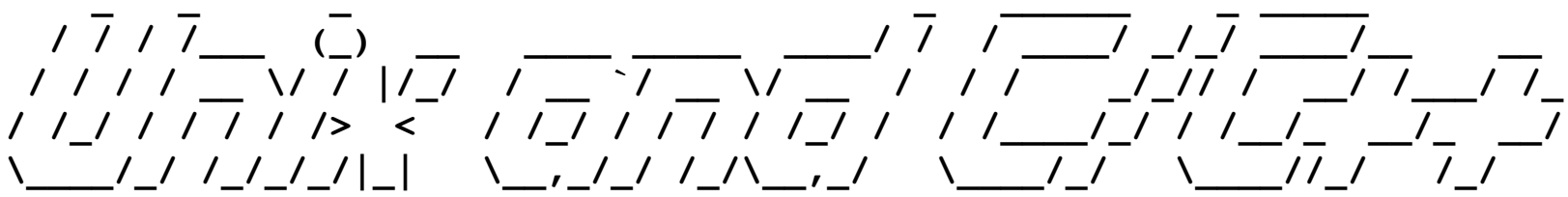
UNIVERSITY OF OREGON

CIS 330:



Lecture 8: function pointers, subtyping, more Unix

April 22nd, 2016

Hank Childs, University of Oregon

Announcements

- Projects
  - 2B prompt available last Saturday AM, due SATURDAY
  - 2C prompt assigned two days ago, due Tuesday
  - 2D today, due Friday
- No class on Weds April 27
  - will be a short YouTube replacement lecture
- No OH on Tues April 26
  - can be a bonus OH this weekend if demand

Grading (1/2)

- code isn't always portable
  - Scenario #1
    - your compiler is smart and glosses over a small problem
    - my compiler isn't as smart, and gets stuck on the problem
    - (fix: gcc –pedantic)
  - Scenario #2
    - memory error doesn't trip you up
    - memory error does trip me up
    - (fix: run valgrind before submitting)

Grading (2/2)

- Graders will run your code
  - If it works for them, then great
  - If not, they may ding you
- → how to resolve?
  - ix.cs.uoregon.edu is my reference machine
  - if it works there, you have a very strong case for getting credit back

Outline

- Review
- Project 2C
- Function Pointers
- Subtyping
- More Unix
- Project 2D
- (Bonus Material)

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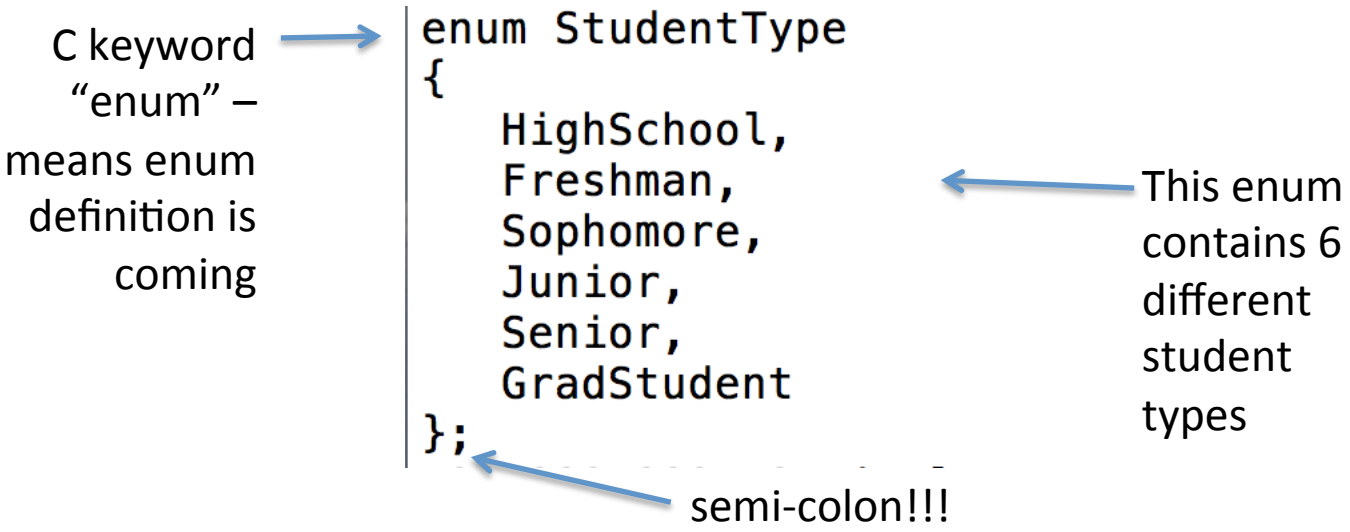
Enums

- Enums make your own type
  - Type is “list of key words”
- Enums are useful for code clarity
  - Always possible to do the same thing with integers
- Be careful with enums
  - … you can “contaminate” a bunch of useful words

enum example



But enums can be easier to maintain than integers

```
enum StudentType
{
    HighSchool,
    Freshman,
    Sophomore,
    Junior,
    Senior,
    PostBacc,
    GradStudent
};
```

```
int AverageAge(enum StudentType st)
{
    if (st == HighSchool)
        return 16;
    if (st == Freshman)
        return 18;
    if (st == Sophomore)
        return 19;
    if (st == Junior)
        return 21;
    if (st == Senior)
        return 23;
    if (st == PostBac)
        return 24;
    if (st == GradStudent)
        return 26;

    return -1;
```

If you had used integers, then this is a bigger change and likely to lead to bugs.

Data types

- float
- double
- int
- char
- unsigned char

All of these are simple data types

Structs: a complex data type

- Construct that defines a group of variables
  - Variables must be grouped together in contiguous memory
- Also makes accessing variables easier … they are all part of the same grouping (the struct)

struct syntax

C keyword "struct" – means struct definition is coming

```
struct Ray
{
    double origin[3];
    double direction[3];
};

int main()
{
    struct Ray r;
    r.origin[0] = 0;
    r.origin[1] = 0;
    r.origin[2] = 0;
    r.direction[0] = 1;
    r.direction[1] = 0;
    r.direction[2] = 0;
}
```

This struct contains 6 doubles, meaning it is 48 bytes

semi-colon!!!

Declaring an instance

"." accesses data members for a struct

Nested structs

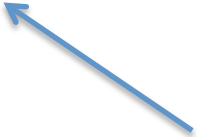
```
struct Origin
{
    double originX;
    double originY;
    double originZ;
};

struct Direction
{
    double directionX;
    double directionY;
    double directionZ;
};

struct Ray
{
    struct Origin ori;
    struct Direction dir;
};
```

```
int main()
{
    struct Ray r;
    r.ori.originX = 0;
    r.ori.originY = 0;
    r.ori.originZ = 0;
    r.dir.directionX = 0;
    r.dir.directionY = 0;
    r.dir.directionZ = 0;
}
```

accesses dir part of Ray



accesses directionZ part of Direction (part of Ray)

typedef

- typedef: tell compiler you want to define a new type

```
struct Ray
{
    double origin[3];
    double direction[3];
};

int main()
{
    struct Ray r;
    r.origin[0] = 0;
    r.origin[1] = 0;
    r.origin[2] = 0;
    r.direction[0] = 1;
    r.direction[1] = 0;
    r.direct
}
```

```
typedef struct
{
    double origin[3];
    double direction[3];
} Ray;

int main()
{
    Ray r;
    r.origin[0] = 0;
    r.origin[1] = 0;
    r.origin[2] = 0;
    r.direction[0] = 1;
    r.direction[1] = 0;
    0;
```

saves you from having to type “struct” every time you declare a struct.

Other uses for typedef

- Declare a new type for code clarity
  - typedef int MilesPerHour;
    - Makes a new type called MilesPerHour.
    - MilesPerHour works exactly like an int.
- Also used for enums & unions
  - same trick as for structs … typedef saves you a word

Unions

- Union: special data type
  - store many different memory types in one memory location

```
typedef union
{
    float x;
    int   y;
    char  z[4];
} cis330_union;
```

When dealing with this union, you can treat it as a float, as an int, or as 4 characters.

This data structure has 4 bytes

Unions

```
128-223-223-72-wireless:330 hank$ cat union.c
#include <stdio.h>

typedef union
{
    float x;
    int   y;
    char  z[4];
} cis330_union;


int main()
{
    cis330_union u;
    u.x = 3.5;  /* u.x is 3.5,     u.y and u.z are not meaningful */
    u.y = 3;    /* u.y is 3,   now u.x and u.z are not meaningful */
    printf("As u.x = %f, as u.y = %d\n", u.x, u.y);
}
128-223-223-72-wireless:330 hank$ gcc union.c
128-223-223-72-wireless:330 hank$ ./a.out
As u.x = 0.000000, as u.y = 3
```

Why are unions useful?

Unions Example

```
typedef struct
{
   int firstNum;
   char letters[3];
   int endNums[3];
} CA_LICENSE_PLATE;

typedef struct
{
   char  letters[3];
   int  nums[3];
} OR_LICENSE_PLATE;

typedef struct
{
   int  nums[6];
} WY_LICENSE_PLATE;

typedef union
{
   CA_LICENSE_PLATE ca;
   OR_LICENSE_PLATE or;
   WY_LICENSE_PLATE wy;
} LicensePlate;
```

Unions Example

```
typedef struct
{
   int firstNum;
   char letters[3];
   int endNums[3];
} CA_LICENSE_PLATE;

typedef struct
{
   char  letters[3];
   int  nums[3];
} OR_LICENSE_PLATE;

typedef struct
{
   int  nums[6];
} WY_LICENSE_PLATE;

typedef union
{
   CA_LICENSE_PLATE ca;
   OR_LICENSE_PLATE or;
   WY_LICENSE_PLATE wy;
} LicensePlate;
```

```
typedef enum
{
   CA,
   OR,
   WY
} US_State;

typedef struct
{
   char *carMake;
   char *carModel;
   US_State  state;
   LicensePlate lp;
} CarInfo;

int main()
{
    CarInfo c;
    c.carMake = "Chevrolet";
    c.carModel = "Camaro";
    c.state = OR;
    c.lp.or.letters[0] = 'X';
    c.lp.or.letters[1] = 'S';
    c.lp.or.letters[2] = 'Z';
    c.lp.or.nums[0] = 0;
    c.lp.or.nums[1] = 7;
    c.lp.or.nums[2] = 5;
}
```

Why are Unions useful?

- Allows you to represent multiple data types simultaneously
  - But only if you know you want exactly one of them
- Benefit is space efficiency, which leads to performance efficiency

Unions are also useful for abstracting type. We will re-visit this when we talk about C++'s templates.

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- Function Pointers
- Subtyping
- More Unix
- Project 2D
- (Bonus Material)

Project 2C

CIS 330: Project #2C
Assigned: April 20th, 2016
Due April 26th, 2016
(which means submitted by 6am on April 27th, 2016)
Worth 4% of your grade

Assignment: You will implement 3 structs and 9 functions. The prototypes for the functions are located in the file prototypes.h (available on the website).

The three structs are Rectangle, Circle, and Triangle, and are described below.

The 3 structs refer to 3 different shapes: Triangle, Circle, and Rectangle.
For each shape, there are 3 functions: Initialize, GetArea, and GetBoundingBox.
You must implement 9 functions total (3*3).

The prototypes for these 9 functions are available in the file prototypes.h

There is also a driver program, and correct output for the driver program.

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Function Pointers

- Idea:
  - You have a pointer to a function
  - This pointer can change based on circumstance
  - When you call the function pointer, it is like calling a known function

Function Pointer Example

```
128-223-223-72-wireless:cli hank$ cat function_ptr.c
#include <stdio.h>
int doubler(int x) { return 2*x; }
int tripler(int x) { return 3*x; }
int main()
{
    int (*multiplier)(int);
    multiplier = doubler;
    printf("Multiplier of 3 = %d\n", multiplier(3));
    multiplier = tripler;
    printf("Multiplier of 3 = %d\n", multiplier(3));
}
128-223-223-72-wireless:cli hank$ gcc function_ptr.c
128-223-223-72-wireless:cli hank$ ./a.out
Multiplier of 3 = 6
Multiplier of 3 = 9
```

Function Pointers vs Conditionals

```
128-223-223-72-wireless:cli hank$ cat function_ptr2.c
#include <stdio.h>
int doubler(int x) { return 2*x; }
int tripler(int x) { return 3*x; }
int main()
{
    int (*multiplier)(int);
    int condition = 1;

    if (condition)
       multiplier = doubler;
    else
       multiplier = doubler;

    printf("Multiplier of 3 = %d\n", multiplier(3));
}
```

```
#include <stdio.h>
int doubler(int x) { return 2*x; }
int tripler(int x) { return 3*x; }
int main()
{
    int val;

    if (condition)
       val = doubler(3);
    else
       val = tripler(3);

    printf("Multiplier of 3 = %d\n", val);
}
```

What are the pros and cons of each approach?

Function Pointer Example #2

```
128-223-223-72-wireless:cli hank$ cat array_fp.c
#include <stdio.h>
void doubler(int *X) { X[0]*=2; X[1]*=2; };
void tripler(int *X) { X[0]*=3; X[1]*=3; };
int main()
{
    void (*multiplier)(int *);
    int A[2] = { 2, 3 };
    multiplier = doubler;
    multiplier(A);
    printf("Multiplier of 3 = %d, %d\n", A[0], A[1]);
    multiplier = tripler;
    multiplier(A);
    printf("Multiplier of 3 = %d, %d\n", A[0], A[1]);
}
128-223-223-72-wireless:cli hank$ gcc array_fp.c
128-223-223-72-wireless:cli hank$ ./a.out
```

Function pointer

Part of function signature

Don’t be scared of extra ‘*’s … they just come about because of pointers in the arguments or return values.

Simple-to-Exotic Function Pointer Declarations

```
void (*foo)(void);
void (*foo)(int **, char ***);
char ** (*foo)(int **, void (*)(int));
```

These sometimes come up on interviews.

Callbacks

- Callbacks: function that is called when a condition is met
  - Commonly used when interfacing between modules that were developed separately.
  - … libraries use callbacks and developers who use the libraries “register” callbacks.

Callback example

```
128-223-223-72-wireless:callback hank$ cat mylog.h
void RegisterErrorHandler(void (*eh)(char *));
double mylogarithm(double x);
```

```
128-223-223-72-wireless:callback hank$ cat mylog.c
#include <mylog.h>

#include <stdio.h>
#include <stdlib.h>
#include <math.h>

/* NULL is an invalid memory location.
 * Useful for setting to something known, rather than
   leaving uninitialized */
void (*error_handler)(char *) = NULL;

void RegisterErrorHandler(void (*eh)(char *))
{
    error_handler = eh;
}

void Error(char *msg)
{
    if (error_handler != NULL)
        error_handler(msg);
}

double mylogarithm(double x)
{
    if (x <= 0)
    {
        char msg[1024];
        sprintf(msg, "Logarithm of a negative number: %f !!", x);
        Error(msg);
        return 0;
    }

    return log(x);
}
```

Callback example

```
128-223-223-72-wireless:callback hank$ cat program.c
#include <mylog.h>
#include <stdio.h>

FILE *F1 = NULL;
void HanksErrorHandler(char *msg)
{
    if (F1 == NULL)
    {
        F1 = fopen("error", "w");
    }
    fprintf(F1, "Error: %s\n", msg);
}

int main()
{
    RegisterErrorHandler(HanksErrorHandler);

    mylogarithm(3);
    mylogarithm(0);
    mylogarithm(-2);
    mylogarithm(5);
    if (F1 != NULL)
       fclose(F1);
}
128-223-223-72-wireless:callback hank$
128-223-223-72-wireless:callback hank$ ./program
128-223-223-72-wireless:callback hank$
128-223-223-72-wireless:callback hank$ cat error
Error: Logarithm of a negative number: 0.000000 !!
Error: Logarithm of a negative number: -2.000000 !!
128-223-223-72-wireless:callback hank$
```

Function Pointers

- We are going to use function pointers to accomplish “sub-typing” in Project 2D.

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Subtyping

- Type: a data type (int, float, structs)
- Subtype / supertype:
  - Supertype: the abstraction of a type
    - (not specific)
  - Subtype: a concrete implementation of the supertype
    - (specific)

The fancy term for this is “subtype polymorphism”

Subtyping: example

- Supertype: Shape
- Subtypes:
  - Circle
  - Rectangle
  - Triangle

Subtyping works via interfaces

- Must define an interface for supertype/ subtypes
  - Interfaces are the functions you can call on the supertype/subtypes
- The set of functions is fixed
  - Every subtype must define all functions

Subtyping

- I write my routines to the supertype interface
- All subtypes can automatically use this code
  - Don't have to modify code when new supertypes are added
- Example:
  - I wrote code about Shapes.
  - I don't care about details of subtypes (Triangle, Rectangle, Circle)
  - When new subtypes are added (Square), my code doesn't change

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Project 2D

- You will extend Project 2C
- You will do Subtyping
  - You will make a union of all the structs
  - You will make a struct of function pointers
- This will enable subtyping
- Goal: driver program works on “Shape”s and doesn’t need to know if it is a Circle, Triangle, or Rectangle.

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"." and ".."

- Unix convention:
  - "." : the current directory
  - ".." : the parent directory

Quiz: you in /path/to/dir and issue "cd ./.././..". Where do you end up?

Answer: "/path"

pwd and $PWD

- pwd: unix command that returns the “present working directory”
- $PWD : environment variable that contains the present working directory
- $OLDPWD : environment variable that contains the previous present working directory
- “-” : shortcut for the previous PWD

```
C02LN00GFD58:~ hank$ echo $PWD
/Users/hank
C02LN00GFD58:~ hank$ pwd
/Users/hank
C02LN00GFD58:~ hank$ cd 330
C02LN00GFD58:330 hank$ echo $OLDPWD
/Users/hank
C02LN00GFD58:330 hank$ cd -
/Users/hank
C02LN00GFD58:~ hank$ echo $OLDPWD
/Users/hank/330
C02LN00GFD58:~ hank$
```

PATH environment variable

```
128-223-223-72-wireless:Documents hank$ echo $PATH
/opt/local/bin:/opt/local/sbin:/usr/bin:/bin:/usr/sbin:/sbin:/us
r/local/bin:/opt/X11/bin:/usr/texbin
128-223-223-72-wireless:Documents hank$ echo $PATH | tr : '\n'
/opt/local/bin
/opt/local/sbin
/usr/bin
/bin
/usr/sbin
/sbin
/usr/local/bin
/opt/X11/bin
/usr/texbin
128-223-223-72-wireless:Documents hank$
```

"tr": Unix command for replacing characters (translating characters).

When the shell wants to invoke a command, it searches for the command in the path

which

```
C02LN00GFD58:330 hank$ which ls
/bin/ls
C02LN00GFD58:330 hank$ which tr
/usr/bin/tr
C02LN00GFD58:330 hank$ which bad_command
C02LN00GFD58:330 hank$ echo $?
1
```

which: tells you the directory the shell is finding a command in.

Invoking programs in current directory

```
C02LN00GFD58:330 hank$ echo "echo hello world" > my_script
C02LN00GFD58:330 hank$ chmod 755 my_script
C02LN00GFD58:330 hank$ my_script
-bash: my_script: command not found
C02LN00GFD58:330 hank$ ./my_script
hello world
```

shell works with ./prog_name since it views this as a path. Hence $PATH is ignored.

Invoking programs in current directory

```
C02LN00GFD58:330 hank$ echo "echo hello world" > my_script
C02LN00GFD58:330 hank$ chmod 755 my_script
C02LN00GFD58:330 hank$ my_script
-bash: my_script: command not found
C02LN00GFD58:330 hank$ ./my_script
hello world
C02LN00GFD58:330 hank$ export PATH=$PATH:.
C02LN00GFD58:330 hank$ my_script
hello world
C02LN00GFD58:330 hank$
```

Trojan Horse Attack

- export PATH=.:$PATH
  - why is this a terrible idea?

```
C02LN00GFD58:330 hank$ echo "rm -Rf ~" > ls
C02LN00GFD58:330 hank$ export PATH=.:$PATH
C02LN00GFD58:330 hank$ chmod 755 ls
C02LN00GFD58:330 hank$ ls # this would be bad...
```

Wild Cards

- '*' (asterisk) serves as a wild card that does pattern matching

```
C02LN00GFD58:330 hank$ ls *.c
330cp.c                 heap_stack.c            struct3.c
copy.c                  purify.c                struct4.c
copy2.c                 recursive.c             t.c
doubler.c               rw.c                    t2.c
doubler_example.c       scope.c                 typedef.c
enum.c                  stack.c                 union.c
enum2.c                 struct.c                union2.c
heap.c                  struct2.c
```

Wild Cards

- You can use multiple asterisks for complex patterns

```
C02LN00GFD58:~ hank$ ls -1 */*.C
330/binary.C
330/cis330.C
Downloads/avtConnComponentsExpression.C
```

if / then / else / fi

- Advanced constructs:

```
C02LN00GFD58:~ hank$ cat script
export X=hank
if [[ $X == "childs" ]] ; then
  echo "matches"
else
  echo "doesn't match"
fi
C02LN00GFD58:~ hank$ ./script
doesn't match
```

for / do / done

```
C02LN00GFD58:330 hank$ cat script
for i in s*.c ; do
  echo $i
  wc -l $i
done
C02LN00GFD58:330 hank$ ./script
scope.c
       8 scope.c
stack.c
      18 stack.c
struct.c
      16 struct.c
struct2.c
      19 struct2.c
struct3.c
      33 struct3.c
struct4.c
      16 struct4.c
C02LN00GFD58:330 hank$
```

-f and -d

- -f : does a file exist?
- -d : does a directory exist?

example:

```
if [[ ! -d include ]] ; then mkdir include ; fi
```

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Problem with C…

```
C02LN00GFD58:330 hank$ cat doubler.c
float doubler(float f) { return 2*f; }
C02LN00GFD58:330 hank$ gcc -c doubler.c
C02LN00GFD58:330 hank$ cat doubler_example.c
#include <stdio.h>

int doubler(int);

int main()
{
    printf("Doubler of 10 is %d\n", doubler(10));
}
C02LN00GFD58:330 hank$ gcc -c doubler_example.c
C02LN00GFD58:330 hank$ gcc -o doubler_example doubler.o doubler_example.o
C02LN00GFD58:330 hank$ ./doubler_example
Doubler of 10 is 2
```

Problem with C…

```
C02LN00GFD58:330 hank$ nm doubler.o
0000000000000048 s EH_frame0
0000000000000000 T _doubler
0000000000000060 S _doubler.eh
C02LN00GFD58:330 hank$ nm doubler
doubler.c          doubler_example    doubler_example.o
doubler.o          doubler_example.c  doubler_user.o
C02LN00GFD58:330 hank$ nm doubler_example.o
0000000000000068 s EH_frame0
0000000000000032 s L_.str
                 U _doubler
0000000000000000 T _main
0000000000000080 S _main.eh
                 U _printf
```

No checking of type…

Problem is fixed with C++…

```
C02LN00GFD58:330 hank$ cat doubler.c
float doubler(float f) { return 2*f; }
C02LN00GFD58:330 hank$ g++ -c doubler.c
clang: warning: treating 'c' input as 'c++' when in C++ mode, this behavior is deprecated
C02LN00GFD58:330 hank$ cat doubler_example.c
#include <stdio.h>

int doubler(int);

int main()
{
    printf("Doubler of 10 is %d\n", doubler(10));
}
C02LN00GFD58:330 hank$ g++ -c doubler_example.c
clang: warning: treating 'c' input as 'c++' when in C++ mode, this behavior is deprecated
C02LN00GFD58:330 hank$ g++ -o doubler_example doubler_example.o doubler.o
Undefined symbols for architecture x86_64:
  "doubler(int)", referenced from:
      _main in doubler_example.o
ld: symbol(s) not found for architecture x86_64
clang: error: linker command failed with exit code 1 (use -v to see invocation)
C02LN00GFD58:330 hank$
```

Problem is fixed with C++…

```
C02LN00GFD58:330 hank$ nm doubler.o
000000000000048 s EH_frame0
000000000000000 T __Z7doublerf
000000000000060 S __Z7doublerf.eh
C02LN00GFD58:330 hank$ nm doubler_example.o
000000000000068 s EH_frame0
000000000000032 s L_.str
                 U __Z7doubleri
000000000000000 T _main
000000000000080 S _main.eh
                 U _printf
C02LN00GFD58:330 hank$
```

```
C02LN00GFD58:330 hank$ nm doubler.o
000000000000048 s EH_frame0
000000000000000 T _doubler
000000000000060 S _doubler.eh
C02LN00GFD58:330 hank$ nm doubler
doubler.c          doubler_example    d
doubler.o          doubler_example.c  d
C02LN00GFD58:330 hank$ nm doubler_examp
000000000000068 s EH_frame0
000000000000032 s L_.str
                 U _doubler
000000000000000 T _main
000000000000080 S _main.eh
                 U _printf
```

Mangling

- Mangling refers to combing information about the return type and arguments and "mangling" it with function name.
  - Way of ensuring that you don't mix up functions.
- Causes problems with compiler mismatches
  - C++ compilers haven't standardized.
  - Can't take library from icpc and combine it with g++.

C++ will let you overload functions with different types

```
C02LN00GFD58:330 hank$ cat t.c
float doubler(float f) { return 2*f; }
int doubler(int f) { return 2*f; }
C02LN00GFD58:330 hank$ gcc -c t.c
t.c:2:5: error: conflicting types for 'doubler'
int doubler(int f) { return 2*f; }
    ^
t.c:1:7: note: previous definition is here
float doubler(float f) { return 2*f; }
      ^
1 error generated.
C02LN00GFD58:330 hank$ g++ -c t.C
C02LN00GFD58:330 hank$
```

C++ also gives you access to mangling via “namespaces”

```
C02LN00GFD58:330 hank$ cat cis330.C
#include <stdio.h>

namespace CIS330
{
    int GetNumberOfStudents(void) { return 56; };
}

namespace CIS610
{
    int GetNumberOfStudents(void) { return 9; };
}

int main()
{
    printf("Number of students in 330 is %d, but in 610 was %d\n",
           CIS330::GetNumberOfStudents(),
           CIS610::GetNumberOfStudents());
}
C02LN00GFD58:330 hank$ g++ cis330.C
C02LN00GFD58:330 hank$ ./a.out
Number of students in 330 is 56, but in 610 was 9
```

Functions or variables within a namespace are accessed with “::”

C++ also gives you access to mangling via “namespaces”

```
C02LN00GFD58:330 hank$ cat cis330.C
```

The “using” keyword makes all functions and variables from a namespace available without needing “::”.
And you can still access other namespaces.

```
namespace CIS610
{
    int GetNumberOfStudents(void) { return 9; };
}

using namespace CIS330;

int main()
{
    printf("Number of students in 330 is %d, but in 610 was %d\n",
           GetNumberOfStudents(),
           CIS610::GetNumberOfStudents());
}
C02LN00GFD58:330 hank$ g++ cis330.C
C02LN00GFD58:330 hank$ ./a.out
Number of students in 330 is 56, but in 610 was 9
C02LN00GFD58:330 hank$
```

Backgrounding

- "&": tell shell to run a job in the background
  - Background means that the shell acts as normal, but the command you invoke is running at the same time.
- "sleep 60" vs "sleep 60 &"

When would backgrounding be useful?

Suspending Jobs

- You can suspend a job that is running

  Press “Ctrl-Z”
- The OS will then stop job from running and not schedule it to run.
- You can then:
  - make the job run in the background.
    - Type “bg”
  - make the job run in the foreground.
    - Type “fg”
      - like you never suspended it at all!!

Web pages

- ssh –l <user name> ix.cs.uoregon.edu
- cd public_html
- put something in index.html
- → it will show up as

  http://ix.cs.uoregon.edu/~<username>

Web pages

- You can also exchange files this way
  - scp file.pdf <username>@ix.cs.uoregon.edu:~/public_html
  - point people to http://ix.cs.uoregon.edu/~<username>/file.pdf

Note that ~/public_html/dir1 shows up as http://ix.cs.uoregon.edu/~<username>/dir1

("~/dir1" is not accessible via web)

Unix and Windows difference

- Unix:
  - "\n": goes to next line, and sets cursor to far left
- Windows:
  - "\n": goes to next line (cursor does not go to left)
  - "\m": sets cursor to far left

- Text files written in Windows often don't run well on Unix, and vice-versa
  - There are more differences than just newlines

vi: "set ff=unix" solves this