6

Formatting

I wrote this nearly two decades ago. The sample projects I used in my statistical analysis are well into their third, and approaching their fourth, decade. And yet there is little I needed to change in this chapter. I was tempted to add statistical studies for some other languages, but I decided that would not improve the message of this chapter. Other languages may result in slightly different numbers, but you, gentle reader, are smart enough to account for those minor differences.

—Uncle Bob

When people look under the hood, we want them to be impressed with the neatness, consistency, and attention to detail that they perceive. We want them to be struck by the orderliness. We want their eyebrows to rise as they scroll through the modules. We want them to perceive that professionals have been at work. If instead they see a scrambled mass of code that looks like it was written by a bevy of drunken sailors, then they are likely to conclude that the same inattention to detail pervades every other aspect of the project.

You should take care that your code is nicely formatted. You should choose a set of simple rules that govern the format of your code, and then you should consistently apply those rules. If you are working on a team, then the team should agree to a single set of formatting rules and all members should comply. It helps to have an automated tool that can apply those formatting rules for you.

The Purpose of Formatting

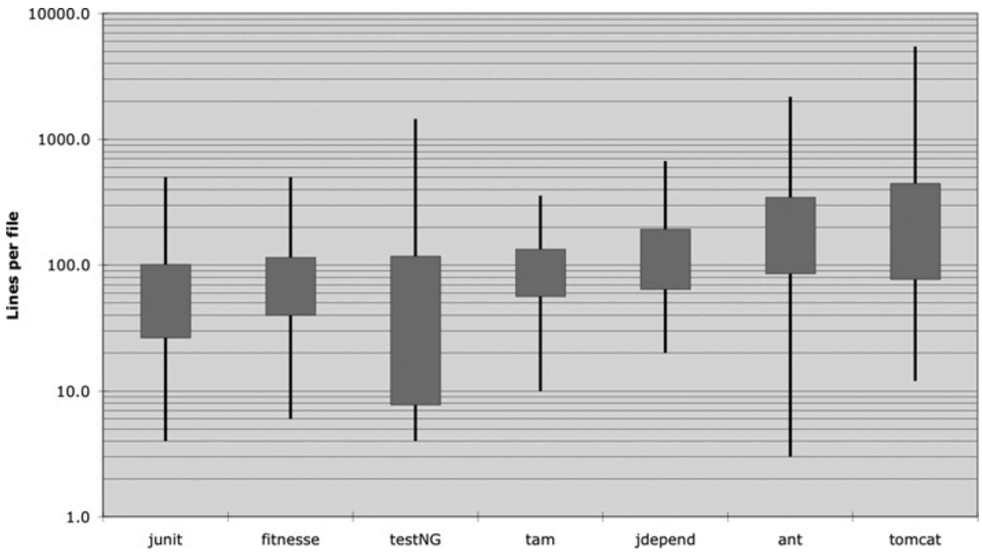
Code formatting is *important*. It is too important to ignore and it is too important to treat religiously. Code formatting is about communication, and communication is the professional developer's first order of business.

Perhaps you thought that "getting it working" was the first order of business for a professional developer. I hope that this book has begun to disabuse you of that idea. The functionality that you create today has a good chance of changing in the next release, but the readability of your code will have a profound effect on all the changes that will ever be made. The coding style and readability set precedents that continue to affect maintainability and extensibility long after the original code has been changed beyond recognition. Your style and discipline survive, even though your code does not.

So, what are the formatting issues that help us communicate best?

Vertical Formatting

Let's start with vertical size. How big should a source file be? It turns out that there is a huge range of sizes and some remarkable differences in style. The following shows some of those differences.



Seven different projects are depicted: Junit, FitNesse, TestNG, Time and Money, JDepend, Ant, and Tomcat. The lines through the boxes show the minimum and maximum file lengths in each project. The box shows approximately one-third (one standard deviation[1]) of the files. The middle of the box is the mean. So the average file size in the FitNesse project is about 65 lines, and about one-third of the files are between 40 and 100+ lines. The largest file in *FitNesse* is about 400 lines and the smallest is 6 lines. Note that this is a log scale, so the small difference in vertical position implies a very large difference in absolute size.

---

1. The box shows sigma/2 above and below the mean. Yes, I know that the file length distribution is not normal, and so the standard deviation is not mathematically precise. But we're not trying for precision here. We're just trying to get a feel.

Junit, FitNesse, and Time and Money are composed of relatively small files. None are over 500 lines and most of those files are less than 200 lines. *Tomcat* and *Ant*, on the other hand, have some files that are several thousand lines long, and close to half are over 200 lines.

What does that mean to us? It appears to be possible to build significant systems (at the time of this analysis, FitNesse was close to 50,000 lines) out of files that are typically 200 lines long, with an upper limit of 500. Although this should not be a hard-and-fast rule, it should be considered very desirable. Small files are usually easier to understand and maintain than large files.

Vertical Openness between Concepts

Nearly all code is read left to right and top to bottom. Each line represents an expression or a clause, and each group of lines represents a complete thought. Those thoughts should be separated from each other with blank lines.

Consider the following code. There are blank lines that separate the package declaration, the import(s), and each of the functions. This extremely simple rule has a profound effect on the visual layout of the code. Each blank line is a visual cue that identifies a new and separate concept. As you scan down the listing, your eye is drawn to the first line that follows a blank line.

```
package fitnesse.wikitext.widgets;

import java.util.regex.*;

public class BoldWidget extends ParentWidget {
  public static final String REGEXP = "'''.+?'''";
  private static final Pattern pattern = Pattern.comp
    Pattern.MULTILINE + Pattern.DOTALL
  );

  public BoldWidget(ParentWidget parent, String text)
    super(parent);
    Matcher match = pattern.matcher(text);
    match.find();
    addChildWidgets(match.group(1));
  }

  public String render() throws Exception {
    StringBuffer html = new StringBuffer("<b>");
    html.append(childHtml()).append("</b>");
    return html.toString();
  }
}
```

Taking those blank lines out has a remarkably obscuring effect on the readability of the code.

```
package fitnesse.wikitext.widgets;
import java.util.regex.*;
public class BoldWidget extends ParentWidget {
  public static final String REGEXP = "'''.+?'''";
  private static final Pattern pattern = Pattern.comp
    Pattern.MULTILINE + Pattern.DOTALL);
  public BoldWidget(ParentWidget parent, String text)
    super(parent);
    Matcher match = pattern.matcher(text);
    match.find();
    addChildWidgets(match.group(1));}
  public String render() throws Exception {
    StringBuffer html = new StringBuffer("<b>");
    html.append(childHtml()).append("</b>");
    return html.toString();
  }
}
```

This effect is even more pronounced when you unfocus your eyes. In the first example, the different groupings of lines pop out at you, whereas the second example looks like a muddle. The difference between these two examples is just a bit of vertical openness.

Vertical Density

If openness separates concepts, then vertical density implies close association. So lines of code that are tightly related should appear vertically dense. Notice how the useless comments in the code below break the close association of the two instance variables.

```
public class ReporterConfig {
  /**
   * The class name of the reporter listener
   */
  private String m_className;

  /**
   * The properties of the reporter listener
   */
  private List<Property> m_properties = new ArrayList
```

```
    public void addProperty(Property property) {
      m_properties.add(property);
    }
  }
```

The code below is much easier to read. It fits in an "eye-full," or at least it does for me. I can look at it and see that this is a class with two variables and a method, without having to move my head or eyes much. The previous listing forces me to use much more eye and head motion, not to mention the extra processing of the distracting comments, to achieve the same level of comprehension.

```
  public class ReporterConfig {
    private String m_className;
    private List<Property> m_properties = new ArrayList

    public void addProperty(Property property) {
      m_properties.add(property);
    }
  }
```

Vertical Distance

Have you ever chased your tail through a class, hopping from one function to the next, scrolling up and down the source file, trying to divine how the functions relate and operate, only to get lost in a rat's nest of confusion? Have you ever hunted up the chain of inheritance for the definition of a variable or function? This is frustrating because you are trying to understand what the system does, but you are spending your time and mental energy on trying to locate and remember where the pieces are.

Concepts that are closely related should be kept vertically close to each other. Clearly this rule doesn't work for concepts that belong in separate files. But then closely related concepts should not be separated into different files unless you have a very good reason. Indeed, this is one of the reasons that `protected` variables should be avoided.

For those concepts that are so closely related that they belong in the same source file, their vertical separation should be a measure of how important each is to the understandability of the other. We want to avoid forcing our readers to hop around through our source files and classes.

Variable Declarations

Variables should be declared as close to their usage as possible. Because our functions are very short, local variables should appear at the top of each function, as in this longish function from JUnit 4.3.1.

```
private static void readPreferences() {
  InputStream is = null;

  try {
    is= new FileInputStream(getPreferencesFile());
    setPreferences(new Properties(getPreferences()));
    getPreferences().load(is);
  } catch (IOException e) {
    try {
      if (is != null)
        is.close();
    } catch (IOException e1) {
    }
  }
}
```

Control variables for loops should usually be declared within the loop statement, as in this cute little function from the same source.

```
public int countTestCases() {
  int count= 0;
  for (Test each : tests)
    count += each.countTestCases();
  return count;
}
```

In rare cases, a variable might be declared at the top of a block or just before a loop in a long-ish function. You can see such a variable in this snippet from the midst of a very long function in TestNG.

```
…
for (XmlTest test : m_suite.getTests()) {
      TestRunner tr = m_runnerFactory.newTestRunner(t
      tr.addListener(m_textReporter);
      m_testRunners.add(tr);

      invoker = tr.getInvoker();

      for (ITestNGMethod m : tr.getBeforeSuiteMethods
        beforeSuiteMethods.put(m.getMethod(), m);
      }

      for (ITestNGMethod m : tr.getAfterSuiteMethods(
        afterSuiteMethods.put(m.getMethod(), m);
      }
    }
…
```

Instance variables, on the other hand, should be declared at either the top or the bottom of a class. This should not increase the vertical distance of these variables, because in a well-designed class, they are used by many, if not all, of the methods of the class.

There have been many debates over where instance variables should go. In `C++`, we commonly practiced the so-called *scissors rule*, which put all the instance variables at the bottom. The rationale for this rule is that public items should go at the top and private items should go at the bottom.

This makes a lot more sense than the Java/C# convention of putting private variables at the top. But since this convention is so pervasive in these languages, it is likely better to follow it than to confuse everyone by appealing to logic and common sense.

The important thing is for the instance variables to be declared in one well-known place. Everybody should know where to go to see the declarations.

Consider, for example, the strange case of the `TestSuite` class in JUnit 4.3.1. I have greatly attenuated this class to make the point. If you look about halfway down the listing, you will see two instance variables declared there. It would be hard to hide them in a better place. Someone reading this code would have to stumble across the declarations by accident (as I did).

```
public class TestSuite implements Test {
  static public Test createTest(Class<? extends TestC
                             String name)  {
    …
  }

  public static Constructor<? extends TestCase>
  getTestConstructor(Class<? extends TestCase> theCla
  throws NoSuchMethodException {
    …
  }

  public static Test warning(final String message) {
    …
  }

  private static String exceptionToString(Throwable t
    …
  }

  private String fName;

  private Vector<Test> fTests= new Vector<Test>(10);

  public TestSuite() {
  }

   public TestSuite(final Class<? extends TestCase> t
     …
  }

  public TestSuite(Class<? extends TestCase>  theClas
    …
  }
  … … … … …
}
```

Dependent Functions

If one function calls another, they should be vertically close, and the caller should be above[2] the callee, if at all possible. This gives the program a natural flow. If the convention is followed reliably, readers will be able to trust that function definitions will follow shortly after their use. Consider, for example, the snippet from FitNesse below. Notice how the topmost function calls (in bold) those below it. Notice also that the called functions appear in the order that they were called. This makes it easy to find the called functions and greatly enhances the readability of the whole module.

---

2. Or below in inverted languages like Clojure.

```
public class WikiPageResponder implements SecureRespo
  protected WikiPage page;
  protected PageData pageData;
  protected String pageTitle;
  protected Request request;
  protected PageCrawler crawler;

  public Response makeResponse(FitNesseContext contex
    throws Exception {
    String pageName = getPageNameOrDefault(request, '
    loadPage(pageName, context);
    if (page == null)
      return notFoundResponse(context, request);
    else
      return makePageResponse(context);
  }

  private String
  getPageNameOrDefault(Request request, String defaul
  {
    String pageName = request.getResource();
    if (StringUtil.isBlank(pageName))
      pageName = defaultPageName;
    return pageName;
  }

  protected void loadPage(String resource, FitNesseCo
    throws Exception {
    WikiPagePath path = PathParser.parse(resource);
```

```
    crawler = context.root.getPageCrawler();
    crawler.setDeadEndStrategy(new VirtualEnabledPage
    page = crawler.getPage(context.root, path);
    if (page != null)
      pageData = page.getData();
  }

  private Response
  notFoundResponse(FitNesseContext context, Request r
    throws Exception {
    return new NotFoundResponder().makeResponse(conte
  }

  private SimpleResponse makePageResponse(FitNesseCor
    throws Exception {
    pageTitle = PathParser.render(crawler.getFullPath
    String html = makeHtml(context);
    SimpleResponse response = new SimpleResponse();
    response.setMaxAge(0);
    response.setContent(html);
    return response;
  }
…
```

As an aside, this snippet provides a nice example of keeping constants at the appropriate level. The `"FrontPage"` constant could have been buried in the `getPageNameOrDefault` function, but that would have hidden a well-known and expected constant in an inappropriately low-level function. It was better to pass that constant down from where knowing it makes sense.

Conceptual Affinity

Certain bits of code want to be near other bits. They have a certain conceptual affinity. The stronger that affinity is, the less vertical distance there should be between them.

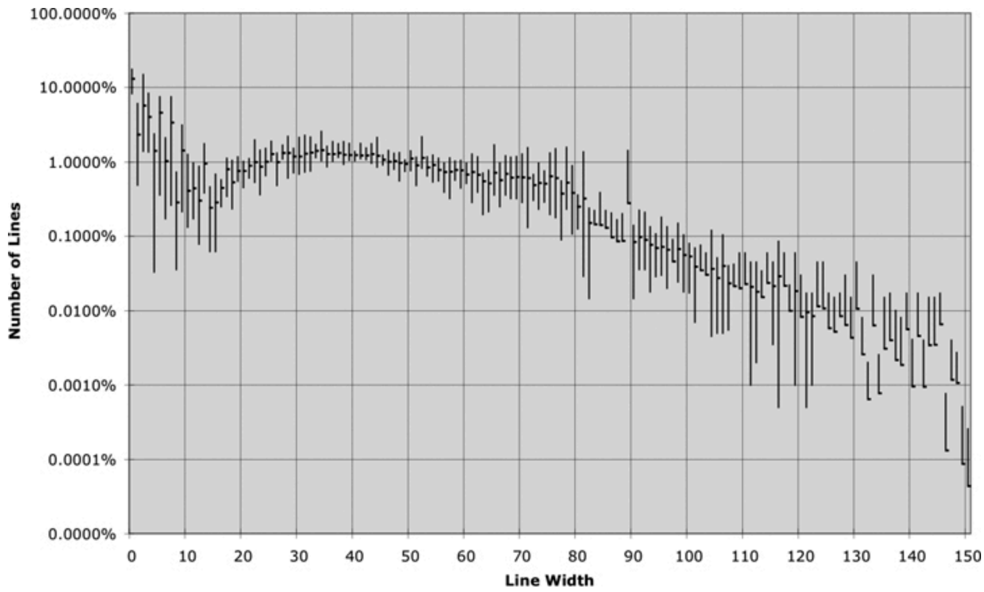
As we have seen, this affinity might be based on a direct dependence, such as one function calling another, or a function using a variable. But there are other possible causes of affinity. Affinity might be caused because a group of functions perform a similar operation. Consider this snippet of code from JUnit 4.3.1:

```
public class Assert {
  static public void assertTrue(String message, boole
    if (!condition)
      fail(message);
  }

  static public void assertTrue(boolean condition) {
    assertTrue(null, condition);
  }

  static public void assertFalse(String message, bool
    assertTrue(message, !condition);
  }

  static public void assertFalse(boolean condition) {
    assertFalse(null, condition);
  }
…
```

These functions have a strong conceptual affinity because they share a common naming scheme and perform variations of the same basic task. The fact that they call each other is secondary. Even if they didn't, they would still want to be close together.

Horizontal Formatting

How wide should a line be? To answer that, let's look at how wide lines are in typical programs. Again, we examine the seven different projects. The following image shows the distribution of line lengths of all seven projects. The regularity is impressive, especially right around 45 characters. Indeed, every size from 20 to 60 represents about 1% of the total number of lines. That's 40%! Perhaps another 30% are less than ten characters wide. Remember, this is a log scale, so the linear appearance of the drop-off above 80 characters is really very significant. Programmers clearly prefer short lines.



This suggests that we should strive to keep our lines short. The old Hollerith limit of 80 is a bit arbitrary, and I'm not opposed to lines edging out to 100 or even 120. But beyond that is probably just careless.

I follow the rule that you should never force your readers to scroll to the right. Given the size and resolution of modern displays I personally set my horizontal limit at 120. I have my IDE draw a soft gray line at that column, and I won't go beyond it.

Horizontal Openness and Density

We use horizontal white space to associate things that are strongly related and disassociate things that are more weakly related. Consider the following function:

```
private void measureLine(String line) {
  lineCount++;
  int lineSize = line.length();
  totalChars += lineSize;
  lineWidthHistogram.addLine(lineSize, lineCount);
  recordWidestLine(lineSize);
}
```

I surrounded the assignment operators with white space to accentuate them. Assignment statements have two distinct and major elements: the left side and the right side. The spaces make that separation obvious.

On the other hand, I didn't put spaces between the function names and the opening parenthesis. This is because the function and its arguments are closely related. Separating them makes them appear disjoined instead of conjoined. I separate arguments within the function call parenthesis to accentuate the comma and show that the arguments are separate.

Another use for white space is to accentuate the precedence of operators.

```
public class Quadratic {
  public static double root1(double a, double b, doub
    double determinant = determinant(a, b, c);
    return (-b + Math.sqrt(determinant)) / (2*a);
  }

  public static double root2(int a, int b, int c) {
    double determinant = determinant(a, b, c);
    return (-b - Math.sqrt(determinant)) / (2*a);
  }

  private static double determinant(double a, double
    return b*b - 4*a*c;
  }
}
```

Notice how nicely the equations read. The factors have no white space between them, because they are high precedence. The terms are separated by white space because addition and subtraction are lower precedence.

Unfortunately, most tools for reformatting code are blind to the precedence of operators and impose the same spacing throughout. So subtle spacings like those shown above tend to get lost after you reformat the code.

Horizontal Alignment

When I was an assembly language programmer,[3] I used horizontal alignment to accentuate certain structures. When I started coding in C, C++, Java, and eventually Clojure, I continued to try to line up all the variable names in a set of declarations, or all the r-values in a set of assignment statements. My code might have looked like this:

3. Who am I kidding? I still am an assembly language programmer. You can take the boy away from the metal, but you can't take the metal out of the boy!

```
public class FitNesseExpediter implements ResponseSer
{
  private   Socket           socket;
  private   InputStream     input;
  private   OutputStream     output;
  private   Request         request;
  private   Response         response;
  private   FitNesseContext context;
  protected long            requestParsingTimeLimit;
  private   long            requestProgress;
  private   long            requestParsingDeadline;
  private   boolean          hasError;

  public FitNesseExpediter(Socket          s,
                           FitNesseContext context) t
  {
    this.context =            context;
    socket =                  s;
    input =                   s.getInputStream();
    output =                  s.getOutputStream();
    requestParsingTimeLimit = 10000;
  }
```

I have found, however, that this kind of alignment is not useful. The alignment seems to emphasize the wrong things and leads my eye away from the true intent. For example, in the list of declarations above, you are tempted to read down the list of variable names without looking at their types. Likewise, in the list of assignment statements, you are tempted to look down the list of r-values without ever seeing the assignment operator.

So, in the end, I don't do this kind of thing anymore. Nowadays, I usually prefer unaligned declarations and assignments, as shown below, because they point out an important deficiency. If I have long lists that need to be aligned, the problem is the length of the lists, not the lack of alignment. The length of the list of declarations in `FitNesseExpediter` below suggests that this class should be split up.

```
public class FitNesseExpediter implements ResponseSer
{
  private Socket socket;
  private InputStream input;
  private OutputStream output;
  private Request request;

  private Response response;
  private FitNesseContext context;
  protected long requestParsingTimeLimit;
  private long requestProgress;
  private long requestParsingDeadline;
  private boolean hasError;

  public FitNesseExpediter
  (Socket s, FitNesseContext context) throws Exceptic
  {
    this.context = context;
    socket = s;
    input = s.getInputStream();
    output = s.getOutputStream();
    requestParsingTimeLimit = 10000;
  }
```

Indentation

A source file is a hierarchy rather like an outline. There is information that pertains to the file as a whole, to the individual classes within the file, to the methods within the classes, to the blocks within the methods, and recursively to the blocks within the blocks. Each level of this hierarchy is a scope into which names can be declared and in which declarations and executable statements are interpreted.

To make this hierarchy of scopes visible, we indent the lines of source code in proportion to their position in the hierarchy. Statements at the level of the file, such as most class declarations, are not indented at all. Methods within a class are indented one level to the right of the class. Implementations of those methods are indented one level to the right of the method declaration. Block implementations are indented one level to the right of their containing block, and so on.

Programmers rely heavily on this indentation scheme. They visually line up the left edge to see what scope each line appears in. This allows them to quickly hop over scopes, such as implementations of `if` or `while` statements, that are not relevant to their current situation. They scan the left for new method declarations, new variables, and even new classes. Without indentation, programs would be virtually unreadable by humans.

Consider the following programs that are syntactically and semantically identical:

```
public class FitNesseServer implements SocketServer
{ private FitNesseContext context;
public FitNesseServer(FitNesseContext context)
{ this.context = context; } public void
serve(Socket s) { serve(s, 10000); }
public void serve(Socket s, long requestTimeout) { tr
{ FitNesseExpediter sender = new FitNesseExpediter(s,
setRequestParsingTimeLimit(requestTimeout);
sender.start(); } catch(Exception e)
{ e.printStackTrace(); } } }

-----

public class FitNesseServer implements SocketServer {
  private FitNesseContext context;

  public FitNesseServer(FitNesseContext context) {
    this.context = context;
  }

  public void serve(Socket s) {
    serve(s, 10000);
  }

  public void serve(Socket s, long requestTimeout) {
    try {
      FitNesseExpediter sender = new FitNesseExpedite
      sender.setRequestParsingTimeLimit(requestTimeou
      sender.start();
    }
    catch (Exception e) {
      e.printStackTrace();
    }
```

```
  }
}
```

Your eye can rapidly discern the structure of the indented file. You can almost instantly spot the variables, constructors, accessors, and methods. It takes just a few seconds to realize that this is some kind of simple front end to a socket, with a timeout. The unindented version, however, is virtually impenetrable without intense study.

Breaking Indentation

It is sometimes tempting to break the indentation rule for short `if` statements, short `while` loops, or short functions. Whenever I have succumbed to this temptation, I have almost always gone back and put the indentation back in. So I usually avoid collapsing scopes down to one line, like this:

```
public class CommentWidget extends TextWidget {
  public static final String REGEXP = "^#[^\r\n]*(?:(

  public CommentWidget(ParentWidget parent, String te
  {super(parent, text);}
  public String render() throws Exception {return "";
}
```

I prefer to expand and indent the scopes instead, like this:

```
public class CommentWidget extends TextWidget {
  public static final String REGEXP = "^#[^\r\n]*(?:(

  public CommentWidget(ParentWidget parent, String te
    super(parent, text);
  }

  public String render() throws Exception {
    return "";
  }
}
```

There are times, however, when a simple one-liner is more visually appealing than dangling braces.

```
public int getCount() {return count;}
```

Team Rules

The title of this section is a play on words. Every programmer has their own favorite formatting rules, but if they work in a team, then the team rules.

A team of developers should agree upon a single formatting style, and then every member of that team should use that style. We want the software to have a consistent style. We don't want it to appear to have been written by a bunch of disagreeing individuals.

When I started the FitNesse project back in 2002, I sat down with the team to work out a coding style. This took about ten minutes. We decided where we'd put our braces, what our indent size would be, how we would name classes, variables, and methods, and so forth. Then, we encoded those rules into the code formatter of our IDE and have stuck with them ever since. These were not the rules that I preferred; they were rules decided by the team. As a member of that team, I followed them when writing code in the FitNesse project.

Remember, the source code of a good software system is a set of documents that read nicely. They need to have a consistent and smooth style. The reader needs to be able to trust that the formatting gestures they have seen in one source file will mean the same thing in others. The last thing we want to do is add more complexity to the source code by writing it in a jumble of different individual styles.

Uncle Bob's Formatting Rules

The rules I use personally are very simple and are illustrated by the code below. Consider this an example of how code makes the best coding standard document.

```
public class CodeAnalyzer implements JavaFileAnalysis
  private int lineCount;
  private int maxLineWidth;
  private int widestLineNumber;
  private LineWidthHistogram lineWidthHistogram;
  private int totalChars;

  public CodeAnalyzer() {
    lineWidthHistogram = new LineWidthHistogram();
  }

  public static List<File> findJavaFiles(File parentD
    List<File> files = new ArrayList<File>();
    findJavaFiles(parentDirectory, files);
    return files;
  }

  private static void
  findJavaFiles(File parentDirectory, List<File> file
    for (File file : parentDirectory.listFiles()) {
      if (file.getName().endsWith(".java"))
        files.add(file);
      else if (file.isDirectory())
        findJavaFiles(file, files);
    }
  }

  public void analyzeFile(File javaFile) throws Excep
    BufferedReader br = new BufferedReader(new FileRe
    String line;
    while ((line = br.readLine()) != null)
      measureLine(line);
  }

  private void measureLine(String line) {
    lineCount++;
    int lineSize = line.length();
    totalChars += lineSize;
    lineWidthHistogram.addLine(lineSize, lineCount);
    recordWidestLine(lineSize);
  }

  private void recordWidestLine(int lineSize) {
    if (lineSize > maxLineWidth) {
```

```
      maxLineWidth = lineSize;
      widestLineNumber = lineCount;
    }
  }

  public int getLineCount() {
    return lineCount;
  }

  public int getMaxLineWidth() {
    return maxLineWidth;
  }

  public int getWidestLineNumber() {
    return widestLineNumber;
  }

  public LineWidthHistogram getLineWidthHistogram() {
    return lineWidthHistogram;
  }

  public double getMeanLineWidth() {
    return (double)totalChars/lineCount;
  }

  public int getMedianLineWidth() {
    Integer[] sortedWidths = getSortedWidths();
    int cumulativeLineCount = 0;
    for (int width : sortedWidths) {
      cumulativeLineCount += lineCountForWidth(width)
      if (cumulativeLineCount > lineCount/2)
        return width;
    }
    throw new Error("Cannot get here");
  }

  private int lineCountForWidth(int width) {
    return lineWidthHistogram.getLinesForWidth(width)
  }

  private Integer[] getSortedWidths() {
    Set<Integer> widths = lineWidthHistogram.getWidth
    Integer[] sortedWidths = (widths.toArray(new Inte
    Arrays.sort(sortedWidths);
    return sortedWidths;
```

```
    }
}
```