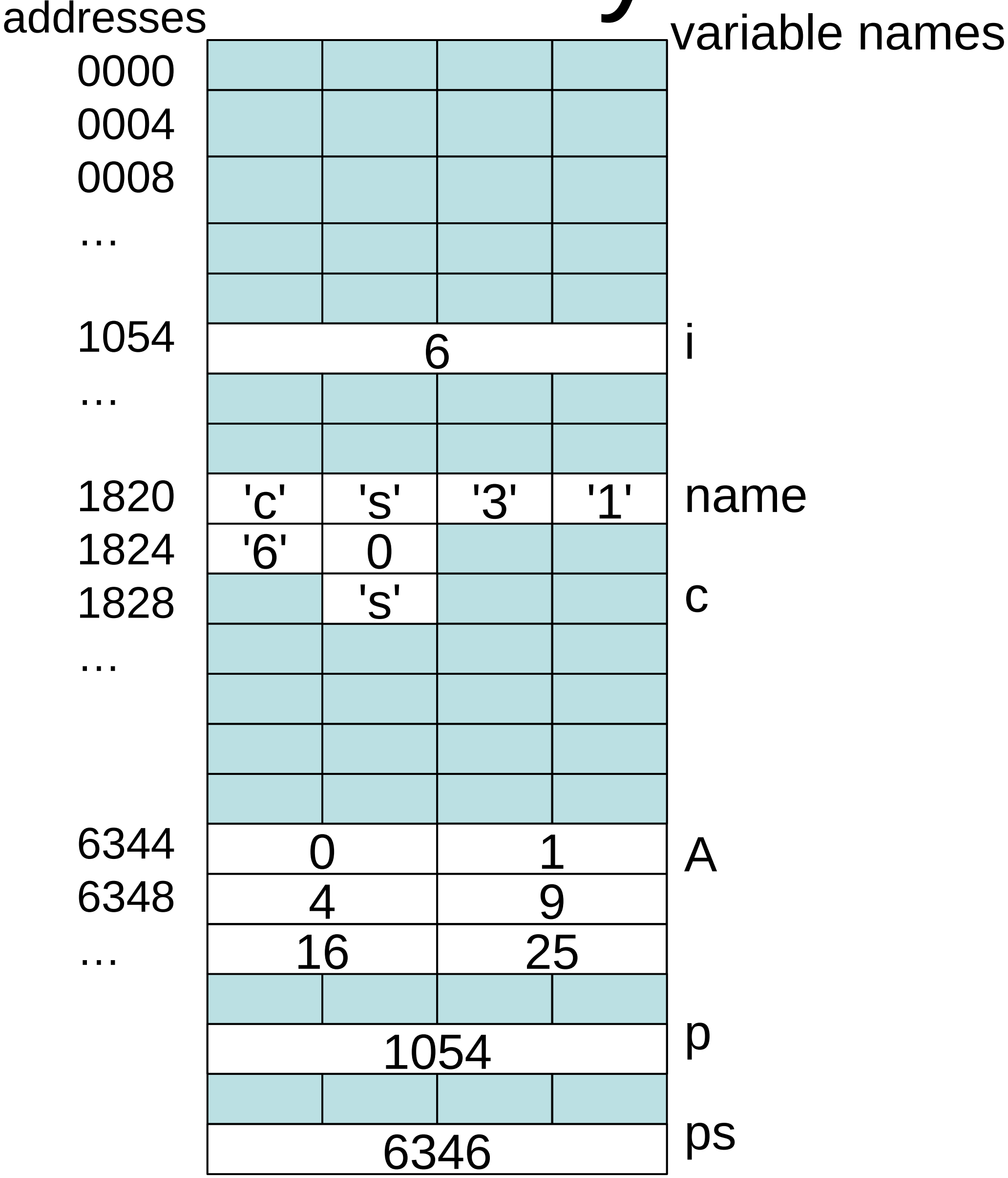
enum: enumerated data-types

```
enum months {
    JANUARY,
    FEBRUARY,
    MARCH,
    ...
};
```

- Each element of enum gets an integer value and can be used as an integer.

```
enum signs {
    CANCER = 6,
    ARIES = 1,
    ...
};
```

Memory




```
int i;
char name[] = "cs316";
short A[6];
for (i = 0; i < 6; i++)
  A[i] = i*i;
char c = name[1];
```

```
int *p;
p = &i;
```

```
short *ps;
ps = &A[1];
```

Pointers

- An 'address' is an index to a memory location (where some variable is stored). (Typically addresses are 32-bits.)
- A 'pointer' is a variable containing an address to data of a certain type.

Declaring pointer variables:

```
int i;
int* p; /* p points to some random location */
```

Creating and using pointer values

```
p = &i; /* p points to integer i */
(*p) = 3; /* variable pointed by p takes value 3 */
```

- & is the address operator, * dereference operator.
- Similar to references in Java.
- Nearly identical to arrays in C
  - array variables can not be changed (only the contents can change)

Pointers (cont.)

Attention: dereferencing an uninitialized pointer can have arbitrary effects (bad!) (including program crash).

Dereferencing a NULL pointer will crash the program (better!)

- Advice:
  - initialize with NULL, or some other value
  - if not sure of value, check it before dereferencing

```
if (p == NULL) {
  printf("ack! where's my pointer!\n"); exit(1);
}
```

Structures

- Like Java classes, but only member variables
  - no static variables
  - no functions

```
struct birthday {
     char* name;
     enum months month;
     int day;
     int year;
};

struct birthday mybirthday = {"elliot",8,21,2002};
mybirthday.name[0] = 'E';
if (mybirthday.month == JUNE)
   printf("%s is a Cancer\n", mybirthday.name);
```

Structures (cont.)

- Members of a struct can be of any type that is already defined.
- Trick: 'struct X' can contain a pointer to 'struct X'

```
struct intlist {
      int data;
      struct intlist* next;
 };
```

- **->** is syntax sugaring for dereference and take element:

```
struct intlist one = {10, NULL};
struct intlist two = {20, NULL};
struct intlist *head = &one;
one->next = &two;
```

Data-type Synonyms

- Syntax: **`typedef X Y;`** **`// Y is a synonym for X`**

```
typedef int CornellID;
CornellID me = 373333;

typedef struct elt* classlist; // bizarre but legal
struct elt {
   CornellID id;
   char *name;
   classlist next; // this is legal
}
```

Memory Allocation and Deallocation

- **Global variables:** declared outside any function.
- Space allocated statically before program execution.
- Initialization statements (if any) done before main() starts.
- Space is deallocated when program finishes.
- Name has to be unique for the whole program (C has flat name space).

Memory Allocation and Deallocation

- **Local variables:** declared in the body of a function or inside a '{ }' block.
- Space allocated when entering the function/block.
- Initialization (if any) before function/block starts.
- Space automatically deallocated when function returns or when block finishes

  Attention: referring to a local variable (by means of a pointer for example) after the function returned will cause unexpected behavior.

- Names are visible only within the function/block

Memory Allocation and Deallocation

- **Heap variables**: memory has to be explicitly
  - allocated: **`void* malloc(int)`**
    (similar to new in Java)

```
char *message = (char *)malloc(100);
intlist *mylist = (intlist *)malloc(sizeof(intlist));
mylist->data = 1;
mylist->next = (intlist *)malloc(sizeof(intlist));
mylist->next->data = 2;
mylist->next->next = NULL;
```

  - deallocated: **`void free(void*)`**

```
free(msg); msg = NULL;
free(mylist->next); free(mylist); mylist = NULL;
```

Malloc/Free and pointers

You must malloc()

reading/writing from random addresses is bad.

You must malloc() the right amount:

reading/writing over the end of the space is bad

```
sizeof(struct birthday)
    strlen(name)+1; // +1 is for the '\0'
```

You must free()

No garbage collector; if you don't have a free() for every malloc(), you will eventually run out of memory.

… but not too much

Freeing same memory twice is bad ("double free").

…and don't use the memory after it is freed

set pointers to NULL after free.

Memory Allocation and Deallocation

```
struct birthday *clone_student(struct birthday *b) {
    struct birthday *b2 = (struct birthday *)malloc(sizeof(struct birthday));
    b2->name = (char *)malloc(strlen(b->name)+1); // or use strdup()
    memcpy(b2->name, b->name, strlen(b->name)+1);
    b2->day = b->day;
    b2->year = b->year;
    b2->month = b->month;
    return b2;
}

void rename(struct birthday *b, char *new_name) {
    free(b->name); // danger: b->name must be a heap variable
    b->name = strdup(new_name); // same as malloc(...) then memcpy(...)
}
```

Functions

- Can declare using a prototype, then define the body of the function later
  - lets function be used before it is defined.
  - (compiler does a single pass through code!)
    - sort of
- Arguments passed by value
  - Use pointers to pass by reference
- Return value passed by value
  - Use malloc()'ed pointer to return by reference

Functions - Basic Example

```
#include <stdio.h>

int sum(int a, int b); /* function declaration or
   prototype */

int main(int ac, char **av){
    int total = sum(2+2,5); /* call function sum with
   parameters 4 and 5 */
    printf("The total is %d\n", total);
}

/* definition of sum; has to match prototype */
int sum(int a, int b) {/* arguments passed by value */
    return (a+b); /* return by value */
}
```

Why pass via pointers?

```
void swap(int, int);
int main(int ac, char **av) {
    int five = 5, ten = 10;
    swap(five, ten);
    printf("five = %d and ten = %d", five, ten);
}
void swap(int n1, int n2) /* pass by value */
    int temp = n1;
    n1 = n2;
    n2 = temp;
}

$ ./swaptest
five = 5 and ten = 10                    NOTHING HAPPENED
```

Why pass by reference?(cont.)

```
void swap(int *, int *);
int main(int ac, char **av) {
    int five = 5, ten = 10;
    swap(&five, &ten);
    printf("five = %d and ten = %d", five, ten);
}
void swap(int *p1, int *p2) /* pass by value */
    int temp = *p1;
    *p1 = *p2;
    *p2 = temp;
}

$ ./swaptest
five = 10 and ten = 5
```

Pointer to Function

```
void kill(int d) { /* do something */ ... }
void eat(int d) { /* do something else */ ... }
typedef void (*simple_function)(int);
        // simple_function is synonym for a pointer to
        // a function returning void and taking an int

void do_stuff(simple_function f, int param) {
     f(param); /* call function f with param */
}

int main(int ac, char **av) {
   kill(3);
   simple_function g = (ac == 1 ? eat : kill);
   do_stuff(g, 8);
}
```

The Preprocessor

- File copy-and-paste

```
/* include standard library declaration */
 #include <stdio.h>
/* include custom declarations */
 #include "myheader.h"
```

- Text substitution

```
 #define DEBUG 0
 #define MAX_LIST_LENGTH 100
 if (DEBUG)
     printf("Max length of list is %d.", MAX_LIST_LENGTH);
```

- Conditional compilation

```
 #ifdef DEBUG
     printf("DEBUG: line " _LINE_ " has been reached.");
 #endif
```

Programs with Multiple Files

- Header file: my_program.h:
  - function prototypes
  - global variable prototypes: extern int x;
- Program files: one.c, two.c, …
  - each file uses **`#include "my_program.h"`**
  - one of them defines main()
  - each prototype defined in exactly one of the files
- compiler produces one.o, two.o, …
  (or one.obj, two.obj on windows)
- compiler then links together to form program