1 Overview	2 Life cycle components	3 Infrastructure components	4 Management components	5 Standards and Organizing
6 Static tesing	7 Dynamic testing	8 Test management	9 Tools	

Static techniques

Learning objectives

- Describe the objective of static analysis and compare it to dynamic testing
- Describe the phases, roles and responsibilities of a typical formal review
- List typical benefits of static analysis
- List typical code and design defects that may be identified by static analysis tools

References

- Dorothy Grahamet, Erik van Veenendaal, Isabel Evans, Rex Black. *Foundations of software testing: ISTQB Certification*
- FSOFT course

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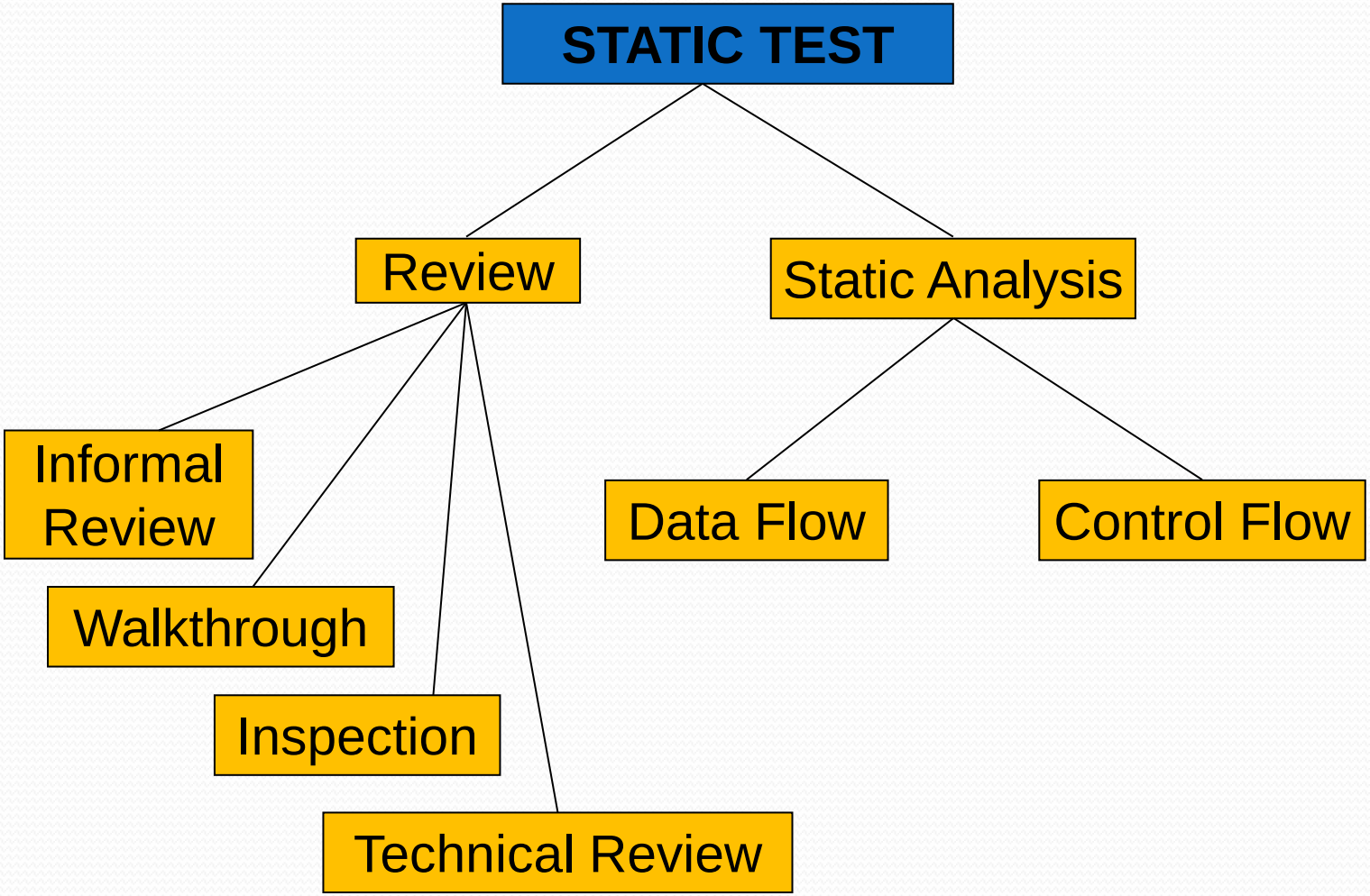
Contents

1. Static testing techniques

- Static testing techniques are those techniques that test a component or system at a specification or implementation level **without execution of the software**
  - review
    - find and remove errors and ambiguities in documents before they are used in the development process
  - static analysis
    - enables code to be analysed for structural defects or systematic programming weaknesses
- Types of defects that are easier to find during static testing are: deviations from standards, missing requirements, design defects, non-maintainable code and inconsistent interface specifications,...

1. Static testing techniques



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1. Static testing techniques
2. Reviews and the test process
3. Review process
4. Static analysis by tools
5. Self- code review

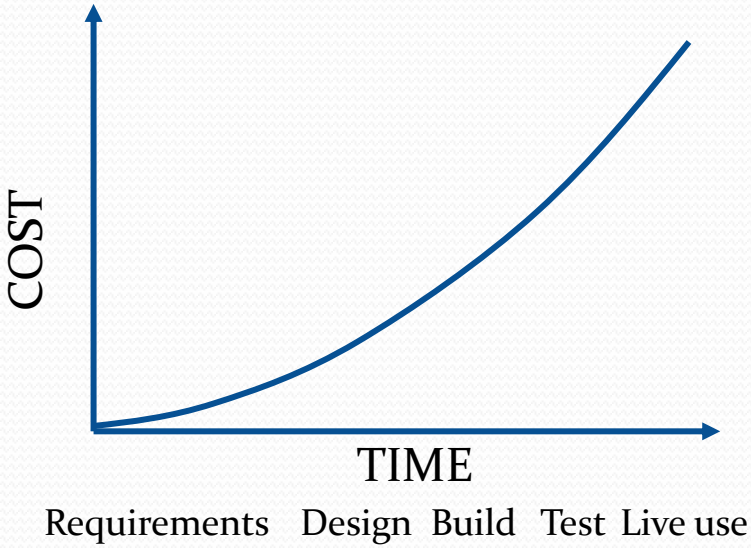
2. Reviews and the test process

- A review is a process or meeting for examination of a document by one or more people
- The objectives of reviews:
  - finding defects
  - informational, communicational and educational

2. Reviews and the test process

Benefits of reviews

- Early feedback on quality issues
- A cheap improvement of the quality of software products
- Development productivity improvement
- Reduced testing time
- A means of customer/user communication



2. Reviews and the test process
What can be reviewed?

- Anything written down
  - Requirement specifications
  - Design document
  - Code
  - Schedules
  - Test plans, test cases, defect reports
  - User manuals, procedures, training material
  - etc.

2. Reviews and the test process

Review inputs

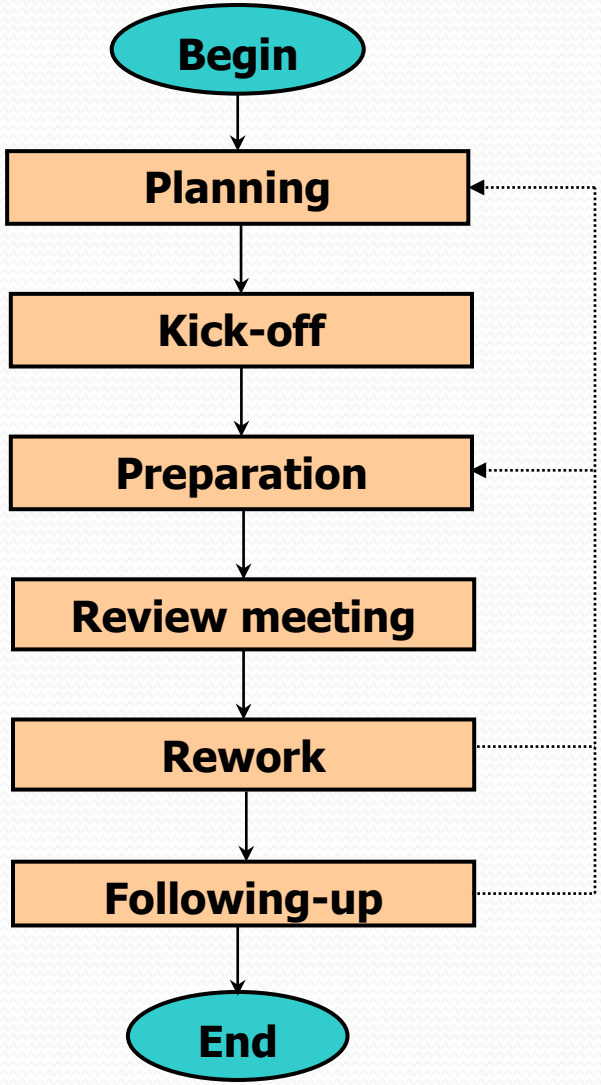
- Statement of **objectives** of the review
- **Material** to be reviewed
- **Checklists** to be used
- **Report** templates

2. Reviews and the test process
Review deliverables

- Edits in review product
- Change requests for source documents
- Process improvement suggestions
  - to the review (Inspection process)
  - to the development process which produced the product just reviewed
- Metrics

Contents

3. Review process
Phases of a formal review



3. Review process
Roles & Responsibilities

- **Describes** and **explains** the item under review
- **Assists** with answering questions
- **Joining** the review
- **Correcting** review defects
- **Providing** corrected items

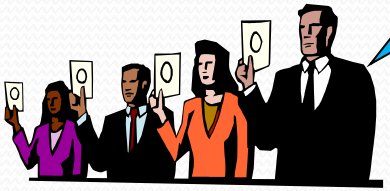
Secretary
(Optional)

- **Assisting** moderator in preparing for the review
- **Joining** the review
- **Preparing** meeting minute

- **Reviewing** documents for defects
- **Sending** feedback
- **Joining** the review

Author

Moderator



Reviewer(s)

Project members
(Optional)

- **Preparing** for the review (agenda, facilities, material, checklists…)
- **Gathering** feedback of reviewers
- **Conducting** review
- **Issuing** report of the review
- **Following-up** to make sure all defects are corrected

- **Assisting** moderator in preparing answer for comments/questions
- **Joining** the review meeting

3. Review process
Example: Functional Design Document

F-48

Add a function to send an order via email

Feilds

- Email ID
- Recipient name

Buton

- Send

3. Review process
Step 1. Planning

- Begins with a 'request for review' to the **moderator** (review leader)
- **Entry check**: to ensure that *the reviewers' time is not wasted* on a document that is not ready for review
  - a short check of a product sample by the moderator (or expert) does not reveal a large number of major defects
    - e.g. 30 minutes , <= 3 major defects / page
  - the document available with line numbers
  - the document has been cleaned up
  - references needed for the inspection are **stable** and **available**

3. Review process
Step 1. Planning (cont'd)

- Decide **which part of the document to review**
  - maximum number of pages depends on the **objective**, **review type** and **document type**
- **Determines the composition of the review team**, normally consists of four to six participants with different roles

3. Review process
Step 2. Kick-off meeting

- An optional stage
- Highly recommended
- Goal is to get everybody *on the same wavelength* regarding the document under review
  - **distributing documents** (document under review, source documents and other related documentation)
  - **explaining the objectives**, **process** and **relationships** between the document under review and the other documents to the participants
- Can be run as a meeting or simply by sending out the details to the reviewers
- Beneficial for new or highly complex projects

3. Review process
Step 3. Preparation

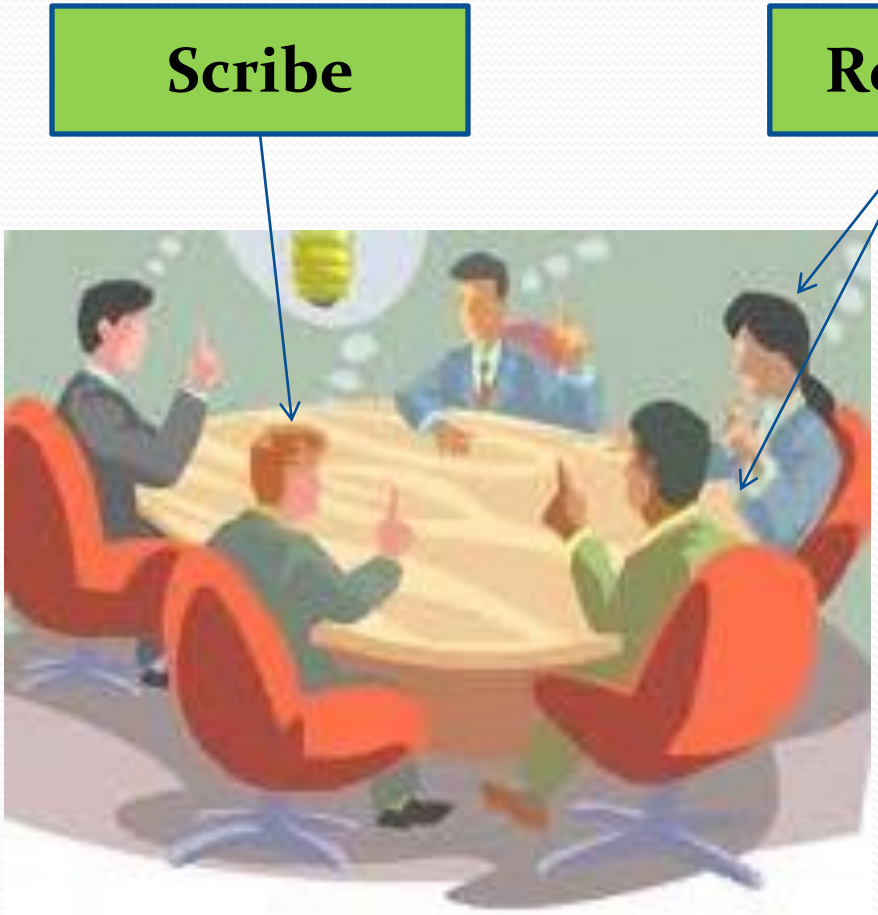
- **Done by each of the participants on their own** before the review meeting, by using the related documents, procedures, rules and checklists provided
- Using **checklists** can make reviews more effective and efficient
- To **identify defects, questions** and **comments** to be asked during the review meeting
- All issues are recorded
- **Checking rate**: the number of pages checked per hour
  - usually in the range of 5-10 pages per hour, but may be much less for formal inspection

3. Review process

Step 4. Review meeting

- Led by a moderator
- The review meeting is limited to two hours
- Consists of (partly depending on the review type)
  - Logging phase
  - Discussion phase
  - Decision phase

3. Review process
Step 4. Review meeting - Logging phase



- The **issues** are mentioned page by page, reviewer by reviewer and are **logged** by the scribe
  - Each defect is logged with a severity (critical, major, minor)
- No real discussion is allowed

3. Review process
Step 4. Review meeting – Discussion phase

Author **Moderator** **Reviewer**

- Participants can take part in the discussion by bringing forward their **comments** and **reasoning**
- The moderator takes care of people issues
  - intervene if the discussion is getting out of control

3. Review process
Step 4. Review meeting - Decision phase

- The participants have to **make a decision on the document**, sometimes based on **exit criteria**
  - the average number of critical and/or major defects found per page
- The moderator then closes the review meeting

Review process
Example: Functional Design Document

F-48

Add a function to send an order via email

Fields

- Email ID
- Recipient name

Button

- Send
- Reset

3. Review process
Step 5. Rework

- **Correcting** the defects
- Based on the defects detected, the author will make changes in the document, as per the action items of the meeting
- Changes on the document should be easy to identify during follow-up
- Not every defect leads to rework
  - judge if a defect has to be fixed
- If nothing is done, it should be reported

3. Review process
Example: Rework

- Example

#	Review comment	Status
1	Add Reset button	Done
2	Add detail about Menu	Done
3	Ask the client about facility to share via Social Networking sites	Not valid. Client does not need it

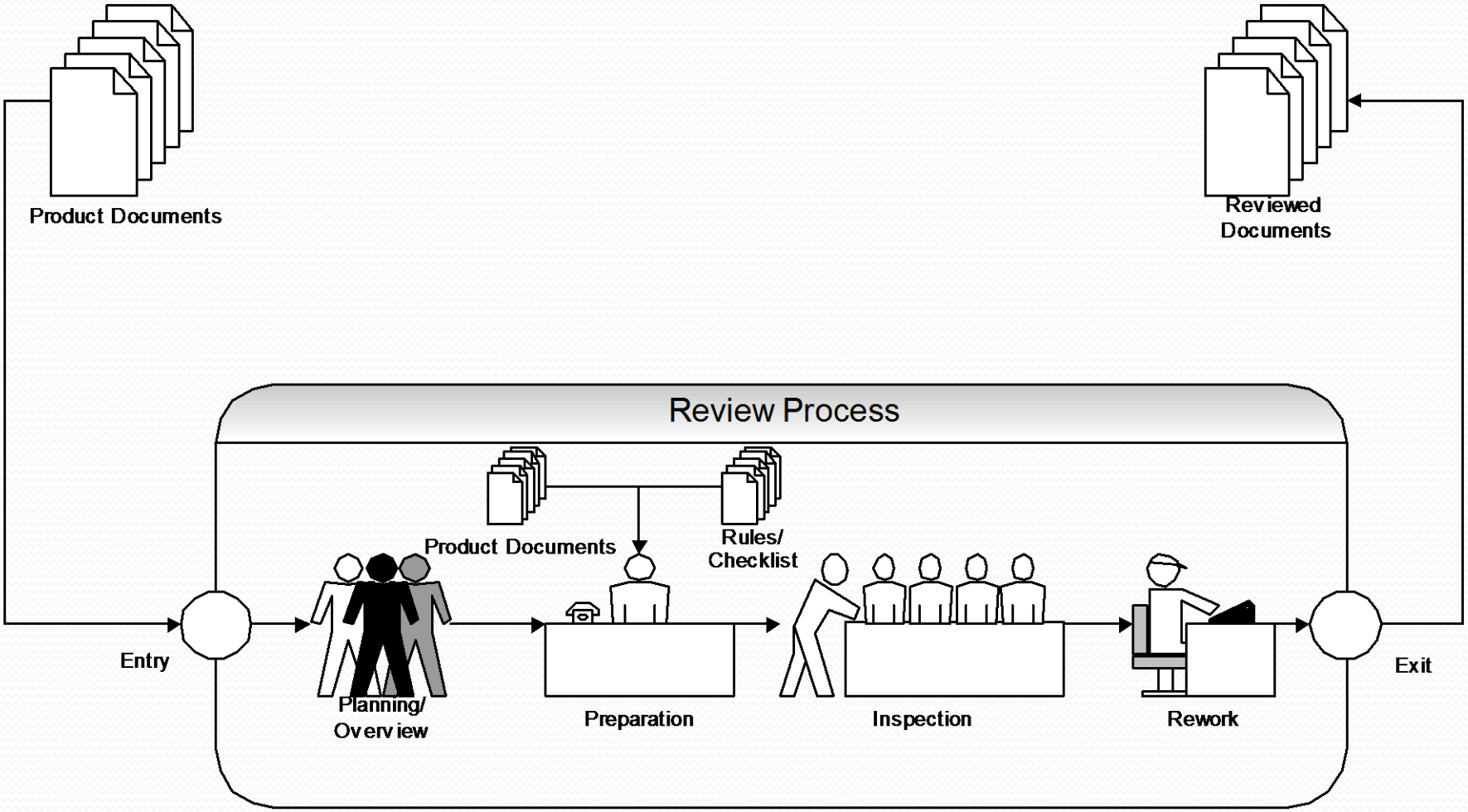
3. Review process
Step 6. Follow-up

- When the rework is completed, **the author and the moderator meet once again** to review the results
- The moderator will
  - check that **the agreed defects** have been addressed
  - check the **exit criteria** to ensure that they have been met
  - decide if **document passes** review or if another review is necessary
  - **circulate** the reworked document all review participants and collects the feedback
  - gather **metrics**

Review process
Metrics of reviews (inspection)

- Review rate
  - the **amount of pages** reviewed in one hour
- Review effort
  - the **amount of time** required to review one page of text
- Defect finding rate
  - the number of defects found during **one hour**
- Defect finding effort
  - the number of defects found per **page**

Review process



Success factors for reviews

- Ebook page 70

Contents

4. Static analysis

- Static analysis: “Analysis of a program carried out without executing the program” – BS 7925-1
- Goal: find errors
  - Unreachable code
  - Data flow anomaly
  - Infinite loops…
- Usually carried out by means of a supporting tool
- Types:
  - coding standards (coding convention)
  - code metrics
  - code structure

4. Static analysis
Coding convention

- Be specific to each programming language
- Recommend programming style, practices, and methods for each aspect of a piece program
- Common conventions may cover the following areas:
  - file organization,
  - naming conventions
  - indentation, white space,
  - comments, declarations, statements,
  - programming practices, principles, rules of thumb,
  - Etc.

4. Static analysis
Coding convention

- Code conventions are important to programmers for a number of reasons:
  - 80% lifetime software cost is for maintenance
  - People maintain the software may be changed
  - Following coding convention strictly helps:
    - Improve the readability of the software
    - Allowing engineers to understand new code more quickly and thoroughly

4. Static analysis
Coding convention

- The reasons to use tool:
  - The number of rules in a coding standard is **usually so large** that nobody can remember them all;
  - Some context-sensitive rules that demand reviews of several files are **very hard to check by human beings**;
  - If people spend time checking coding standards in reviews, that **will distract them from other defects** they might otherwise find, making the review process less effective

4. Static analysis

Coding convention - Common standards

- Tab and Indent
  - 4 spaces should be used as the unit of indentation
  - Tab characters should be avoided
- Line Length: avoid lines longer than 80 or 120 characters
- Wrapping Lines: When an expression will not fit on a single line, break it according to below principles:
  - Break after a comma
  - Break after a logical operator
  - Break before an operator
  - Prefer higher-level breaks to lower-level breaks
  - …
- Comments: beginning, block, single-line, trailing, …
- Number of declarations per line: same types, different types,..

4. Static analysis

Coding convention - Common standards

- Blank Lines improve readability by setting off sections of code that are logically related
  - Two blank lines should always be used:
    - Between sections of a source file
    - Between class and interface definitions
  - One blank line should always be used:
    - Between methods
    - Between the local variables in a method and its first statement
    - Before a block or single-line comment
    - Between logical sections inside a method
- Blank spaces should be used in the following circumstances
  - A keyword followed by a parenthesis should be separated by a space
  - A blank space should appear after commas in argument lists
  - All binary operators except . should be separated from their operands by spaces

4. Static analysis
Coding convention - Naming convention

- General naming rules:
  - Should be functionally meaningful, & indicate identifier's purpose
  - Use terminology applicable to the domain
  - Identifiers must be as short as possible (<=20 characters)
  - Avoid names that are similar or differ only in case
  - Abbreviations in names should be avoided, etc.
- Use a noun or noun phrase to name a class or code module
- Variables names must start with lowercase
- Constants: named in uppercase letters, might have underscore
- Method names must start with lowercase letter, usually use "active verb" as the first word of method name
- Instance /object names follow rules of variable names

4. Static analysis
Code metrics

- Information that can be calculated about **structural attributes** of the code, such as:
  - comment frequency
  - depth of nesting
  - number of lines of code
  - cyclomatic number

4. Static analysis
Code metrics - Cyclomatic complexity metric

- To measure the structural complexity of the code
  - the more complex the structure, the greater the measure
- Can be used to estimate the **testability** and the **maintainability** of the particular program part
- Calculate by
  - the number of decisions (e.g. if, while, for, etc.)
    - complexity = number of decisions + 1
  - by using the **control flow graph** of the program
    - complexity = E − N + 2P

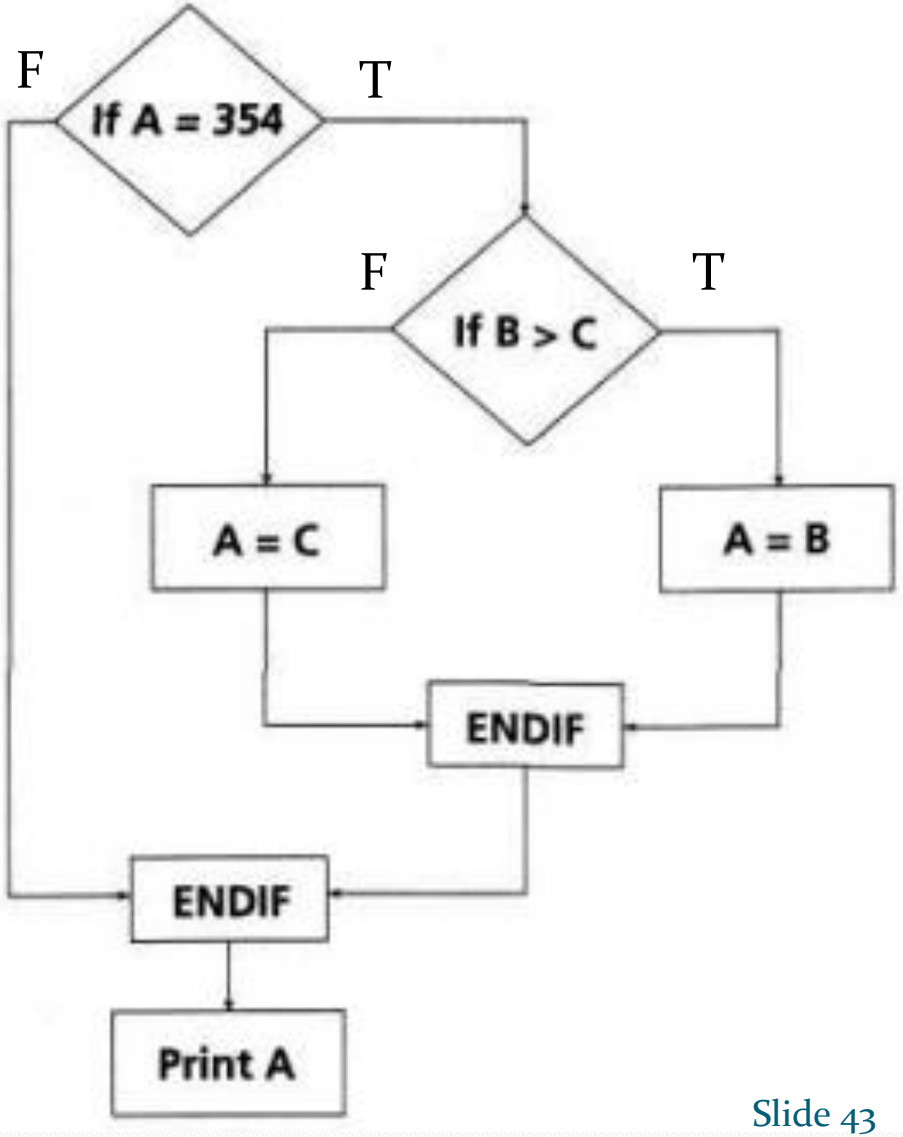
E = the number of edges of the graph
N = the number of nodes of the graph
P = the number of connected components

4. Static analysis

Code metrics - Cyclomatic complexity metric

Example

```
if A = 354
   then if B > C
      then A = B
      else A = C
   endif
endif
Print A
```



Cyclomatic complexity is 8-7 + 2 = 3
or 2 + 1 = 3

4. Static analysis

Code structure

- Control flow structure
- Data flow structure
- Data structure

4. Static analysis
Code structure - Control flow analysis

- Used to discover the **hierarchical flow of control** within a program
- To identify:
  - infinite loops
  - multiple entry to loops
  - unreachable (dead) code,...
- May use a control-flow graph (CFG) as representation
- The code metrics: number of nested levels or cyclomatic complexity

4. Static analysis
Code structure - Control flow analysis

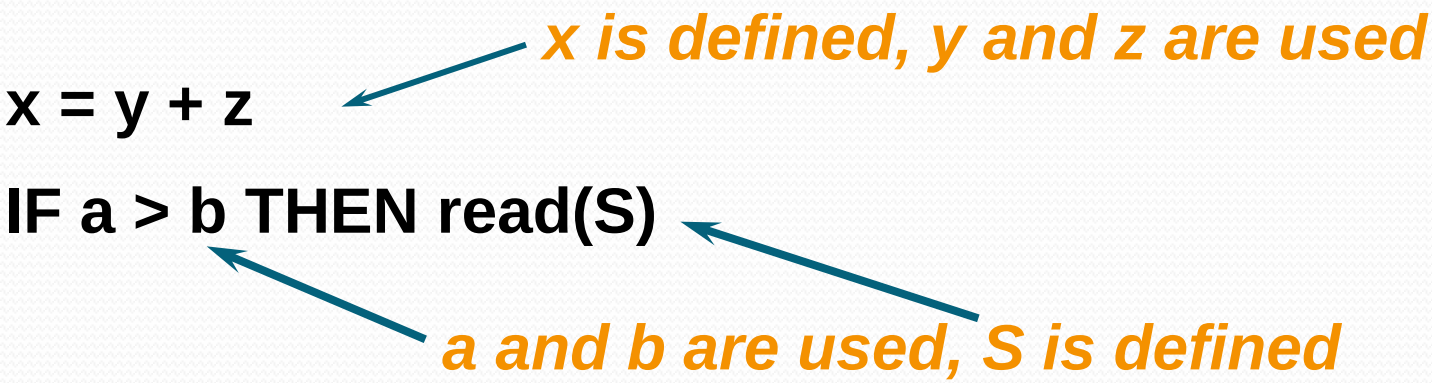
- Example

```
a = 4;
b = 15;
z = 7;
while b > z do
    begin
        writeln(z);
        z++;
        if a>b then
                b=a;
    end
```

unreachable(dead) code

4. Static analysis
Code structure - Data flow analysis

- Focuses on occurrences of variables, following paths *from* the definitions (an assignment of a value to a variable) of a variable *to* its usages (a read of a variable's value)
  - variables that are never used
  - referencing a variable with an undefined value
  - assigning an incorrect or invalid value to a variable,...



4. Static analysis
Code structure - Data flow analysis

- Example

```
n = 0
read(x)
n = 1
while x > y do
    begin
      read (y)
      write( n*y)
      x = x - n
    end
```

*Data flow anomaly: **n is re-defined** without being used*

*Data flow fault: **y is used before it has been defined***

4. Static analysis
Code structure - Data structure analysis

- The organization of the data itself
  - analyses of logical data structures
  - transformations of logical data structures
  - Example: list, queue, stack, ...

- Provides a lot of information about the difficulty in **writing programs to handle the data** and in **designing test cases**

4. Static analysis
Value of static analysis

- **Early detection** of defects prior to test execution
- **Early warning** about suspicious aspects of the code, design or requirements
- Identification of defects not easily found in dynamic testing
- Improved **maintainability** of code and design
- Prevention of defects

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1. Static testing techniques
2. Reviews and the test process
3. Review process
4. Static analysis by tools
5. Self-code review

5. Self-code review [1/3]

- What: **developer to do self-code review** while he/she do the coding, it is to make sure that:
  - Requirement logics are implemented correctly
  - No coding conventions or common defects existed
  - General programming practices are applied
- How:
  - Use code review tools (example)
  - Use team-defined code review checklist

5. Self-code review [2/3]

- Code Review Tools
  - http://en.wikipedia.org/wiki/List_of_tools_for_static_code_analysis
- .NET
  - FxCop http://msdn.microsoft.com/en-us/library/bb429476%28v=vs.80%29.aspx
  - Resharper http://www.jetbrains.com/resharper/
  - StyleCop http://stylecop.codeplex.com/
- JAVA
  - CheckStyle (http://checkstyle.sourceforge.net/)
- C,C++
  - CPPCheck http://sourceforge.net/apps/mediawiki/cppcheck/

5. Self-code review [3/3]

- Code Review checklist
- This is a **team-defined** coding checklist
- Project developers are required to self review their codes following defined checklist items, filled the code review checklist as reviewing results
- Main checklist items
  - General coding conventions
  - Code module, class commenting
  - Source code details: modulation, code structure, loop, naming conventions, comments, etc.

Refer: Code Review CheckList_v1.0.xls

5. Self-code review
Hard code constants

- Issue with giving a **fixed value** in codes, for example:

```
dgrView.PageSize = 10
strErr = "Error message here";
```

  The problem occurs when you should change these values multiple times!!!

- *Preventive Action*: define **constants** in the common constant module or in a configure files

5. Self-code review
Array Index Start from 0

- Issue with below C-Language codes?

```
int i, a[10];
for (i=1; i<=10; i++) a[i] = 0;
```

This made the loop into an **infinite loop**!!!

- Cause: A C array with n elements does not have an element with a subscript of n, as the elements are numbered from 0 through n-1.
- Preventive: programmers coming from other languages must be especially careful when using arrays.

5. Self-code review
The Dangling else Problem

- Issue with below C-Language codes?

```
if (x == 0)
    if (y == 0) error();
else {
    z = x + y;
    f (&z);
}
```

Confused on the **else** using!!!

- Cause: else is always associated with the closest unmatched if.
- Preventive: use appropriated braces ({)

5. Self-code review
Null Pointer Exception

- Issue: the developer got Null-Pointer-Exception run-time error, while he/she did not detect that when compiling the codes

```
pPointer->member = 1;
strReturn = objDoc.SelectNodes(strName);
```

- Cause: the developer does not check null or think about null object before accessing object's value.
- Preventive: Should check null before accessing object or pointer before using its member

```
If ( pPointer != NULL ) pPointer->member = 1;
If (objDoc != NULL)
    strReturn = objDoc.SelectNodes(strName);
```

5. Self-code review
Detect Common Defects Sample

```
public bool IsValidLogin(string userName, string password)       {
        SqlConnection con = null;
        SqlCommand cmd = null;
        bool result = false;
        try {
           con = new SqlConnection(DB_CONNECTION);
           con.Open();
           string cmdtext = string.Format("SELECT * FROM [Users] WHERE [Account]='{0}' AND
                                                                [Password]='{1}' ", userName, password);
           cmd = new SqlCommand(cmdtext);
           cmd.Connection = con;
           cmd.CommandType = CommandType.Text;
           result= cmd.ExecuteReader().HasRows;
           cmd.Dispose();
           con.Dispose();
           return result;
        }
        catch (SqlException) {
             return false;
        }
}
```

Lack of checking for null value(1)

SQL Injection (1)

Hard code !!(1)

SQL Performance Issue !!(1)

Memory leak !! (2)

5. Self-code review
Programming Practices 1

- Issue with variables or create objects in loop?

```
for (int i=0; i<dt.Rows.Count-1; i++)
{
        string strName;
        strName = dt.Rows[i]["Name"].ToString();
        //do something here
}
```

  Impact to the application **performance**!!!
- Cause: memory is allocated repeatedly.
- Preventive:
  - Variables should be declared before the loop statement or inside for() statement
  - Determine objects before loop statement

5. Self-code review Programming Practices 2

- Code redundant issues:
  - Create new Object while we can reuse the object in previous command:

    ```
    BeanXXX bean = new BeanXXX();
    bean = objectYYY.getBeanXXX();
    ```

  - Variables are declared in based class but it is not used
  - Un-used methods/functions are existing in the application
  - Break a complex method/function to more simple methods / functions with only one or two lines of code, and could not be re-use
- Preventive actions:
  - Should verify that the current design is possible and is the best by coding sample
  - Re-check unnecessary code to remove in coding review
  - Supervise and assign person to review code carefully before coding
  - Supervise strictly changing source code from team daily

5. Self-code review
Programming Practices 3

- Avoid **using an object to access a static variable or method**. Use a class name instead.

```
classMethod();                  //OK
AClass.classMethod();           //OK
anObject.classMethod();         //AVOID!
```

- Numerical constants (literals) should not be coded directly, except for -1, 0, and 1, which can appear in a for loop as counter values.
- Avoid assigning several variables to the same value in a single statement.

```
fooBar.fChar = barFoo.lchar = 'c'; // AVOID!
```

5. Self-code review
Programming Practices 4

- Do not use the assignment operator in a place

```
if (c++ = d++) { // AVOID!
    ...
}
```

  - should be written as:

```
if ((c++ = d++) != 0) {
    ...
}
```

- Do not use embedded assignments in an attempt to improve run-time performance.

```
d = (a = b + c) + r;
```

5. Self-code review
Programming Practices 5

- **File operations**: file read operations must be restricted to a minimum
- Clear content of big structure after use: always **clear() the content of Collection/Map** objects after use
- Be **economical** when creating new objects
- In program language that has no garbage collector (i.e C, C++): **free allocated memory** after use:

```
{
    double* A = malloc(sizeof(double)*M*N);
    for(int i = 0; i < M*N; i++){
       A[i] = i;
    }
}
```

memory leak: forgot to call `free(A);`
common problem in C, C++

5. Self-code review
Programming Practices 6

- Use **parentheses** liberally in expressions involving mixed operators to avoid operator precedence problems

```
if (a == b && c == d) // AVOID!
if ((a == b) && (c == d)) // RIGHT
```

- Try to make the structure of your program **match the intent**, for example:

```
if (booleanExpression) {
    return true;
} else {
    return false;
}
```

  - should instead be written as

```
    return booleanExpression;
```