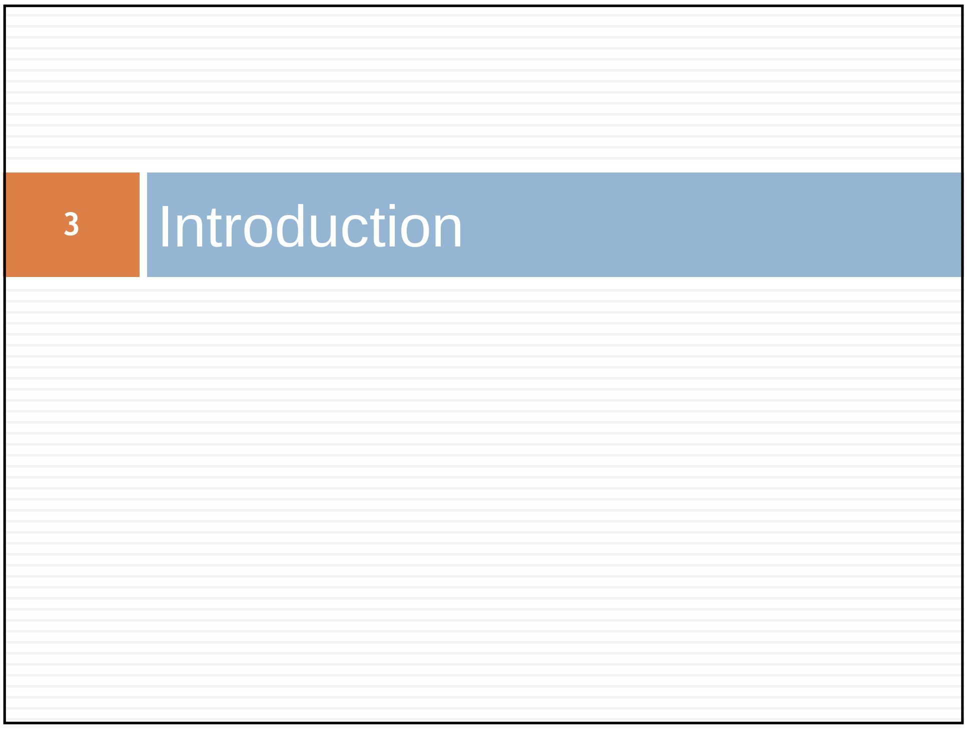
MIEIC - ENGENHARIA DE SOFTWARE - 2010/11

CODE QUALITY

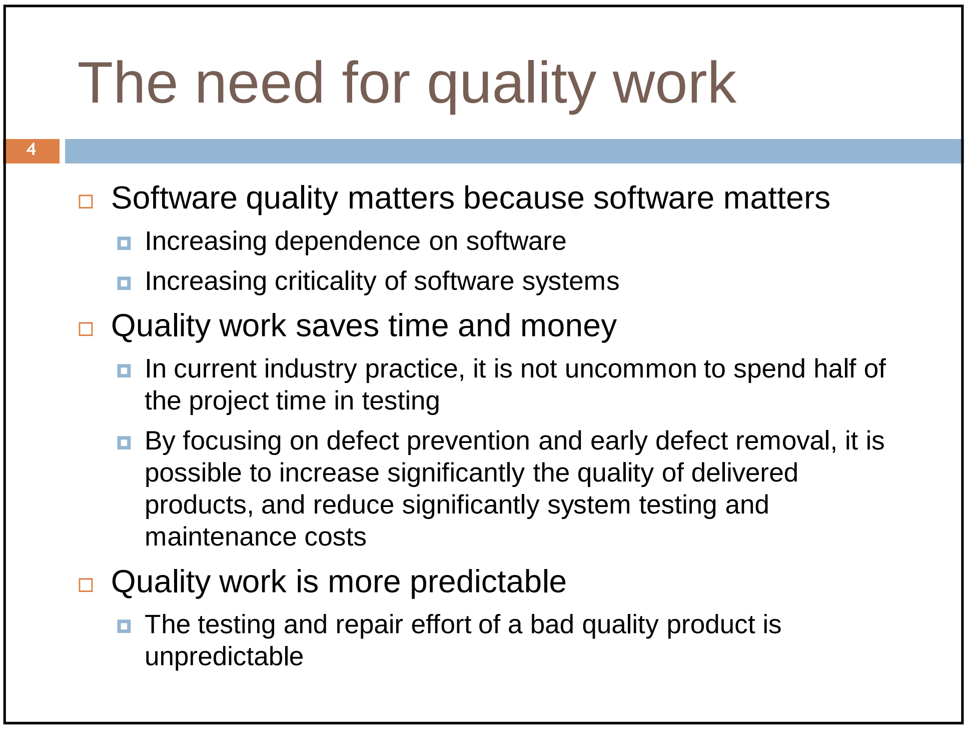
João Pascoal Faria, 6,11/10/2010

Index

- Introduction
- Coding standards
- Code reviews
- Unit testing



Introduction



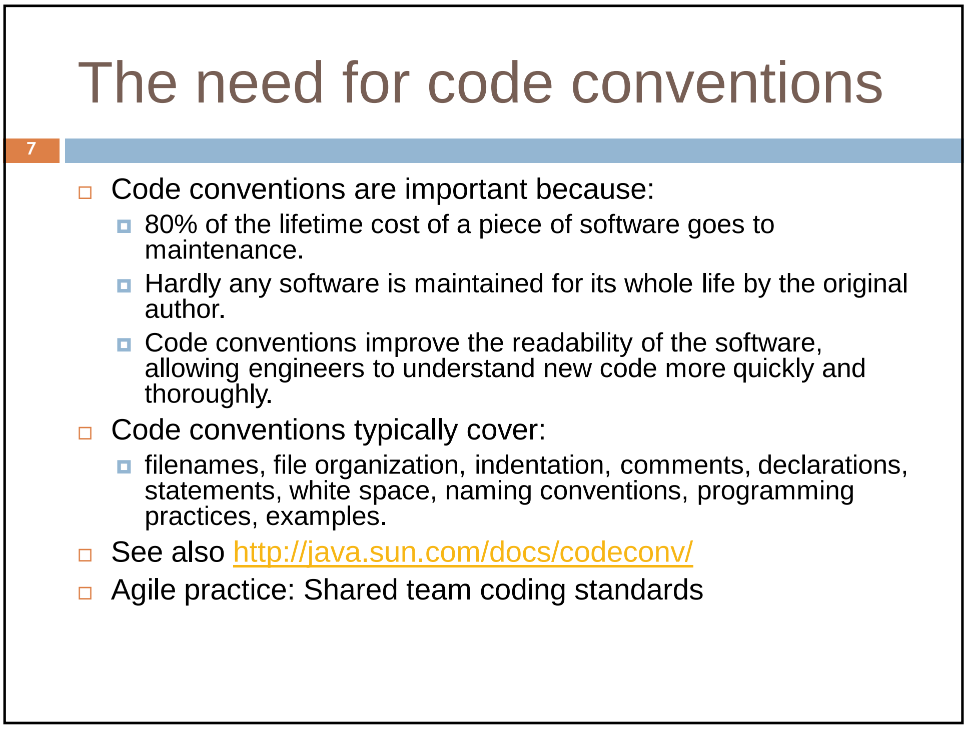
The need for quality work

- Software quality matters because software matters
  - Increasing dependence on software
  - Increasing criticality of software systems
- Quality work saves time and money
  - In current industry practice, it is not uncommon to spend half of the project time in testing
  - By focusing on defect prevention and early defect removal, it is possible to increase significantly the quality of delivered products, and reduce significantly system testing and maintenance costs
- Quality work is more predictable
  - The testing and repair effort of a bad quality product is unpredictable

Personal responsibility

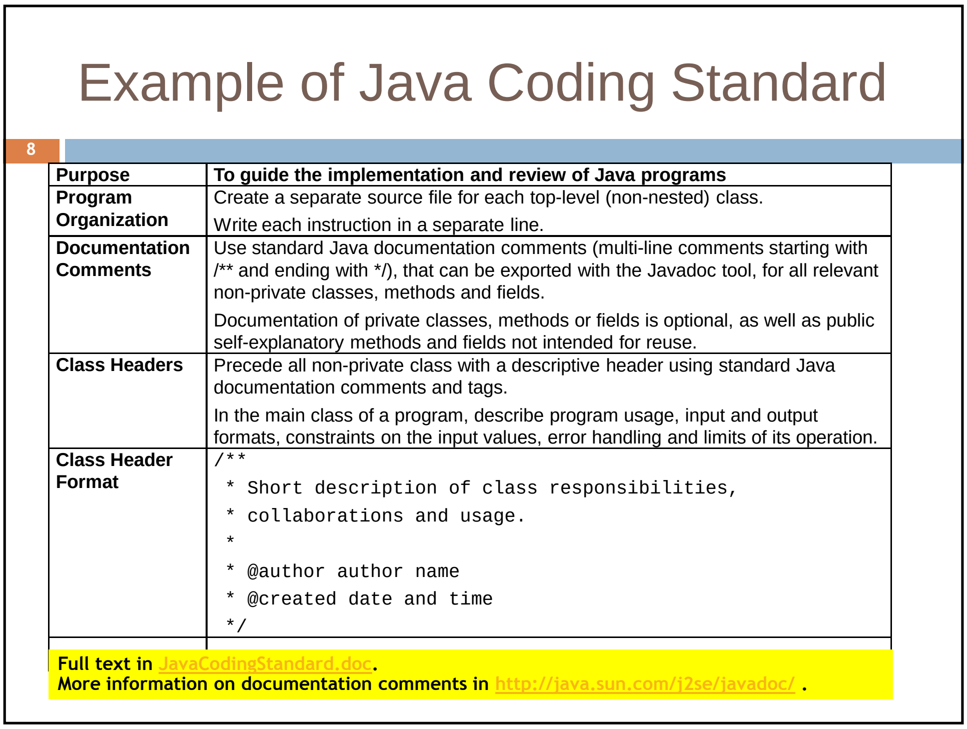
- The only way to build high-quality products in a cost-effective way, is by having developers being personally responsible for the quality of their products
- A software system is as weak as the weakest of its parts
- Even experienced programmers introduce about 100 defects/KLOC (before compile)
- Since defects can best be managed where they are injected, developers should
  - remove their own defects
  - determine the causes of their defects
  - learn to prevent those defects

Coding standards



The need for code conventions

- Code conventions are important because:
  - 80% of the lifetime cost of a piece of software goes to maintenance.
  - Hardly any software is maintained for its whole life by the original author.
  - Code conventions improve the readability of the software, allowing engineers to understand new code more quickly and thoroughly.
- Code conventions typically cover:
  - filenames, file organization, indentation, comments, declarations, statements, white space, naming conventions, programming practices, examples.
- See also http://java.sun.com/docs/codeconv/
- Agile practice: Shared team coding standards



Example of Java Coding Standard

Purpose	**To guide the implementation and review of Java programs**
Program Organization	Create a separate source file for each top-level (non-nested) class. Write each instruction in a separate line.
Documentation Comments	Use standard Java documentation comments (multi-line comments starting with /** and ending with */), that can be exported with the Javadoc tool, for all relevant non-private classes, methods and fields. Documentation of private classes, methods or fields is optional, as well as public self-explanatory methods and fields not intended for reuse.
Class Headers	Precede all non-private class with a descriptive header using standard Java documentation comments and tags. In the main class of a program, describe program usage, input and output formats, constraints on the input values, error handling and limits of its operation.

Class Header Format	`/**`
	`* Short description of class responsibilities,`
	`* collaborations and usage.`
	`*`
	`* @author author name`
	`* @created date and time`
	`*/`

Full text in JavaCodingStandard.doc.
More information on documentation comments in http://java.sun.com/j2se/javadoc/ .

9

CODE REVIEWS

The need for code reviews

10

- Testing alone is not enough
  - Some internal quality attributes cannot be verified by testing
    - Maintainability , including adherence to coding standards
    - Security vulnerabilities (see www.securecoding.cert.org/)
  - Exceptional conditions are very difficult to verify by testing
  - With many defects, testing is less effective, efficient & predictable
  - Testing can only prove the existence of defects, not their absence
- Reviews are predictable and efficient
  - Defects are immediately located
  - Time is proportional to the size of the code
- Testing and reviews play complementary roles

Exercise 1: Discover off-by-one errors

```
int main(int argc, char* argv[]) {
    char source[10];
    int i;
    strcpy(source, "0123456789");
    char *dest = (char *)malloc(strlen(source));
    for (i=1; i <= 11; i++) {
            dest[i] = source[i];
    }
    dest[i] = '\0';
    printf("dest = %s", dest);
}
```

What are the errors?

What is the program output?

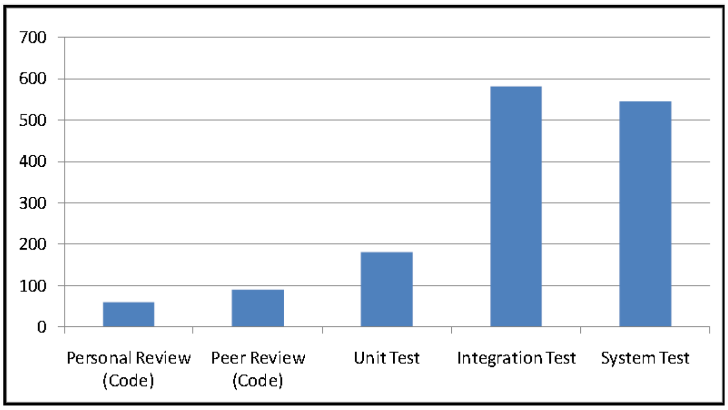
Can the errors be discovered by testing?

Types of code reviews

- Personal reviews
  - In a personal review, you privately review your product
  - Properly done, they are a very efficient defect removal technique
- Peer reviews
  - Have one or more peers review your code
  - Independence of peers lead to the discovery of defects that could pass unnoticed by the author
  - Only have peers review your code after you have reviewed it
    - Show respect, don’t waste their time
    - Allow peers to concentrate or more fundamental problems
- In pair programming, one of the elements may act as reviewer
- Best to use in combination

Efficiency of code reviews

Minutes to Find and Resolve a Defect by Discovery Activity



Source: Inspiring, enabling and driving the Evolution of Quality at Adobe leveraging the TSP, Jim Sartain, Senior Director, Quality, TSP Symposium 2009

Code reviews best practices

- Produce reviewable products
- Use a checklist derived from your historical defect data
- Take enough review time
  - 200 LOC/hour usually gives a good balance efficacy vs efficiency
  - Or take <=50% of the development time
- Review on paper, not on screen
- Take a break between developing and reviewing
- Review in multiple passes
- Review before testing
- Measure the review process and use data to improve
- Follow a disciplined review process

The importance of checklists

- Make the review more effective
  - focus the attention on the most frequent problems
- Make the review more efficient
  - don't waste time looking for non occurring problems
- Reduce the risk of missing critical issues
  - even experts benefit from checklists
- But keep it simple, short and specific

Checklist are like glasses

Peter Pronovost (Dr. Checklist)

http://www.youtube.com/watch?v=xBPt4j1sOuI

* Defeitos mais frequentes

- Para ser mais eficaz, basear revisão em *checklist* de problemas mais frequentes (do próprio, equipa, etc.)
- Exemplo de lista de falhas mais frequentes (IBM)

Classificação	Descrição	Frequência
Algoritmo	execução incorrecta ou em falta que pode ser corrigida sem ser necessário introduzir alterações arquitecturais no software	43.4 %
Atribuição	valores incorrectamente atribuídos ou não atribuídos	22.0 %
Teste	validação de dados incorrecta ou expressões condicionais incorrectas	17.5 %
Função	falha que afecta uma quantidade considerável de código e refere-se a uma capacidade do software que está em falta ou construída incorrectamente	8.7 %
Interface	interacção incorrecta entre módulos/componentes	8.2 %

Example of personal review checklist

Developer	João Pascoal Faria	**Date**	10/Nov/08
Program	Source file comparator	**Program #**	8 (Java)

Past Defects	**Category**	**What to verify**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
4, 5	Environment settings	• Verify that all project settings have been appropriately set. • Verify that regional settings have been appropriately set.	✓					
17,18, 28	Logic	• Verify method bodies (instructions) for logical correctness. • Verify all conditions in branch and loop statements.		#59 (literal)	✓	#60 (varref)	✓	✓
29, 32, 20	Calls	• Verify that all method and library calls are used correctly, without violating any known pre-conditions. • Verify that the correct methods are being called.		✓	✓	✓	✓	✓
13, 33	Exception handling	• Verify that the applicable exceptions are handled. • Verify that all relevant pre-conditions are checked.		✓	✓	✓	✓	✓
12, 15, 16, 19, 26	Comments &messages	• Verify comments for correctness and typing errors. • Verify I/O messgaes for correctness and typing errors.		✓	✓	✓	✓	✓
27	Coding standards	• Ensure that the code conforms to the coding standards. • Check reuse and change control tags.		✓	✓	✓	✓	✓

(1) Overall Program, (2) FileDifferenceCLI, (3) SourceCodeParser, (4) Operation, (5) Delta

Example of PSP code review script (1/2)

Purpose	To guide you in reviewing programs
Entry Criteria	- A completed and reviewed program design - Source program listing - Code Review checklist - Coding standard - Defect Type standard - Time and Defect Recording logs
General	Do the code review with a source-code listing; do not review on the screen!
Steps	(See next slide)
Exit Criteria	- A fully reviewed source program - One or more Code Review checklists for every program reviewed - All identified defects fixed - Completed Time and Defect Recording logs

Example of PSP code review script (2/2)

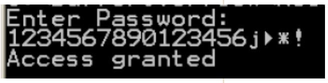
Step	Activities	Description
1	Review	- Follow the Code Review checklist. - Review the entire program for each checklist category; do not try to review for more than one category at a time! - Check off each item as it is completed. - For multiple procedures or programs, complete a separate checklist for each.
2	Correct	- Correct all defects. - If the correction cannot be completed, abort the review and return to the prior process phase. - To facilitate defect analysis, record all of the data specified in the Defect Recording log instructions for every defect.
3	Check	- Check each defect fix for correctness. - Re-review all design changes. - Record any fix defects as new defects and, where you know the number of the defect with the incorrect fix, enter it in the fix defect space.

Exercise 2: Security vulnerabilities

- Most security vulnerabilities have origin in software defects and poor coding practices

```
bool IsPasswordOK(void) {
 char Password[12]; // Memory storage for pwd
 gets(Password);    // Get input from keyboard
 if (!strcmp(Password,"goodpass")) return(true); // Password Good
 else return(false); // Password Invalid
}

void main(void) {
 bool PwStatus;              // Password Status
 puts("Enter Password:");    // Print
 PwStatus=IsPasswordOK();  // Get & Check Password
 if (PwStatus == false) {
      puts("Access denied"); // Print
      exit(-1);              // Terminate Program
 }
 else puts("Access granted");// Print
}
```



```
Enter Password:
1234567890123456j▸*!
Access granted
```

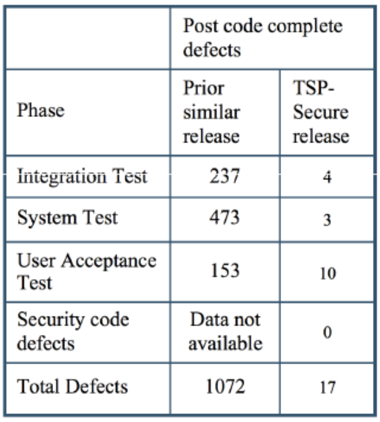
What happened?

What is the cause?

5 min

* Benefits of applying coding standards and code reviews

- Microsoft secure code project
- Relying heavily on coding standards, personal reviews and peer reviews, besides testing
- 8-person software development team
- Created 30 K lines of new and modified code in 7 months



	Post code complete defects	
Phase	Prior similar release	TSP-Secure release
Integration Test	237	4
System Test	473	3
User Acceptance Test	153	10
Security code defects	Data not available	0
Total Defects	1072	17

(Source: TSP Secure, Noopur Davis et al, TSP Symposium 2009)

Unit Testing

Conceitos básicos

- **Teste** : técnica dinâmica de verificação de programas, em que se exercita o programa com determinados casos de teste e se verifica se produz os resultados esperados
  - O objectivo é descobrir defeitos e avaliar a qualidade
  - Testes não permitem provar que um programa está correcto devido à infinidade de casos de teste possíveis
- **Caso de teste** : dados de entrada + resultados esperados

Caso de teste	Dados de entrada		Resultados esperadas
	a	b	mdc(a, b)
1	2	3	1
2	2	4	2

- **Testes unitários:** testes ao nível do método, classe ou módulo, normalmente realizados pelo próprio programador

Boas práticas de teste

- Testar o mais cedo possível
  - Custo de corrigir um *bug* cresce com o tempo decorrido
- Automatizar os testes ⇒ *JUnit*
  - Dada necessidade de re-executar frequentemente os testes
  - Automatizar sobretudo teste de APIs (GUIs é mais difícil)
  - Mas minimizar o código de teste
- Escrever os testes antes do programa a testar ⇒ *TDD*
  - Pelo menos especificar os testes logo após a interface das classes
  - Ajuda a esclarecer requisitos
  - Casos de teste são especificações parciais
- Começar por criar testes baseados na especificação (caixa negra) e complementar com testes para cobrir o código (caixa branca)

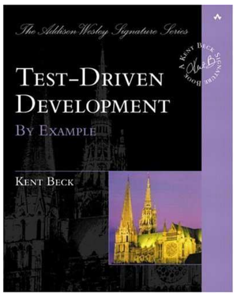
JUnit

- Framework (conjunto de classes) para teste unitário da família xUnit
  - JUnit – Java;   NUnit – C#; CppUnit – C++
- Integrado no Eclipse
- Permite criar classes de teste com métodos de teste com asserções
- Test runner executa os métodos de teste e mostra os que passaram (a verde) e os que falharam (a vermelho)
  - “Keep the bar green to keep the code clean”
- Mais detalhes em www.junit.org

Test Driven Development

- Development approach appropriate for unit testing

- The rhythm of Test-Driven Development can be summed up as follows:
  1. Quickly add a test.
  2. Run all tests and see the new one fail.
  3. Make a little change.
  4. Run all tests and see them all succeed.
  5. Refactor to remove duplication.



Exemplo de código a testar

Especificação

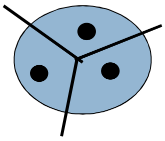
Implementação

```
class MyMath {
  /** Calcula o maior divisor comum positivo de
   *  2 inteiros não nulos. Se algum argumento
   *  for nulo, dá IllegalArgumentException.
   */
   public static int mdc(int a, int b) {
      if (a == 0 || b == 0)
          throw new IllegalArgumentException();
      if (b < 0)
          b = -b;
      if (a < 0)
          a = -a;
      // usa agora algoritmo de Euclides
      while (b > 0) {
          int aux = a % b;
          a = b;
          b = aux;
      }
     return a;
   }
}
```

Técnicas de teste de caixa negra

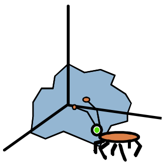
Teste baseado na especificação

- Partição em classes de equivalência
  - Partir domínio de valores de entrada em classes com comportamento esperado similar
  - Distinguir classes de entradas válidas e inválidas
  - Testar pelo menos um valor de cada classe
  - Exemplo a testar sqrt(x): x < 0, x >= 0



Técnicas de teste de caixa negra

- Análise de valores fronteira
  - Testar valores na fronteira de cada classe
  - Testar valores imediatamente acima e abaixo
  - Testar valores especiais (null, 0, etc.)
  - Exemplo a testar abs(x):
    - Classe x<0 : x = min, x = -1
    - Classe x>=0: x = 0, x = 1, x = max

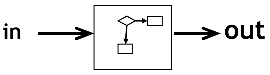


“Bugs lurk in corners and congregate at boundaries.” (B.Beizer)

Teste de caixa negra: Exemplo

Classe	Subclasse	a	b	mdc(a,b)
Entradas válidas positivas	mdc é um dos nºs (múltiplos)	2	4	2
	mdc é 1 (nº primos entre si)	2	3	1
	Caso intermédio	4	6	2
	Valores limite	maxint	maxint	maxint
Entradas válidas negativas	Ambos negativos	-1	-1	1
	Só um negativo (2 casos)	-1	1	1
		1	-1	1
	Valores limite	minint+1	minint+1	maxint
Entradas inválidas	Ambos nulos	0	0	IllegalArgumentException
	Só um nulo (2 casos)	0	1	
		1	0	

Técnicas de teste de caixa branca

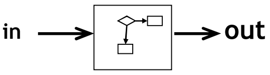


- Teste baseado na implementação
- Usar ferramenta para analisar cobertura de testes de caixa negra, e conceber testes adicionais se necessário

- Cobertura de instruções
  - Garantir que todas as instruções são exercitadas
  - No exemplo do mdc bastam 2 casos de teste

Descrição	a	b	mdc(a,b)
Cobre as duas primeiras instruções	0	1	IllegalArgumentException
Cobre todas as restantes instruções	-1	-1	1

Técnicas de teste de caixa branca



- Cobertura de decisões (ou ramificações)
  - Garantir adicionalmente que todas as decisões (**`if`**, **`while`**, **`for`**, etc.) tomam os valores **`true`** e **`false`**

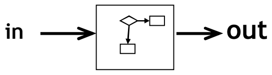
  - No exemplo de mdc, os casos de teste anteriores não garantem a cobertura das decisões **`if`**

```
if (b < 0)
      b = -b;
if (a < 0)
       a = -a;
```

  - Basta acrescentar mais um caso de teste

Descrição	a	b	mdc(a,b)
Cobre as duas primeiras instruções	0	1	IllegalArgumentException
Cobre todas as restantes instruções	-1	-1	1
Cobrir instruções *if*, caso *false*	**1**	**1**	**1**

Técnicas de teste de caixa branca



- Cobertura de condições e decisões
  - Garantir adicionalmente que todas as condições que compõem uma decisão composta tomam os valores **`true`** e **`false`**
  - Os casos de teste anteriores não garantem a cobertura das condições da 1ª decisão (b==0 nunca é avaliado como *true*)
  - Acrescenta-se um caso de teste

```
if (a == 0 || b == 0)
    throw ...();
```

Descrição	a	b	mdc(a,b)
Cobre as duas primeiras instruções	0	1	IllegalArgumentException
Cobre todas as restantes instruções	-1	-1	1
Cobrir instruções *if*, caso *false*	1	1	1
Cobre o caso b==0 avaliado *true*	**1**	**0**	**IllegalArgumentException**

Mas ainda assim não dão garantia suficiente!

Implementação com JUnit 3.8.1

métodos de teste: void testXXX()

assertEquals(*esperado*, *actual*)

fail() - assinala teste falhado

```
import junit.framework.TestCase;
class MyMathTest extends TestCase {

  public void testMdcPositive() {
    assertEquals(1, MyMath.mdc(2, 3));
    assertEquals(2, MyMath.mdc(2, 4));
  }

  public void testMdcNegative() {
    assertEquals(2, MyMath.mdc(-4, 6));
  }

  public void testMdcZero() {
    try { MyMath.mdc(0,1); fail(); }
    catch(IllegalArgumentException e){}
    catch(Exception e) { fail(); }
  }
}
```

*Implementação com JUnit 4.0

```
import org.junit.Test;
import static org.junit.Assert.assertEquals;

class MyMathTest {

  @Test public void testMdcPositive() {
    assertEquals(1, MyMath.mdc(2, 3));
    assertEquals(2, MyMath.mdc(4, 6));
  }

  @Test(expected=IllegalArgumentException.class)
  public void testMdcZero() {
    MyMath.mdc(0,1);
  }
}
```

Tira partido das novas *features* do Java 1.5

References

- Software Engineering, 8th edition, Ian Sommerville, Addison-Wesley, 2006
  - Chapter 22 - Verification and Validation
- Winning with Software: An Executive Strategy, Watts Humphrey, 2001
- Java Coding Standards
  - http://www.ontko.com/java/java_coding_standards.html
- Code Conventions for the Java Programming Language
  - http://java.sun.com/docs/codeconv/html/CodeConvTOC.doc.html
- CERT Secure Coding Standards
  - https://www.securecoding.cert.org/confluence/display/seccode/CERT+Secure+Coding+Standards