Programming Practices

CSE 220: Systems Programming

Ethan Blanton
Department of Computer Science and Engineering
University at Buffalo
Effective Programming

The difference between a programmer and a good programmer is large.

Some of that difference is talent and knowledge.

A lot of that difference is experience and practice.

There are practices you can adopt to become a better programmer.
Administrivia

- Remember your lecture quizzes
- Remember to keep up with your readings
- If you’re feeling behind, come get help!
The advice in this section is mostly things you already know.

- Start early
- Work diligently
- Comment and document
- Write a second draft
- Read and write
Start Early

Start your programs early.

This is more than just time management.

Think about where and when you’ve had programming insights.

- Shower?
- Driving?
- Walking?
- Anywhere there’s no way you can type it in?

Your subconscious will work for you if you give it time.
Comment and Document

Comment your code **judiciously**: 
- Include insightful comments
- Avoid useless comments

Never do this:

```plaintext
i++; /* Increment i */
```

Document **while you are writing the code**.

This will help crystallize your ideas and identify logical errors.
Write a Second Draft

Plan to throw one away; you will, anyhow.
— Fred Brooks, The Mythical Man Month

If you find that your approach is getting unwieldy:

- Stop and consider what you’ve learned
- Rewrite as necessary!
Getting Started

Sometimes the hardest part is **getting started**.

Find **something you know how to do**, and **do it**.

Maybe you can:

- Process program arguments
- Perform a simple sub-calculation
- Define a data structure

Once the problem is **started**, it seems more tractable.
Read and Write

Read documentation
- Man pages
- API specifications
- Standards

Read Programming texts
- There are several in the references

Write code
- There is no substitute!

Write documentation
Top Down and Bottom Up

For many projects, I recommend a two-pass process:

- Divide the task **top down**
- Implement **bottom up**
Top Down Design

Recursively apply the following steps:

- Identify the problem to be solved
- Determine what you need to solve it
- Define a function/data structure/etc. to obtain what you need
- Apply this method to each of those things

Try to identify common functionality among tasks while doing this.
Bottom Up Implementation

Recursively apply the following steps:

- Identify sub-tasks you know how to solve
- Solve them
- Identify sub-tasks that can now be solved

You may need or want to refine your top-down design during this phase!
Managing Complexity

During development, you may find complexity growing.

You can manage this by:

- Identifying routines that can be abstracted into functions
- Defining and using constants
- Creating data structures to simplify computation
- Using standard library functions
Using tools effectively is critical to efficient programming.

These tools might include:

- Your editor
- The compiler
- Build system tools such as make
- The debugger
- Text or data processing tools

It’s worth taking extra time to learn your tools.

It will pay itself back!
The Compiler

The compiler is very helpful in producing correct code.

Always compile with -Wall and maybe -Wextra.

Silence warnings.

Use functions instead of macros to get type checking.

Use the preprocessor for debugging.
The Debugger

You *don’t have time* to not learn `gdb`.

Learn when to `printf()` and when to `gdb`.

Explore `xxgdb`, Emacs `gdb` mode, scripts, *etc.*

We will cover `gdb` in Lab 05.
Your Editor

Find a good editor, and trust it.

If it thinks something is hinky, figure out why.

For example:

- It wants to indent funny
- It colors a variable name unexpectedly
- It can’t find a completion
- …

This may mean things like:

- You’ve misplaced braces
- You’re shadowing a system variable
- etc.
Use helper functions to:

- Factor out repeated operations
- Reduce the state in any given function
- Provide debug assistance

Declare file local helper functions static.

Declare project-wide helper functions in header files.

Keep an eye out for refactoring opportunities:

- Easy ways to handle more cases in the same function
- More code that can be lifted into helpers
- Different approaches that factor out larger blocks
Types

Pay close attention to types!

Don’t fix type errors without understanding them!

Declare variables as the tightest type possible:

- Prefer something * over void *
- Prefer something[] over something *
- Prefer int32_t over int
- ...
Never use magic values!

Use named constants instead of integers or strings with semantic meaning.

#define MESSAGE 2
#define LIVE 'X'

Once you have them, use them.

*(int *)packed = 2; // WHYYYYYYYYYYYY????????
Format Your Code

Format your code precisely.

The style you pick is not as important as picking a style.

Badly-indented code should bother you.

Code formatting should help you spot logical errors.
Invariants

Invariants are properties of a program that are always true, or predictably true.

We often speak of loop invariants.

You should know and define invariants.

A professor once told me:

*If you write a loop and you don’t know its invariant, it’s wrong.*
Violating Invariants

Invariants must often be violated *temporarily*.

If you violate an invariant, you must:

- **not invoke code** that expects it to be maintained
- Know **when and where** it will be restored
- Ensure that it is restored **on every code path**

Example:

A doubly-linked list’s `prev` and `next` pointers are inconsistent during node insertion.
Pre- and Post-Conditions

Closely related to invariants.

Rules that must be maintained before and after an operation.

- Loop
- Function
- I/O
- etc.

Identify and document pre- and post-conditions in comments!

Verify conditions at run time!
Make Purposeful Changes

Don’t just change code without forethought.

Make purposeful changes designed to address an issue.

It is better to take longer and understand the problem.

Programming by Brownian Motion is seldom successful.

Sometimes quick fixes cover up a problem without fixing!
Summary

- Cultivate **good work habits**
- **Design** your programs purposefully
- **Use** your tools!
- **Practice** **good style and form**
- **Debug** **with a plan**

**The only way** to become a good programmer is to **write programs**.
Optional Readings


Copyright 2021 Ethan Blanton, All Rights Reserved.
Copyright 2019 Karthik Dantu, All Rights Reserved.

Reproduction of this material without written consent of the author is prohibited.

To retrieve a copy of this material, or related materials, see https://www.cse.buffalo.edu/~eblanton/.