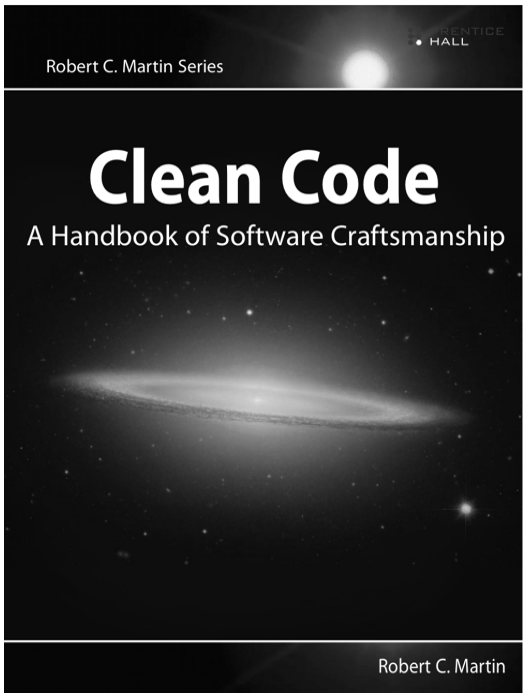

CLEAN CODE III
FUNCTIONS

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The First Line of Organization

- In the early days of programming
  - we composed our systems of routines and subroutines.
  - in Fortran it was programs, subprograms, and functions.
- Nowadays only the function survives.

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A “Long” function in FitNesse

- Not only is it long, but it’s got
  - duplicated code,
  - lots of odd strings,
  - many strange and inobvious data types and APIs.
- See how much sense you can make of it in the next three minutes…

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A “Long” function in FitNesse 1

```
public static String testableHtml(
   PageData pageData,
   boolean includeSuiteSetup
 ) throws Exception {
   WikiPage wikiPage = pageData.getWikiPage();
   StringBuffer buffer = new StringBuffer();
   if (pageData.hasAttribute("Test")) {
     if (includeSuiteSetup) {
       WikiPage suiteSetup =
         PageCrawlerImpl.getInheritedPage(
                 SuiteResponder.SUITE_SETUP_NAME, wikiPage
         );
       if (suiteSetup != null) {
         WikiPagePath pagePath =
```

4

A “Long” function in FitNesse 2

```
    if (setup != null) {
      WikiPagePath setupPath =
        wikiPage.getPageCrawler().getFullPath(setup);
      String setupPathName = PathParser.render(setupPath);
      buffer.append("!include -setup .")
            .append(setupPathName)
            .append("\n");
    }
  }
  buffer.append(pageData.getContent());
  if (pageData.hasAttribute("Test")) {
    WikiPage teardown =
      PageCrawlerImpl.getInheritedPage("TearDown", wikiPage);
    if (teardown != null) {
      WikiPagePath tearDownPath =
```

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A “Long” function in FitNesse 3

```
      if (suiteTeardown != null) {
        WikiPagePath pagePath =
          suiteTeardown.getPageCrawler().getFullPath(suiteTeardown);
        String pagePathName = PathParser.render(pagePath);
        buffer.append("!include -teardown .")
              .append(pagePathName)
              .append("\n");
      }
    }
  }
  pageData.setContent(buffer.toString());
  return pageData.getHtml();
}
```

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How did you do?

- Do you understand the function after three minutes of study?
- Probably not.
  - There's too much going on in there,
  - at too many different levels of abstraction.
  - There are strange strings
  - odd function calls
  - doubly nested if statements controlled by flags.
  - Ick!

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Nothing up my sleve…

- With just a few simple
  - method extractions,
  - some renaming,
  - and a little restructuring,
- I was able to capture the intent of the function.
- See if you can understand the result in the next 3 minutes?

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Refactored Function

```
public static String renderPageWithSetupsAndTeardowns(
   PageData pageData, boolean isSuite
 ) throws Exception {
   boolean isTestPage = pageData.hasAttribute("Test");
   if (isTestPage) {
     WikiPage testPage = pageData.getWikiPage();
     StringBuffer newPageContent = new StringBuffer();
     includeSetupPages(testPage, newPageContent, isSuite);
     newPageContent.append(pageData.getContent());
     includeTeardownPages(testPage, newPageContent, isSuite);
     pageData.setContent(newPageContent.toString());
```

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You probably don't understand it all.

- Still you probably understand that it:
  - includes setup and teardown pages into a test page,
  - renders that page into HTML.

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What's more…

- You also probably realize:
  - That this function belongs to some kind of web-based testing framework.
- Divining that information from the refactored function is pretty easy,
- but it's pretty well obscured by the initial code.

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So what is the magic?

- What is it that makes the refactored function easy to read and understand?
- How can we make a function communicate it's intent?
- What attributes can we give our functions that will allow a casual reader to intuit the kind of program they live inside?

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Small!

The First Rule of Functions.

The rules of functions:

- The first rule:
  - They should be small.
- The second rule:
  - They should be smaller than that.

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A Screenful?

- In the ‘80s we used to say that a function should be no bigger than a screenful.
  - Of course VT100 screens were 24 lines by 80 columns,
  - and our editors used 4 lines for administrative purposes.
- Nowadays with a cranked down font and a nice big monitor
  - you can fit 150 characters on a line, and a 100 lines or more on a screen. Lines should not be 150 characters long.

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Smaller Than a Screenful

- Functions should not be 100 lines long.
- Functions should hardly ever be 20 lines long.
- Indeed, the refactored function was too long.
  - It should have been:

```
public static String renderPageWithSetupsAndTeardowns(
 PageData pageData, boolean isSuite) throws Exception {
 if (isTestPage(pageData))
   includeSetupAndTeardownPages(pageData, isSuite);
 return pageData.getHtml();
}
```

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Blocks

- Smallness implies that blocks within:
  - if statements,
  - else statements,
  - while statements,
  - and etc.,
- should be one line long.
- Probably that line should be a function call.
  - Not only does this keep the function small;
  - but it also adds documentary value

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Indenting

- Smallness also implies:
  - functions should not be large enough to hold nested structures.
  - Therefore the indent level of a function should not be greater than one or two.
- This, of course, makes the functions easier to read and understand.

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Do One Thing

Functions should do one thing.

- They should do it well.
- They should do it only.

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Doing More Than One Thing

- The original code does lots more than one thing.
  - It's creating buffers,
  - fetching pages,
  - searching for inherited pages,
  - rendering paths,
  - appending arcane strings,
  - and generating HTML,
  - among other things.
- The re-refactored code is doing one simple thing.
  - including setups and teardowns into test pages.

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Or is it?

- It's easy to make the case that it's doing 3 things:
  -
  - Determine whether the page is a test page.
  -
  - If so, include setups and teardowns.
  -
  - Render the page in HTML.
- So which is it?
  - Is the function doing one thing

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All At Same Level…

- The steps are one level of abstraction below the name of the function.
- A brief TO paragraph:
  - TO RenderPageWithSetupsAndTeardowns we:
    - check to see if the page is a test page
    - and if so we include the setups and teardowns.
    - In either case we render the page in HTML.
- If a function's steps are one level below the stated name of the function,
  - then the function is doing one thing.

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The reason we write functions is to:

- Decompose a larger concept
  - (i.e. the name of the function)
- into a set of steps at the next level of abstraction.

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Doing One Thing!

- It should be very clear that
  - The original code contains steps at many different levels of abstraction.
  - So it is clearly doing more than one thing.
- Even the first refactoring has two levels of abstraction,
  - as proved by our ability to shrink it down.
- But it would be very hard to meaninfully shrink the final.
  - We could extract the if statment into a function named includeSetupsAndTeardownsIfTestPage,
  - but that simply restates the code without changing the level of abstraction.

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Doing One Thing!

- You can tell that a function is doing more than “one thing”
  - if you can extract a function from it
  - with a name that is not merely a restatement of its implementation.

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Reading code from top to bottom.

- We want the code to read like a top-down narrative.
- We want every function to be followed by those at the next level of abstraction,
  - We can read the program, descending one level of abstraction at a time.
- We want to read the program as if it were a set of TO paragraphs,
  - each of which describes the current level of abstraction
  - and references subsequent TO paragraphs at the next level down.

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To Paragraphs:

- To include the setups and teardowns we
  - include setups,
  - then include the test page content,
  - then include the teardowns.
- To include the setups we
  - include the suite setup if this is a suite,
  - then include the regular setup.
- To include the suite setup we
  - search the parent hiearchy for the “SuiteSetUp” page
  - add an !include with the path of that page.
- To search the parent...

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That's how you do ONE THING.

29

Use descriptive names.

Example

- I changed the name of our example function
  - from testableHtml
  - To renderPageWithSetupsAndTeardowns.
    - This is a far better name.
- I also gave the private methods a descriptive name
  - such as isTestable
  - includeSetupAndTeardownPages.
- It is hard to overestimate the value of good names.

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Remember Ward's principle:

- "You know you are working on clean code when each routine turns out to be pretty much what you expected."
- Half the battle to achieving that principle is
  - choosing good names
    - for small functions
    - that do one thing.

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The Naming Heuristic

- The smaller and more focussed a function is,
  - the easier it is to choose a descriptive name.
- Conversely, if you can't choose a descriptive name
  - Your function is probably too big
  - And does more than ONE THING.

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Long Names

- Don't be afraid to make a name long.
- A long descriptive name is better than
  - a short enigmatic name.
  - a long descriptive comment.
- Use a naming convention that allows multiple words to be easily read in the function names
  - Like Camel Case or Underscores.
    - IncludeSetUpAndTearDown
    - Include_setup_and_teardown
- Make use of those multiple words to give the function a name that says what it does.

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It Takes Time

- Don’t be afraid to spend time choosing a name.
- Indeed, you should try several different names
  - and read the code with each in place.
- Modern IDEs like Eclipse or IntelliJ make it trivial to change names.
- Use one of those IDEs and experiment with different names until you find one that is as descriptive as you can make it.

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Names and Design

- Choosing descriptive names will clarify the design of the module in your mind,
  - and help you to improve it.
- Hunting for a good name often results in a favorable restructuring of the code.

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Consistent Names

- Use the same phrases, nouns, and verbs in the function names you choose for your modules.
  - Consider, for example, the names
    - includeSetupAndTeardownPages,
    - includeSetupPages,
    - includeSuiteSetupPage,
    - includeSetupPage.
  - The similarity of those names allows the sequence to tell a story.
  - Indeed, if I showed you just the sequence above, you'd ask yourself:
    - "What happened to includeTeardownPages, includeSuiteTeardownPage, and includeTeardownPage?"
    - How's that for being "...pretty much what you expected."

37

No more than three arguments.

How many arguments?

- he ideal number of arguments for a function is zero (niladic).
- Next comes one (monadic),
- Followed closely by two (dyadic).
- Three arguments (triadic) should be avoided where possible.
- More than three (polyadic) requires very special justification,
  - and then shouldn't be used anyway.

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Arguments are hard.

- They take a lot of conceptual power.
- That's why I got rid of almost all of them from the example.
- Consider, for example, the StringBuffer in the example.
  - We could have passed it around as an argument
  - rather than making it an instance variable;
  - but then our readers would have had to interpret it each time they saw it.

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Arguments are hard.

- When you are reading the story told by the module,
  - includeSetupPage() is easier to understand than
  - includeSetupPageInto(newPageContent).
- The argument is at a different level of abstraction than the function name,
  - and forces you to know a detail (i.e. StringBuffer) that isn't particularly important at that point.

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Output arguments

- Harder to understand than input arguments.
- We are used to the idea of information going in to the function through arguments
  - and out through the return value.
- We don't usually expect information to be going out through the arguments.
  - So output arguments often cause us to do a double-take.

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Common Monadic Forms

- There are two common reasons to pass a single argument into a function.
  - You may be asking a question about that argument as in: boolean fileExists(“MyFile”).
  - Or you may be operating on that argument,
    - transforming it into something else and returning it.
    - For example: InputStream fileOpen(“MyFile”) transforms a String into an InputStream return value.
- These two uses are what readers expect when they see a function.
  - You should choose names that make the distinction clear.

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Flag Arguments

- Passing a boolean into a function is a truly terrible practice.
- It immediatly complicates the signature of the method,
  - loudly proclaiming that this function does more than one thing.
  - It does one thing if the flag is true, and another if the flag is false!

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Dyadic Functions

- A function with two arguments is harder to understand than a monadic function.
  - writeField(name) is easier to understand than writeField(outputStream, name).
    - the first glides past the eye. easily depositing its meaning.
    - The second requires a short pause until we learn to ignore the first parameter.
  - We should never ignore any part of the code.
    - The parts we ignore are where the bugs will hide.

45

Triads

- Functions that take three arguments are significantly harder to understand than dyads.
  - The issues of ordering, pausing, and ignoring are more than doubled.
- Consider the common overload of assertEquals that takes three arguments:
  - assertEquals(message, expected, actual).
  - How many times have you read the message and thought it was the expected?
  - I have stumbled and paused over that particular triad many times.
  - In fact, every time I see it I do a double-take and then learn to ignore the message.

46

No side-effects.

Side-effects are lies.

- Your function promises to do one thing,
  - but it also does other, hidden, things.
    - to the variables of it's own class.
    - to the parameters passed into the function,
    - to system globals.
- They are devious and damaging mistruths that result in
  - strange temporal couplings
  - and order dependencies.

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Side Effects

- Consider the seemingly innocuous function that uses a standard algorithm to match a userName to a password. It returns true if they match, and false if anything goes wrong.
- But it also has a side-effect.
  - Can you spot it?
  -

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Side Effects

```
public class UserValidator {
  private Cryptographer cryptographer;

  public boolean checkPassword(String userName, String password) {
    User user = UserGateway.findByName(userName);
    if (user != User.NULL) {
      String codedPhrase = user.getPhraseEncodedByPassword();
      String phrase = cryptographer.decrypt(codedPhrase, password);
      if ("Valid Password".equals(phrase)) {
```

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Side Effects

- The side-effect is
  - the call to Session.initialize(),
    - of course.
- The checkPassword function, by its name, says that it checks the password.
  - The name does not imply that it initializes the session.
  - So a caller who believes what the name of the function says, runs the risk of erasing the existing session data when they decide to check the validity of the user.

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Temporal Couplings

- The side-effect creates a temporal coupling.
  - checkPassword can only be called at certain times
    - (i.e. when it is safe to initialize the session).
  - If it is called out of order,
    - session data may be inadvertently lost.
- Temporal couplings are confusing,
  - especially when hidden as a side effect.
- If you must have a temporal coupling,
  - you should make it clear in the name of the function.
  - In this case we might rename the function checkPasswordAndInitializeSession,
    - though that certainly violates “Do One Thing”.

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Command Query Separation

Asking vs. Telling

- Functions should either
  - do something,
  - or answer something,
  - but not both.
- Either your function should
  - change the state of an object,
  - or it should return some information about that object.
- Doing both often leads to confusion.

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Example

- Consider, for example, the following function:

```
public boolean set(String attribute, String value);
```

- It sets the value of a named attribute
  - returns true if it is successful
  - false if no such attribute exists.

55

Example

- This leads to odd statements like this:

```
if (set("username", "unclebob"))...
```

- What does that mean?
  - Is it asking whether the “username” attribute was
    - previously set to “unclebob”?
    - successfully set to “unclebob”?
  - It’s hard to infer the meaning from the call because it’s not clear whether the word “set” is a verb or an adjective.

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Example

- The author intended set to be a verb,
  - but in the context of the if statement it feels like an adjective.
  - So the statement reads as:
    - "If the username attribute was previously set to unclebob"
  - and not as:
    - "set the username attribute to unclebob and if that worked then...".
  - We could try to resolve this by renaming the set function to setAndCheckIfExists,
    - but that doesn't much help the readability of the if statement.

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Example

- The real solution is to separate the command from the query
  - so that the ambiguity cannot occurr.

```
if (attributeExists("username")) {
  setAttribute("username", "unclebob");
  ...
}
```

58

Prefer exceptions to returning error codes.

Returning errror codes

- A subtle violation of command query separation.
- It promotes commands being used as expressions in the predicates of if statements.
-
- if (deletePage(page) == E_OK)
-
- This leads to deeply nested structures.
- The caller must deal with the error immediatly.

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Returning Error Codes

```
if (deletePage(page) == E_OK) {
  if (registry.deleteReference(page.name) == E_OK) {
    if (configKeys.deleteKey(page.name.makeKey()) == E_OK){
      logger.log("page deleted");
    } else {
      logger.log("configKey not deleted");
    }
  } else {
    logger.log("deleteReference from registry failed");
  }
} else {
  logger.log("delete failed");
  return E_ERROR;
}
```

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Using Exceptions

- If you use exceptions then t
  - the error processing code can be separated from the happy-path code,
  - and can be simplified:

```
try {
  deletePage(page);
  registry.deleteReference(page.name);
  configKeys.deleteKey(page.name.makeKey());
}
catch (Exception e) {
  logger.log(e.getMessage());
}
```

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Extract try/catch blocks.

- Try/catch blocks are ugly in their own right.
  - They confuse the structure of the code
  - and mix error processing with normal processing.
- So it is better to extract the bodies of the try and catch blocks out into functions of their own.

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Extract try/catch blocks

```
public void delete(Page page) {
  try {
    deletePageAndAllReferences(page);
  }
  catch (Exception e) {
    logError(e);
  }
}


private void deletePageAndAllReferences(Page page) throws Exception {
  deletePage(page);
  registry.deleteReference(page.name);
  configKeys.deleteKey(page.name.makeKey());
}
```

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```
private void logError(Exception e) {
```

Error handling is one thing.

- A function that handles errors should do nothing else.
- This implies that the keyword try should be the very first word in the function;
- and that there should be nothing after the catch/finally blocks.

65

Structured Programming

- Dijkstra said:
  - every function,
  - and every block within a function,
  - should have one entry and one exit.
- Following these rules means
  - there should only be one return statement in a function,
  - no break or continue statements in a loop,
  - and never, ever, any goto statements.

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Structured Programming Eclipsed

- While we are sympathetic to the goals and disciplines of structured programming,
  - those rules serve little benefit when functions are very small.
  - It is only in larger functions that such rules provide significant benefit.
- So in small functions the occasional:
  - multiple return,
  - break,
  - or continue statement
  - does no harm,
    - and can sometimes even be more expressive than the single entry, single exit rule.
  - But goto should still be avoided.

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Conclusion

Domain Specific Languages

- Every system is built from a domain specific language
  - designed by the programmers to describe that system.
  - Functions are the verbs of that language,
  - classes are the nouns.
- The art of programming is, and has always been, the art of language design.

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Programs as Stories

- Master programmers think of systems as stories to be told
  - rather than programs to be written.
- They use the facilities of their chosen programming language
  - to construct a much richer and more expressive DSL that they use to tell that story.
  - Part of that DSL is the hierarchy of functions that describe all the actions that take place within that system.
  - In an artful act of recursion, those actions are written to use the very DSL they define to tell their own small part of the story.

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The “Clean Code” project.

- Articles:
  - The “Args” article.
  - The “Clean Code” book.

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