CSC215 Lecture

Introduction

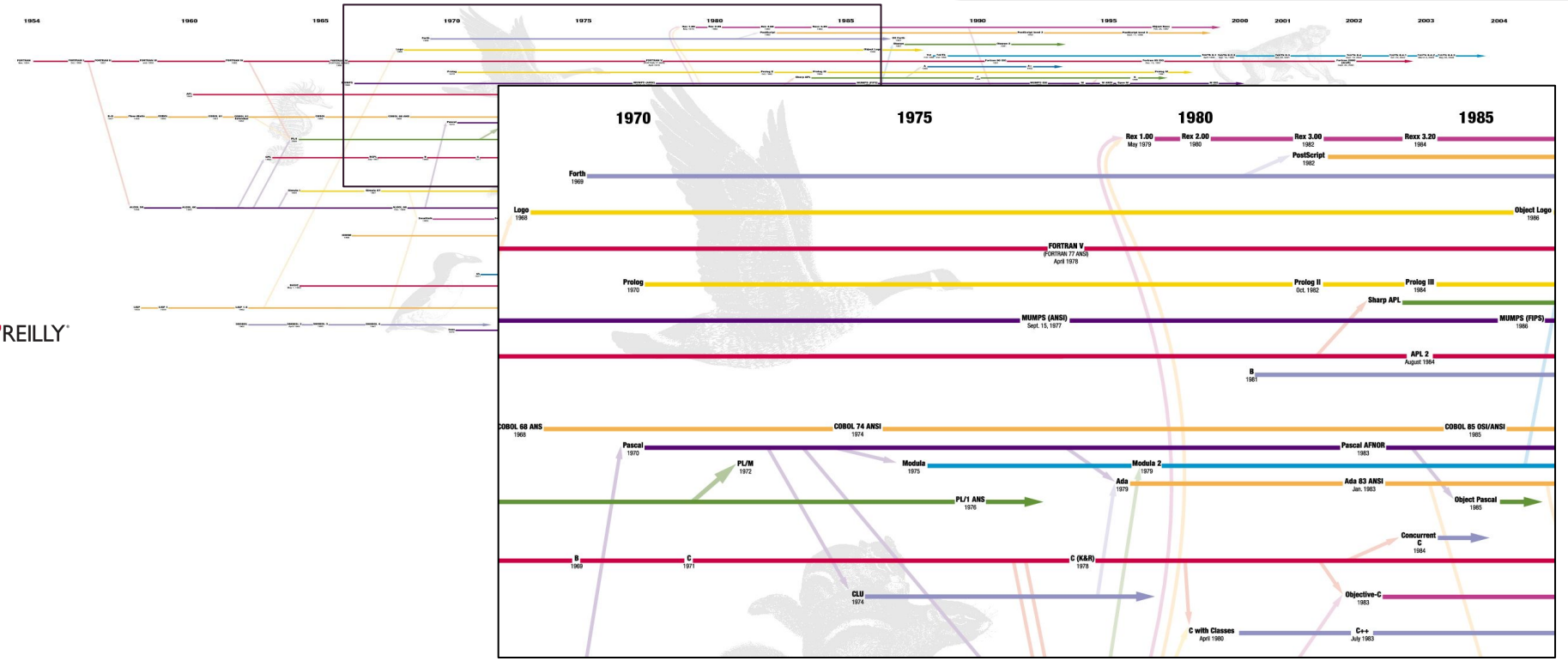
Outline

- Programming Languages
  - Object Oriented Programming
  - Procedural Programming
- What is C?
  - Short history
  - Features, Strengths and weaknesses
  - Relationships to other languages
- Writing C Programs
  - Editing
  - Compiling
- Structure of C Programs
  - Comments
  - Variables
  - Functions: main, function prototypes and functions
  - Expressions and Statements

Programming Languages

- Many programming languages exist, each intended for a specific purpose
  - Over 700 programming language entries on wikipedia
  - Should we learn all?
- Which is the best language? None!
- Choose the right tool for the job based on:
  - problem scope,
  - target hardware/software,
  - memory and performance considerations,
  - portability,
  - concurrency.

Programming Languages



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Object Oriented Programming

- Very useful to organize large software projects
- The program is organized as classes
- The data is broken into ‘objects’ and the sequence of commands becomes the interactions between objects:
  - Decide which classes you need
  - provide a full set of operations for each class
  - and make commonality explicit by using inheritance.
- Covered in CSC111 and CSC113

Procedural Programming

- The program is divided up into subroutines a.k.a procedures a.k.a functions ...
- Allows code to become structured
- The programmer must think in terms of actions:
  - decide which procedures and data structures you want
- Procedural languages include:
  - Fortran
  - BASIC
  - Pascal
  - C

What is C?

- History:
  - 1972 - Dennis Ritchie – AT&T Bell Laboratories
  - 16-bit DEC PDP-11 computer (right)
  - 1978 - Published; first specification of language
  - 1989 - C89 standard (known as ANSI C or Standard C)
  - 1990 - ANSI C adopted by ISO, known as C90
  - 1999 - C99 standard: mostly backward-compatible, not completely implemented in many compilers
  - 2007 - work on new C standard C1X announced
- In this course: ANSI/ISO C (C89/C90)

What is C?

- Features:
  - Provides low -level access to memory
  - Provides language constructs that map efficiently to machine instructions
  - Few keywords (32 in ANSI C)
  - Structures, unions – compound data types
  - Pointers - memory, arrays
  - External standard library – I/O, other facilities
  - Compiles to native code
  - Systems programming:
    - OSes, like Linux
    - microcontrollers: automobiles and airplanes
    - embedded processors: phones, portable electronics, etc.
    - DSP processors: digital audio and TV systems
    - . . . Macro preprocessor
  - Widely used today, ٹxtends to newer system architectures

What is C?

- Strengths:
  - Efficiency: intended for applications where assembly language had traditionally been used
  - Portability: hasn't splintered into incompatible dialects; small and easily written
  - Power: large collection of data types and operators
  - Flexibility: not only for system but also for embedded system commercial data processing
  - Standard library
  - Integration with UNIX
- Weaknesses
  - Error-prone:
    - Error detection left to the programmer
  - Difficult to understand
    - Large programs
    - Difficult to modify
  - Memory management
    - Memory management is left to the programmer

Relationship to Other Languages

- More recent derivatives: C++, Objective C, C#
- Influenced: Java, Perl, Python (quite different)
- In comparison with Java, C lacks:
  - Exceptions
  - Range-checking
  - Memory management and garbage collection.
  - Classes, objects and object-oriented programming
    - Polymorphism, encapsulation, information hiding ...
- Shares with Java:
  - /* Comments */
  - Variable declarations
  - if / else statements
  - for / while loops
  - function definitions (like methods)
  - `main` function starts program

C Programs

- Editing:
  - C source code files has .c extension
  - Text files that can be edited using any text editor: Example `product.c`

```
#include <stdio.h>
main() {
  int a, b, c;
  a = 3; b = 2; c = a * b;
  printf("The product is %d", c);
}
```

- Compiling:
  - `gcc -o product product.c`
    - "`-o`" place the output in file product
    - "`product`" is the executable file
  - To execute the program:
    - `product` on windows or `./product` on Linux and Linux-like

C Compilers

- Several compilers
  - Microsoft compiler
  - GNU Compiler Collection (GCC)
  - : (see a List of C compilers)

- How to install GCC on windows:
  - MinGW: from https://nuwen.net/mingw.html
  - Cygwin: from https://cygwin.com/install.html
  - Don't forget to update the PATH environment variable!
- Compilation options:
  - `gcc -ansi product.c` : check the program compatibility with ANSI C
  - `gcc -Wall product.c` : enables all the warnings that are easy to avoid
  - In this course we will always use:

```
gcc -Wall -ansi -o product product.c
```

- Cross Compilation: compiling on one platform to run on another

Structure of .c File

```
/* Begin with comments about file contents */

/* Insert #include statements and preprocessor definitions */

/* Function prototypes and variable declarations */

/* Define main() function {
     Function body
   }
*/

/* Define other function(s) {
     Function body
   }
*/
```

Structure of .c File: Comments

- /* this is a simple comment */
- Can span multiple lines

```
/* This comment
   Spans
   m u l t i p l e l i n e s */
```

- Completely ignored by compiler
- Can appear almost anywhere

```
/* h e l l o . c –
   our f i r s t C program
   Created for CSC215 */
```

Structure of .c File: #include Preprocessor

- **`#include`** is a preprocessor:
  - Header files: constants, functions, other declarations
  - #include: read the contents of the header file stdio.h
- **`stdio.h`**: standard I/O functions for console and files

```
#include <stdio.h>
/* basic I/O facilities */
```

  - `stdio.h` – part of the C Standard Library
- other important header files:

assert.h	ctype.h	errno.h	float.h	limits.h	locale.h	math.h
signal.h	setjmp.h	stdarg.h	stddef.h	stdlib.h	string.h	time.h

- Included files must be on include path
  - standard include directories assumed by default
  - #include "stdio.h" – searches ./ for stdio.h first

Structure of .c File: #Variables and Constants

- Variables: named spaces in memory that hold values
  - Refer to these spaces using their names rather than memory addresses
  - Names selection adheres to some rules
  - Defined with a type that determines their domains and operations
  - Variable must be declared prior to their use
  - Can change their values after initialization
- Constants:
  - Do not change their values after initialization
  - Can be of any basic or enumerated data type
  - Declared by assigning a literal to a typed name, with the use of the keyword `const`

    ```
    const int LENGTH = 10;
    Const char NEWLINE = '\n';
    ```
  - Can also use the `#define` preprocessor

    ```
    #define LENGTH 10
    #define NEWLINE '\n'
    ```

Structure of .c File: Function Prototype

- Functions also must be declared before use
- Declaration called function prototype
- Function prototypes:

```
int factorial(int);
int factorial(int n);
```

- Prototypes for many common functions in header files for C Standard Library
- General form:

```
return_type function_name(arg1,arg2,...);
```

- Arguments: local variables, values passed from caller
- Return value: single value returned to caller when function exits
- void – signifies no return value/arguments int rand(void);

Structure of .c File: Function main

- `main()`: entry point for C program
- Simplest version:
  - no inputs,
  - outputs 0 when successful,
  - and nonzero to signal some error int main(void);
- Two-argument form of main():
  - access command-line arguments int main(int argc, char **argv);
  - More on the `char **argv` notation later

Structure of .c File: Function Definitions

- Function declaration

```
<return_type> <function_name>(<list_of_parameters>){
  <declare_variables;>
  <program_statements;>
  return <expression>;
}
```

- Must match prototype (if there is one)
  - variable names don't have to match
- No semicolon at end
- Curly braces define a block – region of code
  - Variables declared in a block exist only in that block
  - Variable declarations before any other statements

Structure of .c File: Expressions and statements

- Expression:
  - a sequence of characters and symbols that can be evaluated to a single data item.
  - consists of: literals, variables, subexpressions, interconnected by one or more *operators*
    - Numeric literals like 3 or 4.5
    - String literals like “Hello”
  - Example expressions:
    - Binary arithmetic

      `x+y , x-y , x*y , x/y , x%y`
- Statement:
  - A sequence of characters and symbols causes the computer to carry out some definite action
  - Not all statements have values
  - Example statement:

    ```
    y = x+3*x/(y-4);
    ```
  - Semicolon ends statement (not newline)

Console Input and Output

- stdout, stdin: console output and input streams
  - `puts(<string_expression>)` : prints string to stdout
  - `putchar(<char_expression>)` : prints character to stdout
  - `<char_var> = getchar()` : returns character from stdin
  - `<string_var> = gets(<buffer>)` : reads line from stdin into string
  - `printf(control_string, arg1, arg2, …)` to be discussed later

Output Statements

```
/* The main ( ) function */
int main (void)/* entry point */ {
  /* write message to console */
  puts( "Hello World!" );
  return 0; /* exit (0 => success) */
}
```

- `puts(<string>)`: output text to console window (stdout) and end the line
- String literal: written surrounded by double quotes
- return 0; exits the function, returning value 0 to caller