Maintainability and Readability

- elements of maintainability
- program readability
  - module structure
  - commenting
- coding standards
- code ownership

What is "maintainability"?

- *Given a program, it is relatively easy to*
  - *understand its structure and what each module does.*
- *Given a module, it is relatively easy to*
  - *understand what it does, and the role of each routine.*
- *Given a routine, it is relatively easy to*
  - *understand what variables are and how code works.*
- *Given a problem or enhancement, it is relatively easy to*
  - *safely make the required changes*
- *Given a set of changes, it is relatively easy to*
  - *test and be confident the program works correctly*

The maintainability features must also be maintainable

What makes code "understandable"?

- good architecture
  - intuitive components, well chosen interfaces
  - straight-forward hierarchical structure
- good specifications
  - good overview of system structure & operation
  - clear descriptions of each component
- good design
  - good modularity and cohesion
  - well abstracted interfaces
- readable code
  - it is relatively obvious how the code works

What makes code "readable"?

- module organization
  - order in which we describe/define routines, variables
- visual layout
  - use consistent visual metaphors to convey structure
  - use white-space to delimit functional units
- variable and routine naming conventions
  - to make meaning of code more obvious
- commenting
  - to further accentuate structure
  - to guide us through non-obvious parts of the code
- we call these style; but they are technique

The Elements of Style

"*As you become proficient in the use of language, your style will emerge, because you yourself will emerge, and when this happens you will find it increasingly easy to break through the barriers that separate you from other minds, other hearts — which is, of course, the purpose of writing, as well as its principal reward.*"

Strunk & White

Good and Bad Code

- Get together in groups
  - each identify a personal experience of:
    - some very hard to understand code
    - some very easy to understand code
  - note the factors that made them so
  - reasons why they were done that way
  - prepare a summary of
    - your good/bad examples
    - your conclusions
- Be prepared to share interesting results

General Module Structure

- standard preamble
  - copyrights, version, module overview
- imports/includes, type definitions
- static global, then private data declaration
- routine pre-declarations (if required)
- constructors and destructors (if required)
- public & private routine definitions
  - in some logical order (e.g. functional groups, temporal, alphabetical, ...)

General Routine Structure

- standard preamble
  - description of purpose, context, limitations
  - things caller/maintainer should understand
- routine declaration
  - return type, name, parameters & types
- local variables
  - by type, one per line, with descriptions
- blank-separated paragraphs of code
  - preceded, if necessary, with comments describing, in general, what each does

Explanations and Excuses

- often non-obvious code is bad
  - complexity results from a bad approach
  - it is usually better to fix it than to explain it
- some non-obvious approaches are good
  - eliminate problems, improve performance
  - explain problem and the novel approach
- sometimes we leave code incomplete
  - designed features that aren't yet required
  - work we plan to complete later
  - leave warning, excuse, advice, comment

Commenting Data Items

- we mostly talk about commenting code?
- many data items also need comments
  - who uses it for what purpose
  - units, range, and meanings of its values
  - **validity assertions**, **synchronization rules**
- can be true for all types of declarations
  - basic types, structures, bit-fields, unions, etc.
- associate comments with declarations
  - end-line comments for simple declarations
  - large block comments for stories

non-Readability Comments

- mandatory module preambles
  - copyright notices, legal disclaimers
  - title, version, and authorship information
- information for use by CAD tools
  - semantic interface descriptions
    - for documentation and test generation tools
  - notes for static analysis tools
    - information that is not statically determinable
  - correctness assertions
    - for automated testing or run-time checking

Automatic Documentation

- Construct documentation from the code
  - javadoc, pydoc, doxygen, UMLgraph …
  - easy to keep code/docs in sync
- API documentation directives
  - one-line summary
  - @param, @return, @note, ...
  - @author, @date, @see …
- Structural documentation directives
  - @composed, @has, @depend, @assoc, ...
- Instructions to the document generator
  - @opt, @hidden, ...

Coding Standards - scope

- naming conventions
  - generation, use of case, prefixes, suffixes
- usage conventions
  - e.g. defines, include file processing
- commenting conventions
  - standard module preamble
  - standard routine preamble
- formatting conventions
  - indentation and commenting style

Groups: Code Ownership

- Consider the following:
  - When is code “personal property”?
  - When is code “public property”?
  - Code & people move between communities
  - Some standards may be semi-arbitrary
- How do we draw the lines between:
  - creators’ prerogative
  - social responsibility
  - acceptance of diversity
- Prepare positions to share w/class

For Next Lecture

- McConnell: chapter 23 - Debugging
- Kampe: Forensic Debugging
- Kampe: Root Cause Analysis
- Wiki: Defect Tracking
- Black: Writing a Bug Report
- Kampe: Severity and Priority
- Github Issues … a simple bug tracking system
  - labels (e.g. bug, feature)
  - milestones (when is it needed)
  - assignee (who is supposed to deal with it)

Supplementary Slides

Product Documentation

- design documentation
  - architectural/design introduction/overview
  - component level design specifications
  - design rationale folders
- end-user documentation
  - manuals on how to use the product
- support documentation
  - installation/configuration guidelines
  - trouble-shooting guidelines
  - detailed technical descriptions

Architectural Overviews

- author - lead engineers
- audience - initially developers, later everyone
- form - eventually a polished report/presentation
- content
  - describe overall structure of product
  - goals, principles, components, interfaces
  - later, a technical introduction to the product
- role in code maintainability
  - lays conceptual foundations, intro to design

Design Rationale(s)

- author - architects & designers
- audience - other architects and designers
- form - usually just a collection of notes
  - some may eventually turn into white papers
- content
  - issues, problems, options, decisions
- role in code maintainability
  - explain non-obvious features of the design
  - keep important lessons from being forgotten

Installation/Configuration

- author - responsible engineers
- audience - support and customers
- form - external product documentation
- content
  - process for installing product
  - product configuration options
  - performance considerations and tuning
- role in code maintainability
  - explain how the product is managed

Trouble-Shooting Guidelines

- author - development and support engineers
- audience - technical support
- form - internal product documentation
- content
  - how to diagnose likely problems
  - how to fix or get around them
- role in code maintainability
  - direct how-to guidance for support engineers
  - acquaint maintenance engineers w/problems

Detailed Technical Descriptions

- author - responsible engineers
- audience - support/maintenance engineers
- form - internal product documentation
- content
  - detailed component design descriptions
    - may be at routine level, or even more detailed
- role in code maintainability
  - training for new code maintainers

NOTE: these are not common

Detailed Technical Descriptions

- often mandated by large organizations
  - with very long maintenance commitments
    - e.g. aerospace, government
  - when many maintainers will be trained
    - e.g. military, telecommunications
  - they do improve product maintainability
- they are very expensive to produce
  - documentation takes longer than the code
  - they have to change whenever the code does
- easier just to make code more readable

javadoc

- A commenting discipline and tool for automatically generating documentation from the code.
- A set of standard tags
  - @param, @return, @throws, @serial
  - @link, @see, @version, @since, @author
- A convention for descriptions

```
/**
 * stuff for javadoc
 */
```

choosing good names

- well chosen routine names ...
  - describe what the routine does
  - suggest the meaning of their return value
- well chosen variable names ...
  - tell us what the variable means
  - suggest its scope and general class
- good names are <u>better than comments</u>
  - because they take up much less space
  - because they appear on every usage

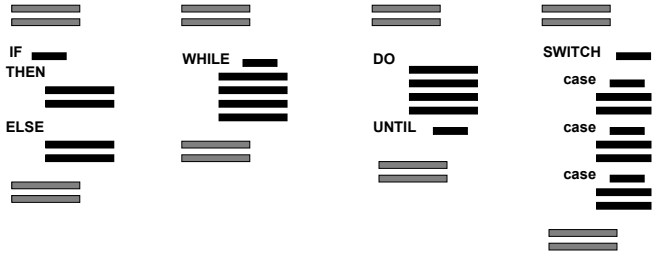
mnemonic naming conventions

- describe the entity/action they represent
  - integer: linesPerPage
  - boolean: outOfSpace
  - routine: pushStack()
- follow recognizable patterns
  - scoreMax, scoreMin, scoreMean, …
  - addStudent(), dropStudent(), ...
- are long enough to make sense
  - but short enough to be manageable
    - easy to type, don't take up the whole line

syntactic naming conventions

- can suggest general variable classes
  - UpperMixed classes and defined types
  - lowerMixed locals and parameters
  - UPPERCASE constants and macros
- can suggest scope
  - m_mixedCase member-private data
  - G_mixedCase global data
- can suggest class from which they come
  - base_Value enumerated types

white-space & program structure



- blank lines make block separation clear
- indentation makes block nesting clear
- visually clearer than keywords or braces

standard (K&R) C indentation

- most braces on same line as keyword
- closing braces, un-indented, on own line
- motivation - ease of editing

```
If (condition) {
    statement;
    statement;
} else {
    statement;
    statement;
}
```

```
while (condition) {
    statement;
    statement;
}
```

```
do {
    statement;
    statement;
} until (condition);
```

```
switch (var) {
  case 1:
    statement;
    statement;
    break;
  case 2:
    statement;
    statement;
    break;
}
```


Indentation Guidelines

- use consistent indentations for all ...
  - lines within a single loop, block, or sub-case
  - loops, blocks or sub-cases at the same level, (especially siblings within a larger block)
  - labels are allowed to hang to the left
- avoid excessively large indentations
  - no more than 50-75% of a line
  - use a smaller indent (e.g. 4 vs 8)
  - put the sub-block into a sub-routine
  - as a last resort, shift whole block left

Line Formatting

- expressions
  - use parens to make precedence explicit
  - use spaces to make sub-expressions obvious

```
((x>4) && ((y/10) > 0))
```
vs.
```
x>4&&y/10>0
```

- continuation lines
  - break line at an argument/operand boundary
  - indent each continuation to same level

```
fprintf( stderr,     "Free space %d entries (%02d\% full)\n",
         cache.totsize - cache.current,
         (cache.current * 100) / cache.totsize );
```


simpler code: boolean exprs

```
If (errors > MAX_ERRORS)
   return( TRUE);
else
   return(FALSE);
```

```
return (errors > MAX_ERRORS);
```

```
If (personType == STUDENT)
   salesTax = 0;
else
   salesTax = 0.085;
```

```
salesTax = (PersonType==STUDENT) ? 0 : 0.085;
```

```
if (((index+1) % tablesize) == 0)
   xxx;
…
if (((index+1) % tablesize) == 0)
yyy;
…
```

```
wrap = ((index+1) % tablesize) == 0;

if (wrap)
   xxx;
…
if (wrap)
   yyy;
```


Useful Code Commenting

- prose or pseudo-code summaries
  - explain the purpose of the code that follows
  - high level overview of the algorithm
  - enumerate pre-conditions that must hold
- rationale and references
  - remind reader of important issues
  - explain non-obvious choices
  - refer reader to more detailed discussions
- draw attention to module sub-sections
  - start of a new class or routine

Labels for non-obvious targets

```
if (queue.numEntries > 0) {
      …
   } else /* (queue.numEntries <= 0) */
```

```
…
      if (request.status == ERR_FATAL)
         break;     /* NextRequest */
      …
   }
   /* NextRequest: */
      …
```


Standards - tools

- static analysis tools (e.g. lint)
  - stricter checking than the C compiler
- style checkers (e.g. cstyle, hdrchk, libchk)
  - audit code against specified standards
- pretty-printers (e.g. indent, C beautifier)
  - reformat code w/standard indents/spacing
- auto-documenters (e.g. doxygen)
  - generate routine documents from comments
- code browsers (e.g. cxref, source navigator)