

# Ateneo de Manila University

## Introduction to GNU Development Tools



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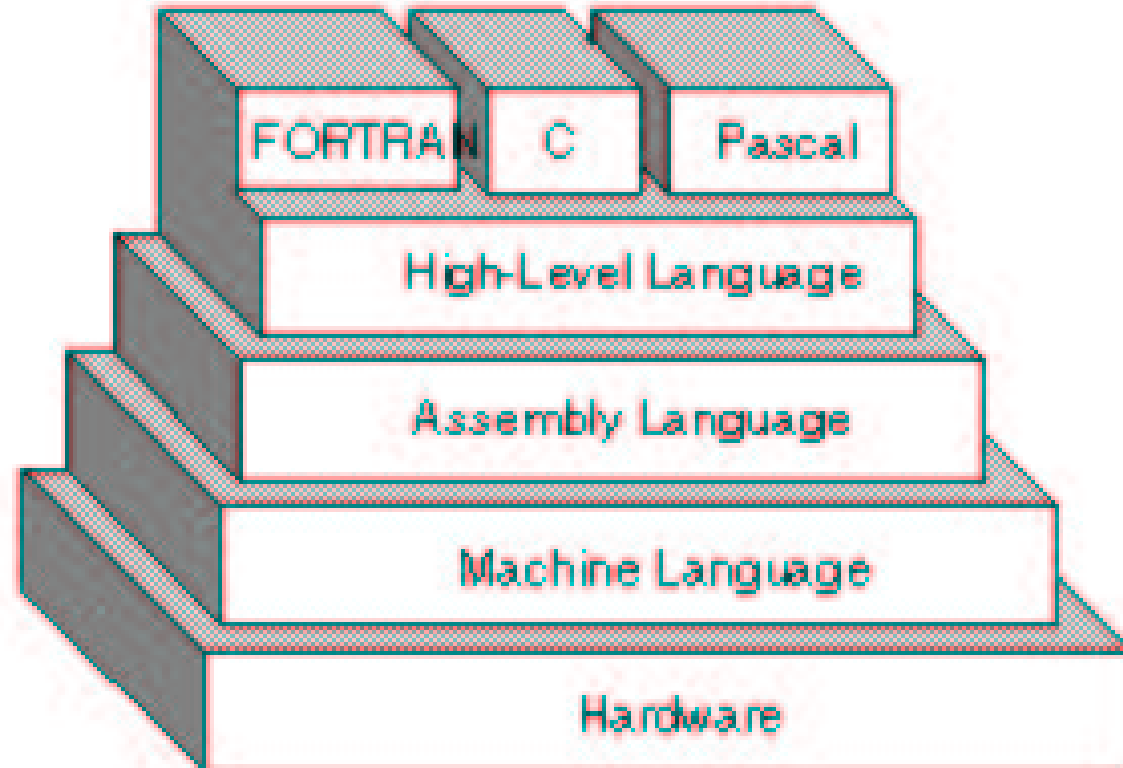
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## Section I

# Introduction

## Software Pyramid



Choose the layer that best suits ones requirements. Are there any layers above the high-level languages layer?

## Programming in the Unix Environment

- ★ several tools available to aid programming and development
- ★ the most common of these tools are the GNU tools
- ★ can be divided into subgroups:
  - ★ compilers and linkers: `cpp`, `gcc`, `as`
  - ★ source code management: `make`
  - ★ troubleshooting: `gdb` and `strace`
  - ★ library manipulation: `ar`, `ranlib`, `nm`
- ★ many other tools

## Section II

# Compilers and Linkers

## Stages of Compilation

- ★ Pre-processing
- ★ Compiling
- ★ Assembling
- ★ Linking

## Pre-processing

- ★ **cpp** is the gcc pre-processor
- ★ this step is usually skipped in modern systems development
- ★ options:
  - ★ **-Wall**: flags all errors and warnings
  - ★ **-IDIRECTORY**: flags a directory to search for header files
  - ★ **-DMACRO**: defines a macro instruction
  - ★ **-DMACRO=value**: defines a macro instruction and its value
  - ★ **-M**: enables dependencies associated with files to be generated
- ★ examples:
  - ★ `cpp example.c`
  - ★ `gcc -E example.c`

## Compile

- ★ **gcc** is the gcc C compiler
- ★ generates assembly code
- ★ options:
  - ★ **-On**: level of optimization where n is from 0 (no optimization) to 3(maximum optimization)
  - ★ **-g**: used for debugging
  - ★ **-Wall**: indicates all errors and warnings
  - ★ **-Werror**: indicates all warnings as errors
- ★ examples:
  - ★ `gcc -S example.c`

## Assembly

- ★ this step is typically combined with the compile stage in modern systems
- ★ example: `as -o example.o example.s`
- ★ this example assembles `example.s` and generates object code `example.o`
- ★ example: `gcc -c example.c -o example.o`
- ★ this example compiles and assembles `example.c` and generates `example.o`

## Linker

- ★ this is the final stage of compilation and is useful when dealing with multiple libraries and object files
- ★ linking is still done with **gcc**
- ★ example: `gcc -o main example.o -lm`
- ★ this example links the `example.o` object file and the `libm.so` library and produces the program `main`

## Section III

# Troubleshooting

## The GNU Debugger

- ★ useful tool for tracing program flow
- ★ monitors variable and memory locations
- ★ set breakpoint during runs
- ★ make changes on run time
- ★ example: `gdb main`
- ★ this example starts the debugger on the program main

## Commands

- ★ **help** - displays the gdb help screen
- ★ **set args** - sets the arguments to be passed to the program
- ★ **break** sets breakpoint on specified location
- ★ **run** - start program execution until a breakpoint or error occurs
- ★ **list** - lists the program code about the current program pointer location
- ★ **print** - displays the contents of a variable
- ★ **step** - executes the program one line at a time
- ★ **next** - same as step but functions are not stepped into
- ★ **continue** - continues program execution
- ★ **where** - finding where the function calls are located
- ★ **quit** - stops debugger

## Strace

- ★ debugging and diagnostics tool
- ★ tracing system calls and signal
- ★ quick tool for running a specified applications until it exits
- ★ records system calls which are called by a process and the signals which are received by such process

## Section IV

# Source Code Management

## GNU Make

- ★ is to determine automatically which pieces of a large program need to be recompiled, and issue the commands to recompile them
- ★ ideal for maintaining source code bases with a large number of files
- ★ looks for a file `makefile` or `Makefile` in the current directory

## Example Makefile

```
CC=gcc
```

```
RM=/bin/rm
```

```
CFLAGS=-g -Wall -Werror
```

```
OBJ=example.o extra.o extra2.o
```

```
PROG=main
```

```
LIB=-lm
```

```
.c.o:
```

```
$(CC) $(CFLAGS) -c $<
```

```
$(PROG): $(OBJ)
```

```
$(CC) $(CFLAGS) $(OBJ) -o $(PROG) $(LIB)
```

```
clean:
```

```
$(RM) -f $(OBJ) $(PROG)
```

```
example.o : example.c example.h
```

```
extra.o : extra.c example.h
```

```
extra2.o : extra2.c example.h
```

## Section V

# Library Creation

## nm

- ★ lists symbols in an object file
- ★ useful for determining function in a library and their state
- ★ states are defined as:
  - ★ **U** undefined symbol
  - ★ **W** probably overloaded symbol
  - ★ **T** symbol defined normally
- ★ example: `nm /lib/libm.so.6`
- ★ this example lists all symbols in the libm.so.6 library

## Static Libraries

- ★ linked with actual object files to generate executable during compile time

- ★ handled like object files on compile

1. compile and assemble code

- ★ example: `gcc -c complex.c -o complex.o`

- ★ creates an object file `complex.o` from source

2. insert object file into library or create library

- ★ example: `ar cru libcomplex.a complex.o`

- ★ creates a new library if not existent and appends to the existing library if existent

3. generate index to archive

- ★ example: `ranlib libcomplex.a`

- ★ generates the library index

## Dynamic Libraries

- ★ linked with actual program files during runtime
- ★ enables other programs to share the same libraries
- ★ also known as shared objects (so)
  1. compile and assemble object code using the -fPIC option
    - ★ example: `gcc -c -fPIC complex.c -o complex.o`
    - ★ generates object code for creating a dynamic library
  2. use link edits to generate library
    - ★ example: `gcc -shared -Wl -soname libcomplex.so.1 -o libcomplex.so.1.0 complex.o`
    - ★ links a dynamic library with proper name `libcomplex.so.1` and physical name `libcomplex.so.1.0`
    - ★ this is to allow the existence of multiple existence of these libraries

## References

- W. Richard Stevens, “Advanced Programming in the Unix Environment”
- W. Richard Stevens, “Unix Network Programming”
- Eric S. Raymond, “The Art of Unix Programming,”  
<http://www.catb.org/esr/writings/taoup/>



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