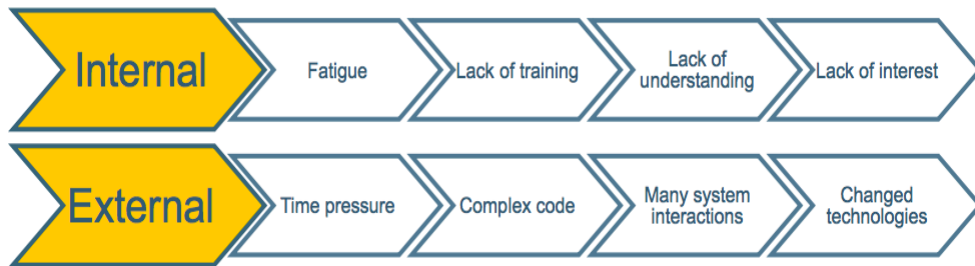


# INF3121 – Software Testing

## Week 1 - Fundamental concepts in testing

Defect – something that is messed up, under certain conditions, within the concept of the software

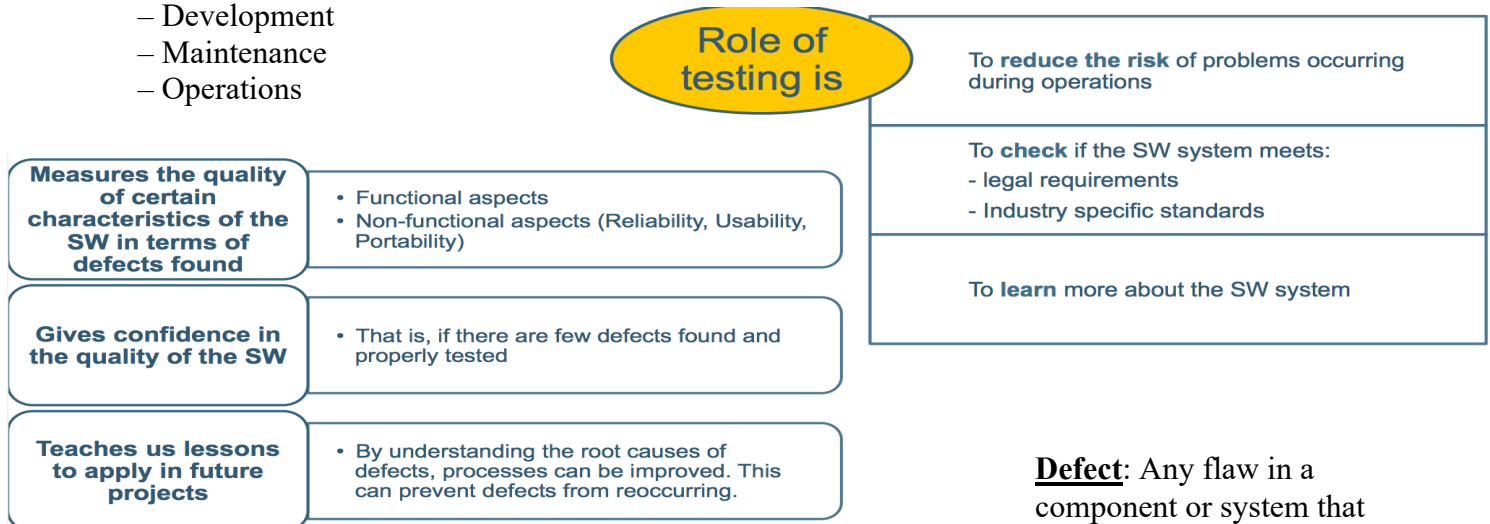
Human errors:



non-controllable events like environmental conditions (radiation, magnetism, pollution)

Testing has an important role in all the stages of SW products life cycle:

- Development
- Maintenance
- Operations



The process consisting:

- of all life cycle activities: both static and dynamic, concerned with:

- planning, preparation and evaluation

of:

- software products and related work products

to:

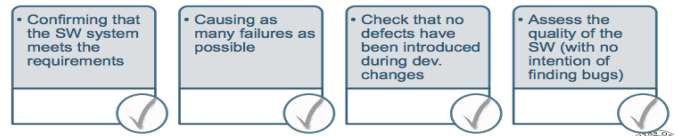
- determine that they satisfy specified requirements
- to demonstrate that they are fit for purpose
- and to detect defects.

**Defect:** Any flaw in a component or system that can cause the component or system to fail to perform its required function.

**Error:** A human action that produces an incorrect result.

**Failure:** Deviation of the component or system from its expected delivery, service or result

## Testing principles:



### **P1: Testing shows presence of defects**

- Testing can show that defects are present, but cannot prove there are no defects.
- Testing reduces the probability of undiscovered defects remaining in the software; but even if no defects are found, this is not a proof of correctness.

### **P2: Exhaustive testing is impossible**

- Testing everything is not feasible. We use risks and priorities to focus test effort.

### **P3: Early testing**

- Testing should start as soon as possible in the development lifecycle and should be focused on defined objectives.

### **P4: Defect clustering**

- A small number of modules contain most of the defects discovered during pre-release testing.

### **P5: Pesticide paradox**

- If the same set of tests will be repeated over and over, it will no longer find new bugs.

### **P6: Testing is context dependent**

- I.e., safety-critical SW is tested differently from an ecommerce site.

### **P7: Absence-of-errors fallacy**

- Finding and fixing defects does not help if the SW system is un-usable or does not meet user's expectations.

## Analysis and design

### **Review test basis:**

- Requirements
- Product architecture
- Product design
- Interfaces

### **Analysis:** general test objectives are transformed into:

- Test conditions
- Test cases

### **Design:**

- Test cases
- Test environments
- Test data

## Implementation and execution

### **Implement:**

- Group tests into scripts
- Prioritize the scripts
- Prepare test oracles
- Write automated test scenarios

### **Execute:**

- Run the tests and compare results with oracles
- Report incidents
- Repeat test activities for each corrected discrepancy

## Evaluate exit criteria and report

### **Evaluate:**

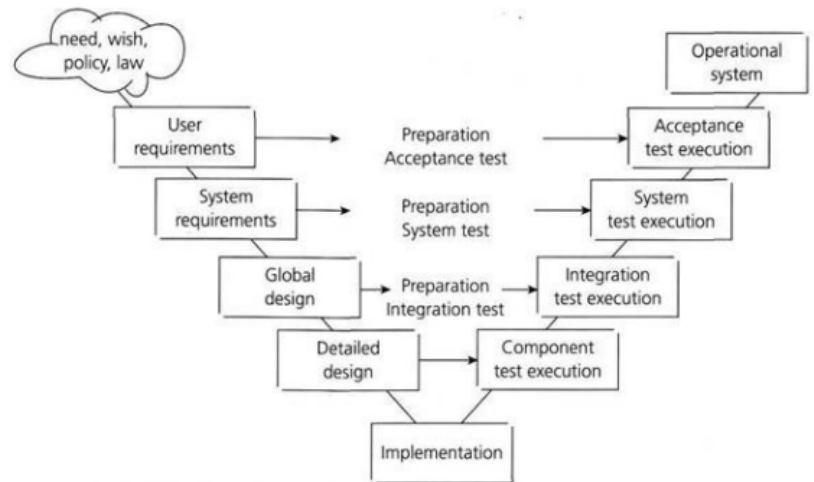
- Assess test execution against the defined objectives
- Check if:
  - More tests are needed
  - Exit criteria should be changed

### **Report:**

- Write or extract a test summary report for the stakeholders.

## **Week 2 - Testing throughout the software life cycle**

Testing needs to begin as early as possible, easier to fix the problem. Follow the sequential development model(v-model). Testing in the v-model takes place especially during the early and late stages in the life cycle. Testing often, this is why this model is an improvement of the waterfall model(fossefall).

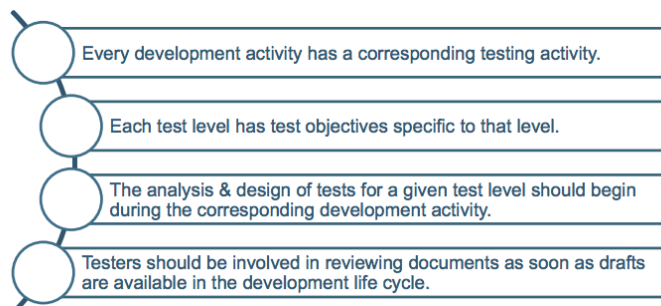


**Iterative-incremental development** is the process of :

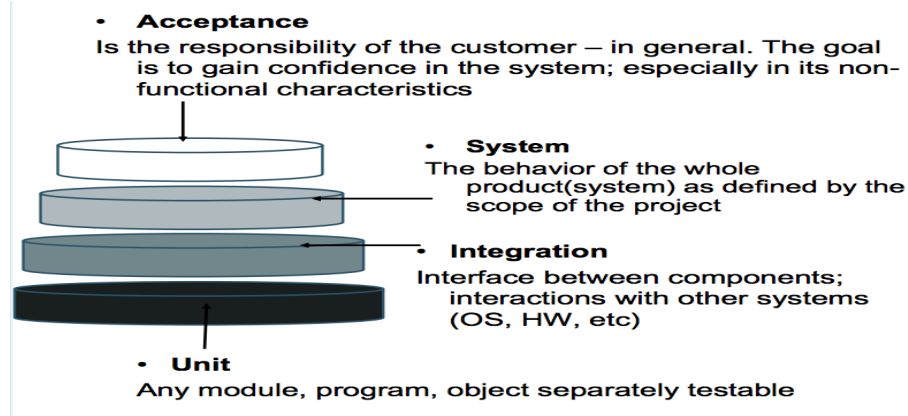
- establishing requirements,
- designing,
- building
- and testing a system,

done as a series of shorter development cycles.

In any life cycle model, there are several characteristics of good testing:



## Test levels:



## Component testing

**Objectives:** Component testing includes testing of functionality and specific non-functional characteristics, such as:

- resource-behavior (e.g. memory leaks)
- robustness testing
- structural testing (e.g. branch coverage).

### **Test basis:**

- specification of the component
- software design
- the data model

**Tools:** Stubs, drivers and simulators may be used.

### **Approaches:**

- test-driven development (prepare and automate test cases before coding)
- Defects are fixed as soon as they are found, without formal recording of incidents

**Responsible:** (QA or programmer in theory) Programmer in practice

## Integration testing

### **Objectives:**

It tests:

- interfaces between components,
- interactions with different parts of a system, such as :
  - the operating system,
  - file system,
  - hardware,
  - interfaces between systems.

Types of integration tests:

1. Component integration : tests the interactions between software components
  - is done after component testing;
2. System integration: tests the interactions between different systems
  - is done after system testing.

**Approaches:** to reduce the risk of late defect discovery, integration should normally be incremental rather than “big bang”.

**Responsible:** Ideally, testers should understand the architecture and influence integration planning.

## System testing

**Objectives:** testing the behavior of the whole system as defined by the scope of the project.

### Test basis:

- System requirements specification
- Business processes
- Use cases
- Other high level description of the: system behavior, interactions with OS/system

resources.

Requirements may exist as text and/or models.

Testers also need to deal with incomplete or undocumented requirements.

### Approaches:

- test environment should correspond to the production environment as much as possible.

- First, the most suited black-box technique
- Then, white-box technique to assess the thoroughness of testing

**Responsible:** independent test team

### Acceptance testing

**Objectives:** to establish confidence in the system / part of system / non-functional characteristics of the system.

#### Types of acceptance testing:

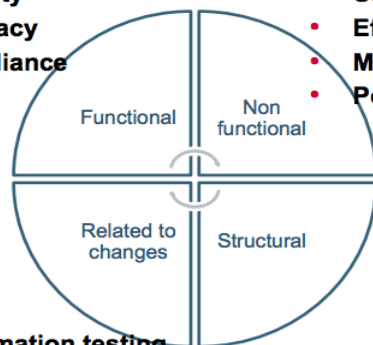
- User acceptance testing - verifies the fitness for use of the system by users.
- Operational testing (done by the system administrators, and include):
  - testing of backup/restore;
  - disaster recovery;
  - user management;
  - maintenance tasks;
  - periodic checks of security vulnerabilities.
- **Contract and regulation acceptance testing** - performed against a contract's acceptance criteria (i.e. governmental, legal or safety regulations)
- **Alpha and beta testing**
  - Alpha testing is performed at the developing organization's site.
  - Beta testing (field testing), is performed by people at their own locations.Both are performed by potential customers, not the developers of the product.
- **Responsible:** customers or users of a system; other stakeholders may be involved as well

#### *"What" the system does*

- **Suitability**
- **Interoperability**
- **Security**
- **Accuracy**
- **Compliance**

#### *"How" the system works*

- **Performance, Load, Stress**
- **Reliability** (*robust, fault tolerant, recoverable*)
- **Usability** (*understand, learn, operate, like*)
- **Efficiency** (*time behavior, resource utilization*)
- **Maintainability** (*analyze, change, stabilize, test*)
- **Portability** (*adapt, install, co-exist, replace*)



- **Confirmation testing**
- **Regression testing**

- **Code coverage**

## **Functional testing (Black box testing)**

**Objectives:** Test what a system should do and considers the external behavior of the software.

**Test levels:** may be performed at all test levels (e.g. tests for components may be based on a component specification).

**Test basis:** The expected behavior description can be found in work products such as:

- requirements specification
- use cases
- functional specification
- may be undocumented.

## **Non functional testing**

**Objectives:** measuring characteristics of software that can be quantified on a varying scale:

- ex: response times for performance testing.

• **Test levels:** may be performed at all test levels.

## **Structural testing (white box testing)**

**Objectives:** help measure the thoroughness of testing through assessment of coverage of a type of structure.

**Test levels:** may be performed at all test levels, but especially in component testing and component integration testing

**Approach:**

- Structural techniques are best used *after specification-based* techniques, in order to help measure the thoroughness of testing
- Structural testing is based on the architecture of the system(i.e. a calling hierarchy)

## **Testing related to changes**

**Confirmation testing:** After a defect is detected and fixed, the software should be retested to confirm that the original defect has been successfully removed.

**Regression testing:** the repeated testing of an already tested program, after modification, to discover any defects introduced or uncovered as a result of the change(s).

**Test levels:**

- may be performed at all test levels,
- applies to functional, non-functional and structural testing.

**Approach:**

- The extent of regression testing is based on the risk of finding defects in software that was working previously.
- Regression test suites are run many times and generally evolve slowly, so regression testing is a strong candidate for automation.

## **Maintenance testing**

**Objectives:** Maintenance testing is done on an existing operational system, and is triggered by modifications, migration, or retirement of the software or system.

**Types of maintenance testing:**

- Modifications:
  - planned enhancement changes (e.g. release-based),
  - corrective and emergency changes (patches), and changes of environment (operating system or database upgrades)
- Migration (e.g. from one platform to another) :
  - operational tests of the new environment

- tests on the changed software.
- Retirement of a system :
  - the testing of data migration or archiving if long data-retention periods are required.
- The scope of maintenance testing is related to:
  - the risk of the change,
  - the size of the existing system
  - the size of the change.
- Test levels: Depending on the changes, maintenance testing may be done at any or all test levels and for any or all test types.
- Approach:
  - Determining how the existing system may be affected by changes is called impact analysis, and is used to help decide how much regression testing to do.
- Note:
  - Maintenance testing can be difficult if specifications are out of date or missing.

### **Week 3 - Static Techniques**

#### ***Static Techniques and the Test Process***

Reviews, static analysis and dynamic testing have the same objective – identifying defects. They are complementary. Compared to dynamic testing, static techniques find causes of failures (defects) rather than the failures themselves.

**Dynamic testing** - requires the execution of software.

**Static testing** - manual examination and automated analysis of the code or documentation.

**Reviews** = a way of testing software products (including code) and can be performed well before dynamic test execution.

#### **Reason to make reviews**

- Defects detected during reviews early in the life cycle are often cheaper to remove than those detected while running tests.
- Reviews can find omissions, for example, in requirements, which are unlikely to be found in dynamic testing.

**Tools (manual + tool support)** The main manual activity is to examine a work product and make comments about it.

- **Object of reviews:** Any software work product can be reviewed:
  - requirements specifications
  - design specifications
  - code
  - test plans, test specifications, test cases, test scripts
  - user guides
  - web pages.
- **Benefits:**
  - early defect detection and correction
  - development productivity improvements
  - reduced development timescales
  - reduced testing cost and time
  - lifetime cost reductions
  - fewer defects and improved communication

- **Typical defects** (easier to find in reviews than in dynamic testing):
  - deviations from standards
  - requirement defects
  - design defects
  - insufficient maintainability
  - incorrect interface specifications

## Review Process

Background:

Different types of reviews vary from:

- very informal (e.g. no written instructions for reviewers)
- to very formal (i.e. well structured and regulated).

The formality of a review process is related to factors like:

- the maturity of the development process
- any legal or regulatory requirements
- the need for an audit trail.

The way a review is carried out depends on the agreed **objective** of the review:

- find defects
- gain understanding
- discussion and decision by consensus

### Phases of a formal review

<b>1. Planning</b>	<ul style="list-style-type: none"> <li>• select the personnel</li> <li>• allocate roles</li> <li>• define the entry and exit criteria for more formal review types (e.g. inspection)</li> <li>• select which parts of documents to look at</li> </ul>
<b>2. Kick-off</b>	<ul style="list-style-type: none"> <li>• distributing documents</li> <li>• explaining the objectives</li> <li>• process and documents to the participants</li> <li>• and checking entry criteria (for more formal review types)</li> </ul>
<b>3. Individual preparation</b>	Work done by each of the participants on their own before the review meeting, noting potential defects, questions and comments.
<b>4. Review meeting</b>	<ul style="list-style-type: none"> <li>- Discussion or logging, with documented results or minutes (for more formal review types).</li> <li>- The meeting participants may simply note defects, make recommendations for handling the defects, or make decisions about the defects.</li> </ul>
<b>5. Rework</b>	fixing defects found, typically done by the author.
<b>6. Follow-up</b>	<ul style="list-style-type: none"> <li>• check that defects have been addressed</li> <li>• gather metrics</li> </ul>

### Roles and responsibilities

<b>1. Manager</b>	<ul style="list-style-type: none"> <li>• decides on the execution of reviews</li> <li>• allocates time in project schedules</li> <li>• determines if the review objectives have been met</li> </ul>
<b>2. Moderator</b>	<ul style="list-style-type: none"> <li>• leads the review of the document or set of documents</li> <li>• planning the review</li> <li>• running the meeting</li> <li>• and follow-up after the meeting</li> <li>• If necessary, the moderator may mediate between the various points of view and is often the person upon whom the success of the review rests</li> </ul>
<b>3. Author</b>	<ul style="list-style-type: none"> <li>• the writer or person with chief responsibility for the documents to be reviewed.</li> </ul>
<b>4. Reviewers</b>	<ul style="list-style-type: none"> <li>• Individuals with specific technical or business background</li> <li>• Identify and describe the findings in the product under review</li> </ul> <p>Note: reviewers should be chosen to represent different perspectives and roles in the review process</p> <p>Note: reviewers should take part in the review meeting</p>
<b>5. Scribe</b>	<ul style="list-style-type: none"> <li>• Documents all the issues, problems and open points that were identified during the meeting</li> </ul>

### Types of reviews

<b>1. Informal review</b>	<ul style="list-style-type: none"> <li>• <b>Purpose: inexpensive way to get some benefit.</b></li> <li>• Form: pair programming or a technical lead reviewing designs and code</li> <li>• no formal process</li> <li>• optionally may be documented</li> </ul>
<b>2. Walkthrough</b>	<ul style="list-style-type: none"> <li>• <b>Purposes: learning, gaining understanding, defect finding.</b></li> <li>• Form: meeting led by author</li> <li>• scenarios, dry runs, peer group</li> <li>• open-ended sessions</li> <li>• may vary in practice from quite informal to very formal</li> </ul>
<b>3. Technical review</b>	<ul style="list-style-type: none"> <li>• <b>Purposes: discuss, make decisions, evaluate alternatives, find defects, solve technical problems and check conformance to specifications and standards.</b></li> <li>• Form: may be performed as a peer review without management participation</li> <li>• ideally led by trained moderator</li> <li>• documented, defined defect-detection process; includes peers and technical experts</li> <li>• pre-meeting preparation</li> <li>• optionally the use of checklists, review report, list of findings and management participation</li> </ul>
<b>4. Inspection</b>	<ul style="list-style-type: none"> <li>• <b>Purpose: find defects.</b></li> <li>• Form: usually peer examination led by trained moderator (not the author)</li> <li>• formal process based on rules and checklists with entry and exit criteria</li> <li>• pre-meeting preparation</li> <li>• defined roles</li> <li>• includes metrics</li> <li>• inspection report, list of findings</li> <li>• formal follow-up process</li> </ul>





### ***Success factors for reviews***

**Objectives:** each review has a clear predefined objective.

**Roles:** the right people for the review objectives are involved.

**Approach:**

- Defects found are welcomed, and expressed objectively.
- Apply suitable review techniques for the type and level of software products.
- Use checklists or roles if appropriate to increase effectiveness of defect identification.
- Management supports a good review process (e.g. by incorporating adequate time for review activities).

**Training and learning:**

- Training is given in review techniques, especially the more formal techniques, such as inspection.
- There is an emphasis on learning and process improvement

### ***Static Analysis by Tools***

**Objectives of static analysis:** Find defects in:

- software source code
- software models.
- Note! Static analysis finds defects rather than failures

Static analysis is performed **without actually executing the software** being examined by the tool;

Static analysis tools analyze program code (e.g. control flow and data flow), as well as generated output such as HTML and XML.

**Typical defects** discovered by static analysis tools include:

- referencing a variable with an undefined value;
- inconsistent interface between modules and components;
- variables that are never used;
- unreachable (dead) code;
- programming standards violations;
- security vulnerabilities;
- syntax violations of code and software models.

Developers	Use static analysis before and during: -Component testing -Integration testing
Designers	Use static analysis during software modeling

**Practical side:** Static analysis tools may produce a large number of warning messages, which need to be well managed to allow the most effective use of the tool.

**Why is static analysis valuable?**

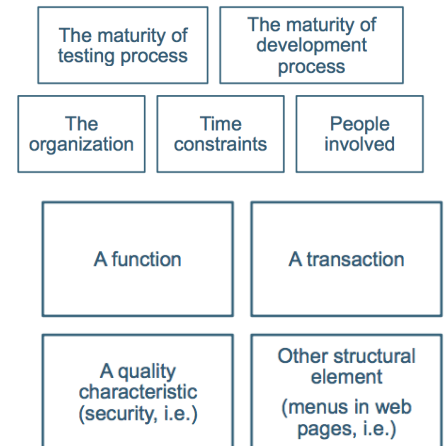
- Early detection of defects prior to test execution.
- Early warning about suspicious aspects of the code or design, by the calculation of metrics, such as a high complexity measure.
- Identification of defects not easily found by dynamic testing.
- Detecting dependencies and inconsistencies in software models, such as links.
- Improved maintainability of code and design.
- Prevention of defects, if lessons are learned in development.

## Week 4 - Test Design Techniques

### *The test development process*

#### Background

The test design process can be done in different ways, from very informal (little or no documentation), to very formal. The level of formality depends on the context of the testing, including:



#### Test analysis

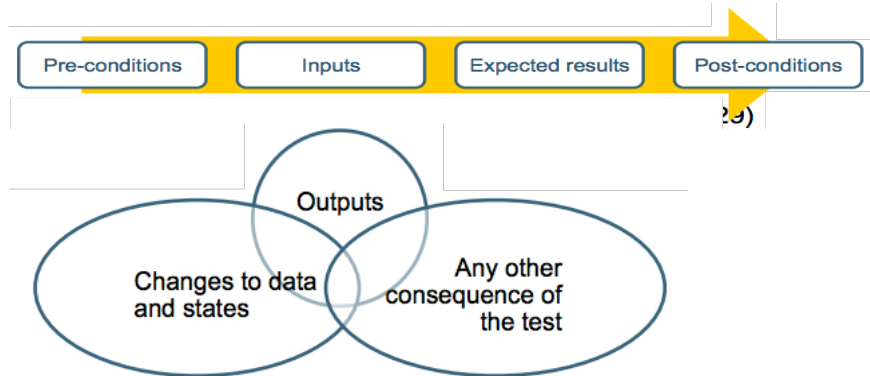
**The test basis documentation** is analyzed in order to determine what to test, i.e. to identify the test conditions.

- Test condition (Def.) = an item or event that could be verified by one or more test cases Examples:

#### Test design

During test design: *Test cases* + *Test data* are created and specified.

Test case = a set of:



Expected results include:

#### Test implementation

During test implementation the test cases are:

in the test procedure specification.

**The test procedure** (= *manual test script*):

specifies the sequence of action for the execution of a test.

**Test script** (= *automated test procedure*)

If tests are run using a test execution tool, the sequence of actions is specified in a test script.



**The test execution schedule** defines:

- The order of execution of the test procedures & (possibly) automated test scripts
- When they are to be carried out
- By whom to be executed.

The test execution schedule will take into account such factors as:

- regression tests,
- prioritization,
- technical and logical dependencies.

## **Categories of test design techniques**

- *Common features of black-box techniques:*

We use models (formal or informal) to specify the problem to be solved, the software or its components. We derive systematically the test cases from these models.

- *Common features of white-box techniques:*

The test cases are derived from information about how the software is constructed for example: code and design.

For the existing test cases, we can measure the coverage of the software

Further test cases can be derived systematically to increase coverage.

- *Common features of experience-based techniques:*

The test cases are derived from the knowledge and experience of people:

Knowledge of testers, developers, users and other stakeholders about the software, its usage and its environment.

Knowledge about likely defects and their distribution

## **Specification-based testing (Black-box)**

### **Equivalence partitioning**

**Technique:** Inputs/Outputs/Internal values of the software are divided into groups that are expected to exhibit similar behavior.

Equivalence partitions (or classes) can be found for both valid data and invalid data, i.e. values that should be rejected.

Notes:

- Tests can be designed to cover partitions.
- Equivalence partitioning is applicable at all levels of testing.
- Equivalence partitioning as a technique can be used to achieve input and output coverage.

### **Boundary value analysis**

**Boundary analysis:** analysis at the edge of each equivalence partition. Why: because there, the results are more likely to be incorrect.

The maximum and minimum values of a partition are its boundary values.

*Valid and invalid boundary:*

- A boundary value for a valid partition is a valid boundary value;
- The boundary of an invalid partition is an invalid boundary value.

Tests can be designed to cover both valid and invalid boundary values.

Notes:

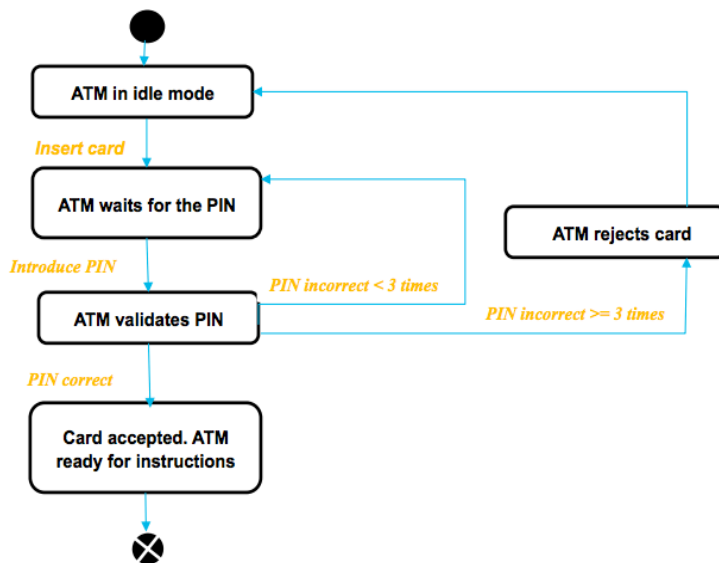
- Boundary value analysis can be applied at all test levels.
- It is relatively easy to apply and its defect finding capability is high;
- Detailed specifications are helpful.
- This technique is often considered as an extension of equivalence partitioning
- Boundary values may also be used for test data selection.

## Decision table testing

- Decision tables are a good way to:
  - capture system requirements that contain logical conditions,
  - and to document internal system design.
- The input conditions and actions are most often stated in such a way that they can either be true or false (Boolean).
- The strength of decision table testing is that it creates combinations of conditions that might not otherwise have been exercised during testing. It may be applied to all situations when the action of the software depends on several logical decisions.

## State transition testing

Typical problem:



**Why?** Because a system may exhibit a different response depending on current conditions or previous history (its state).

- It allows the tester to view:
    - the software in terms of its states,
    - transitions between states,
    - the inputs or events that trigger state changes (transitions)
    - the actions which may result from those transitions.
  - The states of the system under test are separate, identifiable and finite in number.
- A state table can highlight possible transitions that are invalid.
  - Tests can be designed:
    - To cover a typical sequence of states,
    - To cover every state,
    - To exercise every transition,
    - To exercise specific sequences of transitions
    - To test invalid transitions.

## Use case testing

**Use case** - describes interactions between actors (including users and the system), which produce a result of value to a system user.

- Each use case has pre-conditions, which need to be met for a use case to work successfully.
- Each use case terminates with post-conditions, which are the observable results and final state of the system after the use case has been completed.
- A use case usually has a **mainstream** (i.e. most likely) scenario, and sometimes **alternative branches**.
- Use cases are very useful for designing acceptance tests with customer/user participation.

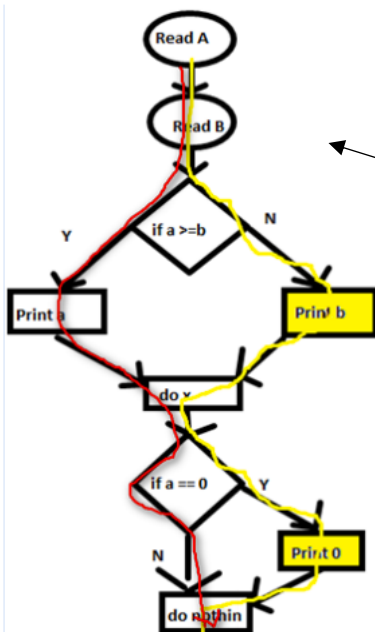
## Structure-based testing (White-box)

### Background

- Structure-based testing (white-box) is based on an identified structure of the software.
  - Component level: the structure is that of the code itself:
    - statements, decisions or branches.
  - Integration level: the structure may be a call tree (a diagram in which modules call other modules).
  - System level: the structure may be a menu structure, business process or web page structure.

### Statement testing & coverage

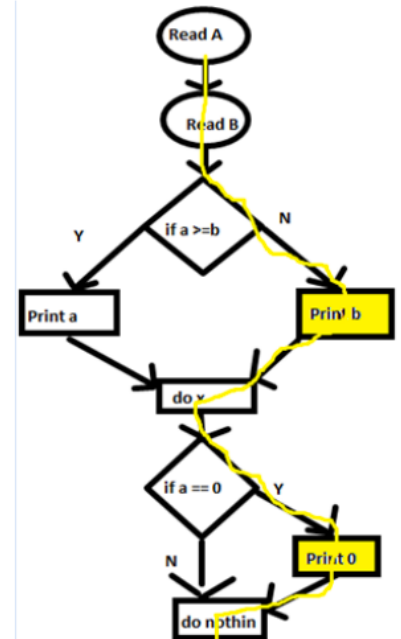
In component testing: **Statement coverage** is the percentage of executable statements that have been exercised by a test case suite.



### Decision testing & coverage

**Decision coverage** - is the assessment of the percentage of decision outcomes (e.g. the True and False options of an IF statement) that have been exercised by a test case suite.

Decision coverage is stronger than statement coverage: 100% decision coverage guarantees 100% statement coverage, but not vice versa.



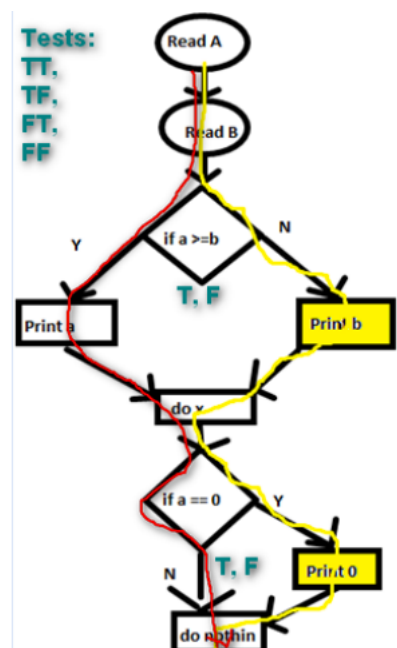
### Other structure-base techniques

There are stronger levels of structural coverage beyond decision coverage, i.e.:

- multiple condition coverage.

The concept of coverage can also be applied at other test levels, (i.e. integration level) where the percentage of

- modules, components or classes that have been exercised by a test case suite could be expressed as
- module, component or class coverage.



## Experienced-based testing

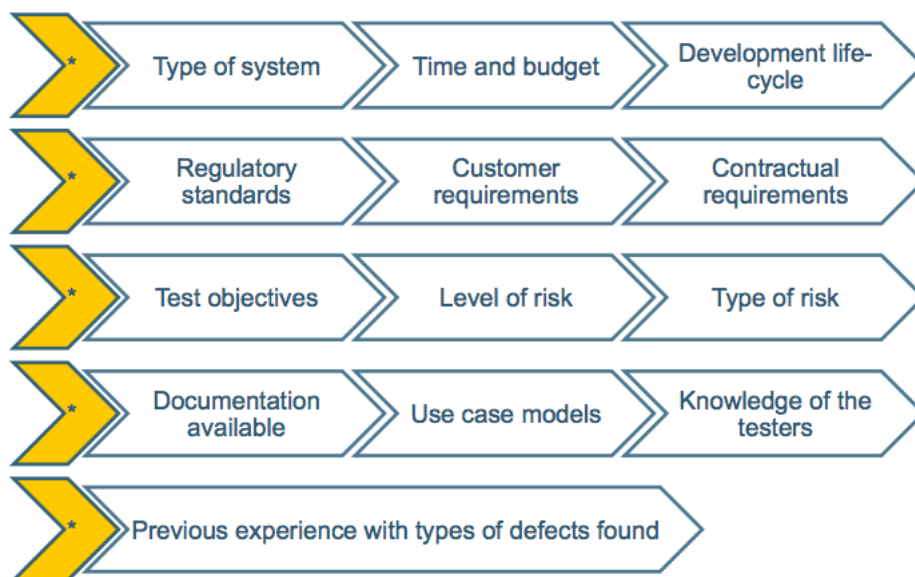
- Tests are derived from the tester's skill and intuition and their experience with similar applications and technologies.
- Especially applied after more formal approaches

1. *Error guessing* = a commonly used experienced-based technique.
  - Generally testers anticipate defects based on experience.
  - A structured approach to the error guessing technique is to enumerate a list of possible errors and to design tests that attack these errors.
  - This systematic approach is called fault attack.
2. *Exploratory testing* = **concurrent test design, test execution, test logging and learning**, based on a test charter containing test objectives, and carried out within time-boxes.

### It is most useful:

- where there are few or inadequate specifications
- under severe time pressure,
- to complement other, more formal testing. It can serve to help ensure that the most serious defects are found.

The choice of which test techniques to use depends on a number of factors, including:



## Week 5 – Test Management

### **Test organization**

#### *Test organization and independence*

- The effectiveness of finding defects by testing and reviews can be improved by using independent testers.
- Options for independence are:

\*Independent testers outsourced or external to the organization. (Highest level of independence, but not so used in practice)



1. No independent testers. Developers test their own code.
2. Independent testers within the development teams.
3. Independent test team or group within the organization, reporting to project management or executive management.
4. Independent testers from the business organization or user community.
5. Independent test specialists for specific test targets such as usability testers, security testers or certification testers (who certify a software product against standards and regulations).

## Test organization and independence

- For large, complex or safety critical projects, it is usually best to have multiple levels of testing, with some or all of the levels done by independent testers.
- Development staff can participate in testing, especially at the lower levels

### Advantages:

- Independent testers see other and different defects, and are unbiased.
- An independent tester can verify assumptions people made during specification and implementation of the system.

### disadvantages:

- Isolation from the development team (if treated as totally independent).
- Independent testers may be the bottleneck as the last checkpoint.
- Developers may lose a sense of responsibility for quality.

**Note:** Testing tasks may be done by people in a specific testing role, or may be done by someone in another role, as: project manager, quality manager, developer, business and domain expert, infrastructure or IT operations etc.

## Tasks of the test leader

Test leader = test manager/coordinator

The test leader **plans, monitors** and **controls** the *testing activities and tasks*

### Tasks of the test leader

Coordination	of the test strategy and plan with project managers
Plan the tests	Understanding the test objectives and risks – including: <ul style="list-style-type: none"><li>• selecting test approaches</li><li>• estimating the time, effort and cost of testing</li><li>• acquiring resources</li><li>• defining test levels, cycles</li><li>• planning incident management.</li></ul>
Test specs, preparation and execution	Initiate the specification, preparation, implementation and execution of tests; also: <ul style="list-style-type: none"><li>• monitor the test results</li><li>• check the exit criteria.</li></ul>
Adapt planning	based on test results and progress and take any action to compensate for problems.
Manage test configuration	Set up adequate configuration management of testware for traceability.
Introduce metrics	for measuring test progress and evaluating the quality of the testing & the product.
Automation of tests	Decide what should be automated, to what degree, and how.
Select test tools	Select tools to support testing and organize trainings for tool users.
Test environment	Decide about the implementation of the test environment.
Test summary reports	Write test summary reports based on the information gathered during testing.





## Tasks of the tester

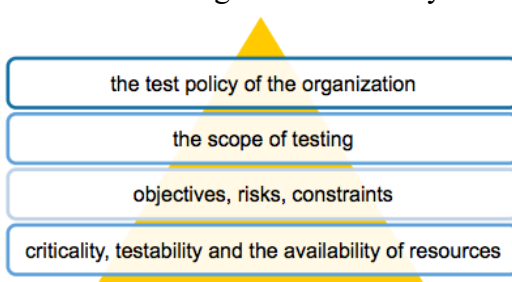
Test plans	Review and contribute to test plans
Requirements and specs	Analyze, review and assess user requirements, specifications and models for testability.
Test specifications	Create test specifications.
Test environment	Set up the test environment (often coordinating with system administration and network management).
Test data	Prepare and acquire test data.
Testing process	Implement tests on all test levels, execute and log the tests, evaluate the results and document the deviations from expected results.
Test tools	Use test administration or management tools and test monitoring tools as required.
Test automation	Automate tests (may be supported by a developer or a test automation expert).
Other metrics	Measure performance of components and systems (if applicable).
Help the others	Review tests developed by others

## Test planning and estimation

### Test planning

- Test planning is a **continuous activity** and is performed in **all life cycle** processes and activities
- Feedback from test activities is used to recognize changing risks so that planning can be adjusted.
- Planning may be documented in:
  - o a project or **master test plan**
  - o and in **separate test plans for test levels**, such as system testing and acceptance testing.

Planning is influenced by:



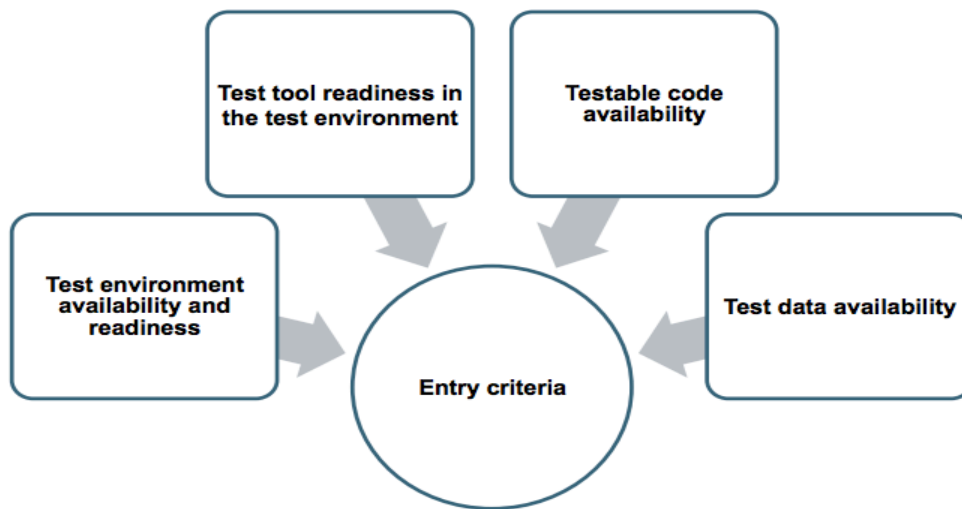
### Test planning activities

Scope and risk	Determining the scope and risks of testing
Objectives	Identifying the objectives of testing.
Overall approach	Defining the overall approach of testing, including: <ul style="list-style-type: none"> <li>• the definition of the test levels</li> <li>• entry and exit criteria.</li> </ul>
Test activities	Integrating and coordinating the testing activities into the software life cycle activities: <ul style="list-style-type: none"> <li>• acquisition,</li> <li>• supply,</li> <li>• development,</li> <li>• operation and</li> <li>• maintenance.</li> </ul>
Strategy	Making decisions about: <ul style="list-style-type: none"> <li>• what to test</li> <li>• what roles will perform the test activities</li> <li>• how the test activities should be done</li> <li>• and how the test results will be evaluated.</li> </ul>
Schedule	Scheduling test analysis and design activities. Scheduling test implementation, execution and evaluation.
Resources	Assigning resources for the different activities defined..
Metrics	Selecting metrics for monitoring and controlling test preparation and execution, defect resolution and risk issues.



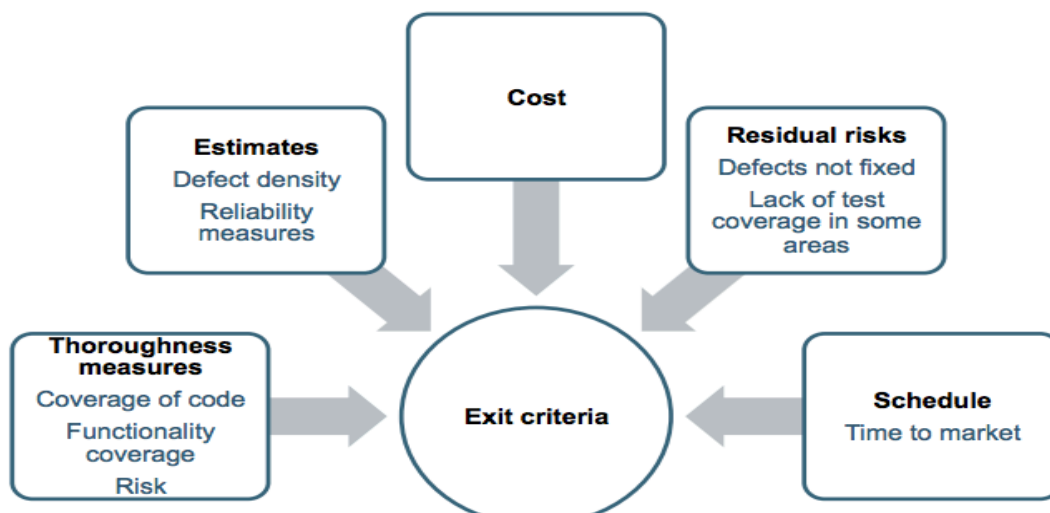
## Entry criteria

Entry criteria defines when to start testing, typically entry criteria consists of:



## Exit criteria

The purpose of exit criteria is to define *when to stop testing*, such as at the end of a test level or when a set of tests has a specific goal. Example:



## Test estimation

Two approaches for the estimation of test effort:

### The metrics-based approach

Estimating the testing effort based on metrics of former or similar projects or based on typical values

### The expert-based approach

Estimating the tasks by the owner of these tasks or by experts

Once the test effort is estimated, resources can be identified and a schedule can be drawn up.

The testing effort may depend on a number of factors, like:

Characteristics of the product	<ul style="list-style-type: none"><li>the quality of the specification</li><li>the size of the product</li><li>the complexity of the problem domain</li><li>the requirements for reliability and security</li></ul>
Characteristics of the development process	<ul style="list-style-type: none"><li>skills of the people involved</li><li>and time pressure</li></ul>
The outcome of testing	<ul style="list-style-type: none"><li>the number of defects</li><li>the amount of rework required</li></ul>

## Test approaches (test strategies)

### *Preventative approaches*

Tests are designed as early as possible

### *Reactive approaches*

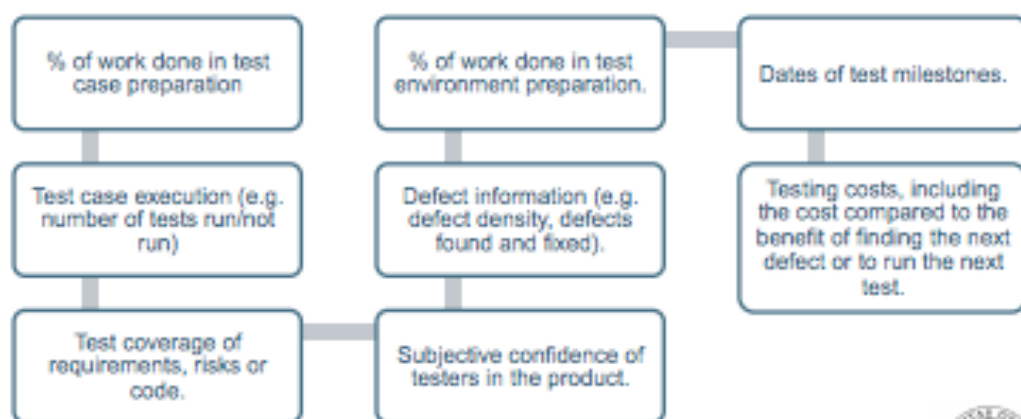
Test design comes after the software or system has been produced

Typical approaches or strategies include:

<b>Analytical appr.</b>	risk-based testing - testing is directed to areas of greatest risk.
<b>Model-based appr.</b>	stochastic testing using statistical information about failure rates (such as reliability growth models)
<b>Methodical appr.</b>	failure-based (including error guessing and fault-attacks), experienced-based, check-list based, and quality characteristic based.
<b>Process- or standard-compliant appr.</b>	specified by industry-specific standards or the various agile methodologies.
<b>Dynamic and heuristic appr.</b>	exploratory testing, execution & evaluation are concurrent tasks.
<b>Consultative appr.</b>	test coverage is evaluated by domain experts outside the test team.
<b>Regression-averse appr.</b>	include reuse of existing test material, extensive automation of functional regression tests.

## Test progress monitoring

- The purpose of test monitoring is to give feedback and visibility about test activities
- Information to be monitored may be collected manually or automatically and may be used to measure exit criteria, such as coverage.
- Metrics may also be used to assess progress against the planned schedule and budget.
- Common test metrics include:



**Test reporting** is concerned with summarizing information about the testing endeavor, including:

- What happened during a test period of testing (ex: dates when exit criteria were met)

- Analyzed metrics to support decisions about future actions (ex: the economic benefit of continued testing)

Metrics are collected at the end of a test level in order to assess:

- The adequacy of the **test objectives** for that test level.
- The adequacy of the **test approaches** taken
- The **effectiveness of the testing** with respect to its objectives.

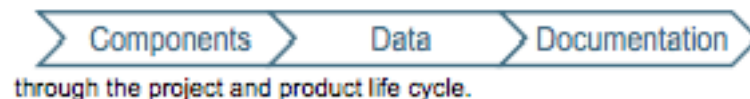
**Test control** describes any guiding or corrective actions taken as a result of information and metrics gathered and reported.

Examples:

- Making decisions based on information from test monitoring
- Re-prioritize tests when an identified risk occurs (eg. software delivered late)
- Change the test schedule due to availability of a test environment
- Set an entry criterion requiring fixes to have been retested (confirmation tested) by a developer before accepting them into a build

### Configuration management

The purpose of configuration management is to establish and maintain the integrity of the products of the software.



For testing, configuration management may involve ensuring that:

- All items of testware are
  - o Identified
  - o Version controlled
  - o Tracked for changes

So that traceability can be maintained throughout the test process

- All identified documents and software items are **referenced unambiguously in test documentation**

For the tester, configuration management helps to uniquely identify (and to reproduce)



### Risk and testing

Risk = (def.) the chance of an event, hazard, threat or situation occurring and its undesirable consequences, a potential problem. Level of risk is determined by: **The likelihood** of an adverse event happening and **The impact**, the harm resulting from that event.

### Project risks

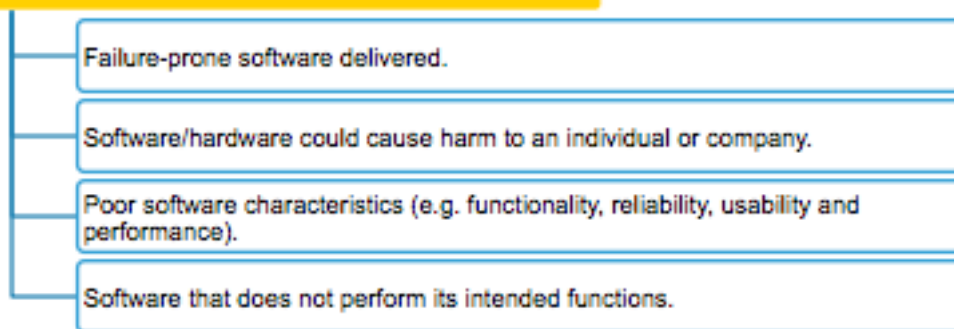
When **analyzing, managing and mitigating** these *risk*, the test manager is following well established project management principles.

**Project risks** = the risks that surround the project's capability to deliver its objectives, such as:

Organizational factors:	Technical issues:	Supplier issues:
<ul style="list-style-type: none"><li>• skill and staff shortages</li><li>• personal and training issues</li><li>• political issues (i.e. problems with testers communicating their needs and test results)</li><li>• improper attitude toward testing (i.e. not appreciating the value of finding defects during testing).</li></ul>	<ul style="list-style-type: none"><li>• problems in defining the right requirements</li><li>• the extent that requirements can be met given existing constraints</li><li>• the quality of the design, code and tests.</li></ul>	<ul style="list-style-type: none"><li>• failure of a third party</li><li>• contractual issues.</li></ul>

**Product risks**, potential failure areas in the software.

They are a risk to the quality of the product, i.e:



Risks are used to decide where to start testing and where to test more;

Testing is used to:

- reduce the risk of an adverse effect occurring,
- reduce the impact of an adverse effect.

In a risk-based approach the risks identified may be used to:

- Determine the test techniques to be employed.
- Determine the extent of testing to be carried out.
- Prioritize testing in an attempt to find the critical defects as early as possible.
- Determine whether any non-testing activities could be employed to reduce risk (e.g. providing training to inexperienced designers).

## Incident management

**Incident** = (Def.) discrepancies between actual and expected test outcomes.

When to raise incidents: during development, review, testing or use of a software product.

Statuses of incident reports:

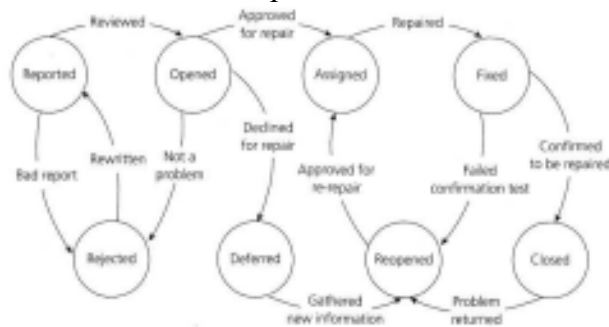
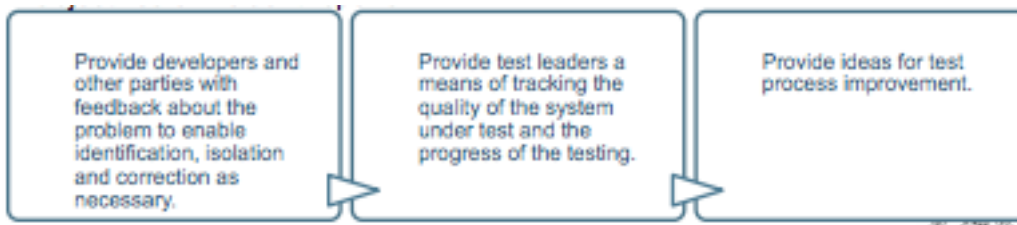


FIGURE 5.3 Incident report life cycle

Objectives of incident reports:



## Week 6 – Tool support for testing

### Types of test tools

Test tools can be used for one or more activities that support testing, like:

- Tools that are directly used in testing (*example*: testing execution tools, test data generation tools, result comparison tools)
- Tools that help in managing the testing process (*example*: test results, requirements, incidents, defects) and for monitoring and reporting the test execution.
- Tools that are used in exploration (*example*: tools that monitor the file activity for an application)
- Any tool that aids in testing

### Purpose

Tools support for testing can have one or more of the following purposes, depending on the context:

- Improve the efficiency of the test activities (*example*: by automating repetitive tasks)
- Automate activities that require significant resources when done manually (*example*: static testing)
- automate activities that cannot be done manually (*example* large-scale performance testing of client-server applications)
- increase reliability of testing (by automating large data comparisons or simulating complex behavior)

## Test tool classification

Tools are classified in this course according to the testing activities that they support:

- One activity
- More than one activity, but classification falls under main activity

### *Note:*

1. Some types of test tool can be intrusive - the tool itself can affect the outcome of the test. (i.e. timing measurements may be different depending on how you measure it with different performance tools). The consequence of intrusive tools is called the probe effect.
2. Some tools offer support more appropriate for developers. Such tools are marked with "(D)" in this chapter

## *Tools support for management of testing & tests*

### Characteristics:

- Support for the management of tests and the testing activities.
- Interfaces to:
  - Test execution tools
  - Defect tracking tools
  - Requirement management tools.
- Support for traceability of tests, test results and incidents to source documents, such as requirements specifications.
- Generation of progress reports
- Logging test results.
- Offer info on metrics related to the tests.

### Requirements management tools

- Store requirements
- Check for consistency and undefined (missing) requirements
- allow prioritization
- enable individual tests to be traceable to requirements

### Incident management tools

- Store and manage incident reports
- Support management of incidents reports

### Configuration management tools

- are necessary to keep track of different versions and builds of the SW and tests
- are particularly useful when developing on more than one configuration of the HW/SW environment

## *Tools support for static testing*

### Review tools

- store information about review processes
- store and communicate review comments, report on defects and effort
- They can provide aid for online reviews, which is useful if the team is geographically dispersed.

### **Static analysis tools (D)**

- Major purpose:
  - o The enforcement of coding standards.
  - o The analysis of structures and dependencies (e.g. linked webpages)
  - o Aiding in understanding the code.
- support developers, testers and quality assurers in finding defects before dynamic testing.
- Static analysis tools can calculate metrics from the code (e.g. complexity), which can give valuable information for planning or risk analysis.

### **Modeling tools (D)**

- Validate models of the software.

*The major benefit of static analysis tools and modeling tools is the cost effectiveness of finding more defects at an earlier time in the development process. As a result, the development process may accelerate and improve by having less rework*

### *Tools support for test specification*

#### **Test design tools**

- Generate test inputs or executable tests:
  - o from requirements,
  - o from a graphical user interface,
  - o from design models (state, data or object)
  - o or from code.
- This type of tool may generate expected outcomes as well (i.e. may use a test oracle)
- They can save valuable time and provide increased thoroughness of testing because of the completeness of the tests that the tool can generate.

#### **Test data preparation tools**

- Manipulate databases or files to set up test data to be used during the execution of tests
- *Benefit:* they ensure that live data in a test environment is made anonymous, for data protection.

### *Tools support for test execution & logging*

#### **Test execution tools**

- Enable tests to be executed automatically using stored inputs & expected outcomes
- The scripting language allows to manipulate the tests with little effort(i.e. repeat the test with other data)
- Can also be used to record tests(capture & playback tools)

#### **Test harness / unit test framework tools (D)**

- Facilitate the test of components of a system - simulating the environment in which that test object will run.
- They may be called unit test tools when they have a particular focus on the component test level.

### Test comparators

- Determine differences between files, databases or test results
- Test execution tools include dynamic comparators, but post-execution comparison may be done by a separate comparison tool.
- A test comparator may use a test oracle, especially if it is automated.

### Coverage measurement tools (D)

- Can be intrusive or non intrusive (depends on the measurement technique used)
- Measure the percentage of specific types of code structure that have been exercised

### Security tools

- Search for specific vulnerabilities of the system

### *Tools support for performance & monitoring*

#### Dynamic analysis tools (D)

- Find defects that appear only when software is executing (i.e. memory leaks)
- They are typically used in component and component integration testing

#### Performance testing/ load testing/ stress testing tools

- Monitor and report on how a system behaves under a variety of simulated usage conditions.
- They simulate a load on:
  - o an **application**, a **database**, or a **system environment**.
- They are often based on automated repetitive execution of tests, controlled by parameters.

#### Monitoring tools

- Are not strictly testing tools but provide information that can be used for testing purposes.
- Analyze, verify and report on usage of specific system resources, and give warnings of possible service problems.

### Tools support for specific application areas

There are tools specialized for use in a particular type of application.

#### Example:

performance testing tools specifically for web-based applications

dynamic analysis tools specifically for testing security aspects.

Example of targeted areas: embedded systems.



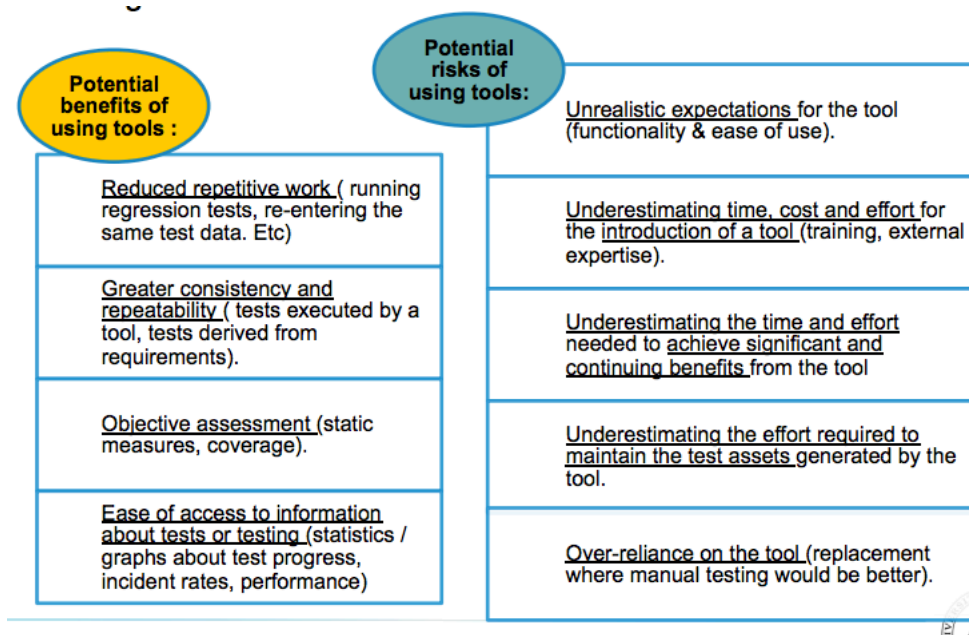
## Tools support using other tools

- This is not a complete list of tools of this category.
- Testers may use:
  - o word processor
  - o spreadsheetsas a testing tool, but they are often used to store:
  - o test designs
  - o test scripts
  - o test data
- Testers may use SQL to set up and query databases containing test data.
- Tools used by developers when **debugging**, to help localize defects and check their fixes, are also testing tools.
- It is a good idea to look at any type of tool available to you for ways it could be used to help support any of the testing activities.

## Effective use of test tools

### Potential benefits and risks

- Simply purchasing or leasing a tool does not guarantee success with that tool.
- Each type of tool may require additional effort to achieve real and lasting benefits.



## Special considerations

### 1. Test execution tools

- This type of tool often requires significant effort in order to achieve significant benefits.
- Capturing tests by recording the actions of a manual tester seems attractive, but this approach does not scale to large numbers of automated tests. This type of script may be unstable when unexpected events occur.
- Data-driven approach: separates out the test inputs (the data) and uses a more generic script that can read the test data and perform the same test with different data.
- In a keyword-driven approach: the spreadsheet contains keywords with the actions to be taken (also called action words), and test data. Testers can then define tests using the keywords.

## 2. *Performance testing tools*

- These tools need tester with expertise in performance testing to design the tests and interpret results.

## 3. *Static analysis tools*

- These tools applied to source code can enforce coding standards, but if applied to existing code may generate a lot of messages
- A gradual implementation with initial filters to exclude some messages would be an effective approach.

## 4. *Test management tools*

- They need to interface with other tools or spreadsheets in order to produce information in the best format for the current needs of the organization.
- The reports need to be designed and monitored so that they provide benefit.

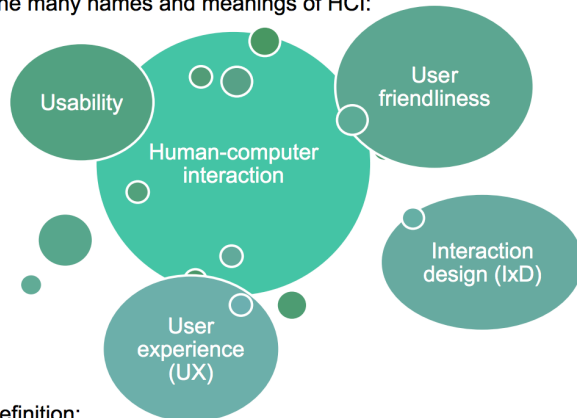
### **Introducing a tool into an organization**

- The **main considerations** in selecting a tool for an organization include:
  - Assess the organizational maturity, strengths and weaknesses
  - Evaluate against clear requirements and objective criteria.
  - A proof-of-concept to test the required functionality and determine whether the product meets its objectives.
  - Evaluation of the vendor (including training, support and commercial aspects).
  - Identification of internal requirements for coaching and mentoring in the use of the tool.
- Introducing the selected tool into an organization starts with a **pilot project, with the following objectives**:
  - Learn more detail about the tool.
  - Evaluate how the tool fits with existing processes and practices, and determine what would need to change.
  - Decide on standard ways of using and maintaining the tool and the test
  - Assess whether the benefits will be achieved at reasonable cost.
- **Success factors** for the deployment of the tool within an organization include:
  - Roll out the tool to the rest of the organization incrementally.
  - Adapt and improve processes to fit with the use of the tool.
  - Provide training and coaching/mentoring for new users.
  - Define usage guidelines.
  - Implement a way to learn lessons from tool use.
  - Monitor the tool use and benefits.

## Week 7 - Usability Testing

### **HCI – definition and purpose**

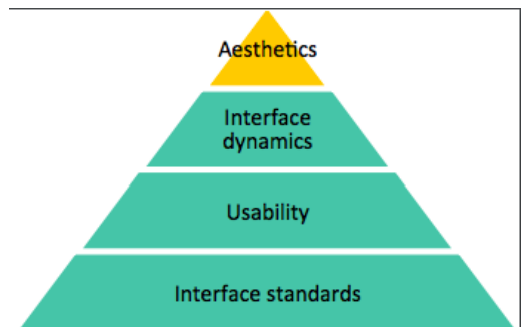
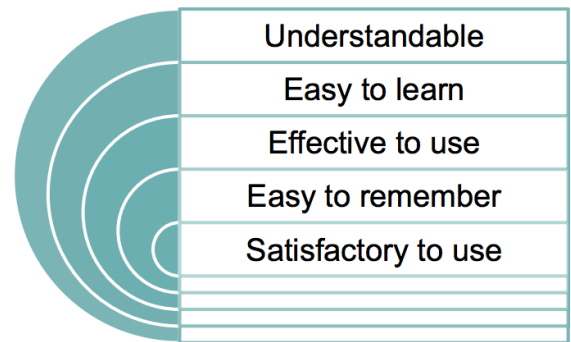
The many names and meanings of HCI:



Definition:

"The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." (ISO 9241-11)

The purpose of HCI testing is to make a software system:



### **HCI framework**

#### **Interface standards**

Interface standards are constituted by:

- Best practices
- Consistent behavior and design
- Decrease work load
- Faster development

These standards have to be followed for both user interfaces and also APIs.

#### **Usability**

Usability means:

- Effectiveness
- Efficiency
- Satisfaction

Note: The key is to understand the target users and their needs and create a user-centric design.

#### **Interface dynamics**

An interface (whether visual or API) has to be designed in such way that it is:

- Responsive and fast
- Adaptable to the users needs and context
- Empowering for the user
- Captivating
- Dynamic

#### **Aesthetics**

- Responsible for the first impression
- Modern, fresh, appealing design
- Recognition of a company's applications
- A company's graphical profile

## User-centric design process

### Synopsis:

When designing a user-centric software system, one has to:

- Understand how the users think and behave
- Gather fact and data instead of rely on opinion or speculation
- Perform studies, design and test on users before implementation
- Iterate!

There are many different methods available to help in the process.

- Understand user context
  - Interview
  - Survey
  - **User observation**
  - Competitive analysis
  - Expert evaluation
  - Domain knowledge / experience
  - Support statistics
- Specify demands
  - **Personas**
  - User scenarios and cases
  - Prioritized list of requirements
- Develop concept
  - Card sorting
  - Mind map
  - **Low-fidelity prototyping**
  - High-fidelity prototyping
- Evaluate concept
  - **User tests**
  - Expert evaluation
  - Comparative tests

### User observation - understand user context

Most important step in the process:

- Who are the users?
- In what environment/situation do they use the product?
- What goals shall the product help the user to achieve?
- What demands must the application fulfil to satisfy the user?

### Purpose of user observation

- It studies user behavior
- Identifies 60-80% of usability problems with 3-5 users
- Note: Just observe what are they doing – do not tell them what to do

### How to perform user observation

It's hard to convince the users to participate in an observation. Therefore, the user needs to feel safe, not criticized.

### **Prior to the observation:**

- Contact the user
  - Ex: email, phone. Express the intent of the observation, what would be the user's role, what would be your role
- Send out background questions about the user
  - Ex: what are your daily tasks? Which of your tasks do you perform in the ?
  - How often do you use the ?
  - How long have you used the ?
  - Do you have background education on how to use the software?
- Prepare observation guide, focus areas
  - Login
  - Do you find everything you are looking for in the ?
  - Ask the user to find a specific item
  - Ask the user to add / remove a specific item
  - Design a workflow that you would like the user to go through (searches, filters, approvals, rollbacks)

### **How to perform user observation**

#### **During the observation:**

- Visit user's workplace
- Use think-aloud techniques (ask the user to describe what he is trying to do)
- Document with notes and video recorders

### **User observation tools**

*Silverback(Mac)*

*Techsmith Morae(Windows)*

- Recorder
  - Displays tasks in screen
  - Records screen interaction
  - Records user video and audio
  - Mouse clicks
- Observer
  - Connect observers
  - Possibility to make notes
  - Chat between observers
- Manager: Analysis
- Gathers recorder and observer data.
- Measures time, mouse clicks per task

### **User observation tips**

- Start looking for users quite long in advance.
- Be realistic about how many observations you have time for.
- Give the user time to perform the task. Do not interrupt or show them how to do something.
- Make it a positive experience for the user: you are not testing users, you are just discovering problems in the software, with the users help.
- Collect general impressions at the end.
- Start looking for users quite long in advance.
- Be realistic about how many observations you have time for.
- Give the user time to perform the task. Do not interrupt or show them how to do something.

- Make it a positive experience for the user: you are not testing users, you are just discovering problems in the software, with the users help.
- Collect general impressions at the end.

Specify demands

Most important steps of this process:

- Document the problems
- Summarize, analyze and compare the results
- Create a basis for the conceptualizing step

## Specify demands - personas

Personas:

- Are a design and specification tool.
- A description of a representative user (a pretended person who represents our user).
- Tell us who are the users, their goals, activities, motivations to use our products.
- Helps us define how can we make their work routines more effectively.

Personas =

- Informed based on research
- Check and validate your assumptions.

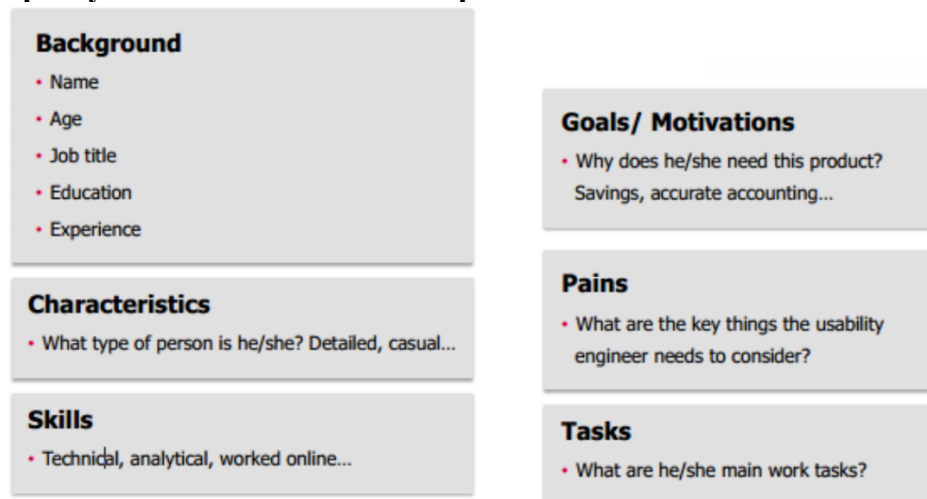
User profiles = What we believe is true about our users

## Specify demands – how to identify personas

Find patterns and identify personas, based on:

- statistics
- workshops, interviews and user studies
- surveys

## Specify demands – how to create personas



## Specify demands – how to use the personas

- Make them visible throughout the development and marketing teams.
- Ask stakeholders to communicate the user's needs through personas.
- Refer to the personas when creating and testing requirements, specifications and stating assumptions. (How would Hanna use it?)
- When creating a new functionality, test if it's in line with the persona's needs.

### **Develop concept – Low-fidelity prototyping – why?**

Low-fi prototyping is:

- Fast (quick progress on requirements specification and testing)
- Easy (anyone can do this) • Cheap (it takes a pen and a paper)
- Sketchy
- Relevant Note: Low-fidelity prototypes are also called wireframes or mock-ups

### **Develop concept – Low-fidelity prototyping –how to apply it**

- Always start on paper
  - paper prototyping
- Focus on structure and function, no details
- Do not apply any design
- Create multiple concepts
- Evaluate (to get feedback), refine and narrow down

**Note:** it's not supposed to be pretty!

### **Develop concept – Low-fidelity prototyping – tools**

Examples are: Photoshop, PowerPoint, Visio, Balsamiq

**Note:** use the tool you are comfortable with

### **Evaluate concept**

- Evaluate against demands
- Find areas of improvement
- Iterate!

### **Evaluate concept – user testing**

The user testing is the evaluation of a product by the users. You will present the product to real users with interactive prototypes. The goal is to discover errors and areas of improvement.

### **Evaluate concept – types of user testing**

Face to face, Remote, Test labs

Evaluate concept – prepare for user testing

- Decide what will you use in the testing:
  - Paper prototypes
  - Software prototype
  - A beta version of software
- Set goals for the user testing: what do I want users to accomplish? (learn, remember the software, discover new features etc).
- Plan the test tasks based on real problems to be solved or workflows to be followed.
- Select a user group to test at a time.
- Choose between alfa-testing or beta-testing (at your company's site or at user's site).

**Note:** it's a good idea that 1 person leads the test and 1 person documents the users' answers.

### **Evaluate concept – conduct the user test**

- Welcome and introduce user to the test
- Provide one task at the time

- Use think-aloud technique
- Document with notes and record the screen
- Do not help the user during the test
  - Ex: Q: “Can I do it like this?”  
A:”You can do all you want. Try to find out.”

## HCI guidelines

### Purpose of guidelines

- Gathered interface standards - Windows, OS X and web guidelines such as W3C
- They give the developers and testers a set of best practices, which in their turn provide:
- Consistent behavior and design of software
  - Decrease people’s work load
  - Faster development cycles

### Guidelines - Usability elements





The following are the basic usability elements that the guidelines refer to. The tester has to compare the following elements against the specifications of the provided guidelines:

- Workflows
- Navigation
- Search and filter
- Grids
- Flow on page (top-left to bottom right, in the western cultures)
- Placement of important buttons, like Save and Cancel (Windows / OX standard)
- Tab order(has to follow the reading order; columns over rows; within each group box)
- Alignment
- Grouping (level of boxes, use and overuse)
- Active / inactive elements (the inactive elements must always be disabled)
- Destructive actions (never put Save and Delete next to each others; have confirmation for destructive actions)
- Placement of checkboxes and radio buttons (Win / OX standard)

### System messages

System messages, the way they behave and the way they must be designed and used are the second category included in the HCI guidelines.

Error and warning messages must explain the (potential) problem and provide a solution

- Never use error codes, jargon or technical terms
  - speak the users language
- Never use capital letters or exclamation mark
  - you scream at the user
- Choosing the right type of message:
  -  – Error: alerts the user of a problem that has occurred
  -  – Warning: to make the user aware of a potential problem
  -  – Information – inform the user – Question
  -  – requesting a response from the user

**Note:** - Keep the message short, people do not read!

- Use the right action buttons:
  - Errors and warnings are never OK, use Close
  - To have Yes, No and Cancel for a question is confusing



## **Week 8 – Accessibility Testing**

### *The context of accessibility*

#### **Definition of accessibility**

**Disability:** The outcome of the interaction between a person and the environmental and attitudinal barriers they may face. (*World Health Organization, International Classification of Functioning (ICF)*)

**Usability:** The effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment (ISO 9241-11)

**Accessibility:** The usability of a product, service environment or facility by the people with the widest range of capabilities. (ISO 9241-20) (Accessibility is the degree to which a product, device, service or environment is available to as many people as possible.)

#### **Barriers**

What problems will stop someone from being able to use a software product?

Barrier priority	What it covers
Critical	Barriers that stop someone from using a software product or some of its features successfully
Serious	Problems that cause frustration, slow someone down or require work-arounds
Annoying (moderate)	Things that are frustrating, but won't stop someone from using the site
Noisy (minor)	Minor issues that might cause someone a problem, but which mainly damage credibility

#### **Why is accessibility not considered more in the UX work**

- Because it might be *invisible*, *hidden* or *misunderstood*

#### **International accessibility legislation**

([http://ec.europa.eu/justice/discrimination/disabilities/disabilitystrategy/index\\_en.htm](http://ec.europa.eu/justice/discrimination/disabilities/disabilitystrategy/index_en.htm))

**EU:** The European Union which has signed the United Nations' Convention on the Rights of Persons with Disabilities, also has adopted a European Disability Strategy for 2010-20. The Strategy includes the following goals, among others:

- Ensuring the European Platform Against Poverty includes a special focus on people with disabilities.
- Working towards the recognition of disability cards throughout the EU to ensure equal treatment when working, living or travelling in the bloc
- Developing accessibility standards for voting premises and campaign material
- Taking the rights of people with disabilities into account in external development programs and for EU candidate countries.

The purpose is to offer equal access to social, political, and economic life which includes not only physical access but access to the same tools, services, organizations and facilities for which everyone pays (e.g., museums).

### *Accessibility personas*

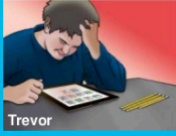
#### **The role of personas in the accessibility study**

The personas can help address big challenges in approaching the usability issues:


- Give a realistic view of the people we design for.

- Helping taking different users into account (will tell a story we can relate to)
- Help organizing increasing amounts of data; will document our assumptions
- Build consensus around a clear, consistent view on accessibility needs to be solved


### (1) Autism spectrum disorder

 <p><b>Trevor, 18</b> "I like consistent, familiar places on the web"</p> <ul style="list-style-type: none"> <li>- Lives with family</li> <li>- Goes to secondary school</li> <li>- Computers at school; laptop at home, basic mobile phone with SMS</li> </ul>	
<b>Characteristic</b>	Uses larger text and a program who hides everything but the text, so he doesn't get distracted
<b>Aptitude</b>	Uses the computer well for games, but doesn't learn new sites easily
<b>Attitude</b>	Prefers familiar sites in an established routine
<b>Assistive technology</b>	Text preference settings, power keyboard user


### (2) Cerebral palsy

 <p><b>Emily, 24</b> "I want to do everything for myself"</p> <ul style="list-style-type: none"> <li>- High school graduate, working on a college degree</li> <li>- Lives independently in a small apartment</li> <li>- Works part-time at a local community center</li> </ul>	
<b>Characteristic</b>	Difficult to use hands and has some difficulty speaking clearly; uses a motorized wheel chair
<b>Aptitude</b>	Uses the computer well, with the right input device, good at finding efficient search terms
<b>Attitude</b>	Wants to do everything for herself; can be impatient
<b>Assistive technology</b>	Communicator with speech generator, iPad, power wheelchair


### (3) Blindness with some light perception

 <p><b>Jacob, 32</b> "The right technology lets me do anything"</p> <ul style="list-style-type: none"> <li>- College graduate, legal training courses</li> <li>- Paralegal, reviews and writes cases</li> <li>- Shares apartment with a friend</li> <li>- Laptop, braille display, smartphone</li> </ul>	
<b>Characteristic</b>	Blind since birth with some light perception
<b>Aptitude</b>	Skilled technology user
<b>Attitude</b>	Digital native, early adopter, persists until he gets it
<b>Assistive technology</b>	Screen reader, audio note-taker, Braille display


### (4) Fibromyalgia (fatigue)

 <p><b>Lea, 35</b> "No one gets that this really is a disability"</p> <ul style="list-style-type: none"> <li>- Masters degree</li> <li>- Writes for a trade publication</li> <li>- Works from home</li> <li>- Computer, tablet</li> </ul>	
<b>Characteristic</b>	Fatigue, more pronounced when using trackballs and keyboards
<b>Aptitude</b>	Average user
<b>Attitude</b>	Wishes people would understand how hard it can be for her to make it through the day
<b>Assistive technology</b>	Split keyboard, speech recognition software

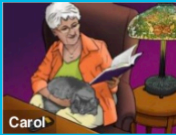
### (5) Deaf-mute

 <p><b>Steven, 38</b> "My only disability is that not everyone can sign"</p> <ul style="list-style-type: none"> <li>- Art school</li> <li>- Graphic designer in a small ad agency</li> <li>- Computers, laptops, tablets, smartphones</li> </ul>	
<b>Characteristic</b>	Native in ASL (American sign language)
<b>Aptitude</b>	Good with graphic tools
<b>Attitude</b>	Can be annoyed about accessibility, like lack of captions
<b>Assistive technology</b>	Sign language, CART (communication access real-time translation), captions, video-chat


### (6) Visual impairment

 <p><b>Vishnu, 48</b> "I want to be on the same level as everyone else"</p> <ul style="list-style-type: none"> <li>- Born in India, finished school in Malaysia, lives in Singapore</li> <li>- Engineering degree, speaks 3 languages</li> <li>- Works for a medical software company on international projects</li> <li>- High-tech dedicated devices at work, two mobile phones and a laptop</li> </ul>	
<b>Characteristic</b>	Uses contrast adjustment to see the screen clearly
<b>Aptitude</b>	Expert user of technical tools
<b>Attitude</b>	Sees himself as a world citizen and wants to be able to use any site
<b>Assistive technology</b>	Contrast adjustment, screen magnification, personalized style sheets

## (7) ARMD (age-related macular degeneration)

 <div>Carol, 74 "My grandkids are dragging me in the world of technology"</div> <ul style="list-style-type: none"><li>- Retired, worked as a bookkeeper</li><li>- Lives alone in an apartment</li><li>- Older computer at home, basic mobile phone</li></ul>	
<b>Characteristic</b>	Cannot see so well Hearing aid Doesn't have any special AT on the computer
<b>Aptitude</b>	Used computers when she worked as a bookkeeper, but now her grandkids keep her old home-computer updated
<b>Attitude</b>	Willing to learn
<b>Assistive technology</b>	Enlarges text

## (8) Non-English speaker

 <div>Maria, 49 "I love the internet. It's all here... when I can find it"</div> <ul style="list-style-type: none"><li>- High-school graduate</li><li>- Married, grown children</li><li>- Community health worker</li><li>- Smartphone from her work, home computer – mainly used for her husband's work</li></ul>	
<b>Characteristic</b>	Needs to use sites in Spanish (when she can find them) Needs computer instructions written clearly
<b>Aptitude</b>	Curious but not very proficient Husband and daughter set-up bookmarks for her.
<b>Attitude</b>	Thinks it's nice to be able to have her favorite websites with her at all times
<b>Assistive technology</b>	Skype, online translation sites

### Accessible design

Has to comply with the following:

1. **People first:** design for differences
2. **Solid structure:** built to standards
3. **Easy interaction:** everything works
4. **Helpful way-finding:** guide the users
5. **Clear presentation:** supports meaning
6. **Plain language:** easy to understand
7. **Accessible media:** supports all senses

### Web-content accessibility guidelines

#### Introduction

Web Content Accessibility Guidelines (WCAG) 2.0 covers a wide range of recommendations for making Web content more accessible. <http://www.w3.org/TR/WCAG20/>

- **Principles** – At the top are four principles that provide the foundation for web accessibility: *perceivable, operable, understandable* and *robust*.
- **Guidelines** – Under the principles are guidelines. The 12 guidelines provide the basic goals to make content more accessible to users with different disabilities.
- The guidelines are not testable, but provide the framework and overall objectives to help understand the success criteria and better implement the techniques.
- **Success Criteria** – For each guideline, testable success criteria are provided to allow WCAG 2.0 to be used.
- **Sufficient and Advisory Techniques** – For each of the guidelines and success criteria there is a list of test techniques. The techniques are informative and fall into two categories: those that are sufficient for meeting the success criteria and those that are advisory.

#### Principle 1 – Perceivable

- **Perceivable** – *Information and user interface components must be presentable to users in ways they can perceive it.*

#### Guidelines:

- **Text Alternatives:** Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language.

- Time-based Media: Provide alternatives for time-based media
- Adaptable: Create content that can be presented in different ways (example: simpler layout) without losing information or structure.
- Distinguishable: Make it easier for users to see and hear content including separating foreground from background.

#### **Advisory techniques for development and testing:**

- Identify informative non-text content
- Describe images that include text
- Link to textual information that provides comparable information (e.g., for a traffic webcam, a municipality could provide a link to the text traffic report)
- Provide more than two modalities of CAPTCHAs
- Provide a transcript of a live audio-only presentation
- Provide a note saying "No sound is used in this clip" for video-only clips
- Use readable fonts
- Make sure any text in images of text is at least 14 points and has good contrast
- Provide a highly visible highlighting mechanism for links or controls when they receive keyboard focus
- Convey information redundantly using color
- The visual presentation of text and images of text has to have a contrast ratio of at least 4,5:1 (21:1 for black: white)

#### **Principle 2 – Operable**

**Operable** – *User interface components and navigation must be operable.*

##### **Guidelines:**

- Keyboard Accessible  
Make all functionality available from a keyboard.
- Enough time  
Provide users enough time to read and use content.
- Seizures  
Do not design content in a way that is known to cause seizures
- Navigate  
Provide ways to help users navigate, find content, and determine where they are.

#### **Advisory techniques for development and testing:**

- Provide keyboard shortcuts to important links and form controls
- Use unique letter combinations to begin each item of a list
- Avoid use of common user-agent keyboard commands for other purposes
- Provide a mechanism to stop all content that blinks within a web page
- Provide the user with a means to stop moving content even if it stops automatically within 5 seconds
- Limit the number of links per page
- Provide mechanisms to navigate to different sections of the content of a Web page
- Make links visually distinct
- Highlight search terms
- Provide keyboard access to important links and form controls
- Provide skip links to enhance page navigation
- Provide access keys
- Using the 'live' property to mark live regions

### **Principle 3 – Understandable**

**Understandable** – *Information and the operation of user interface must be understandable.*

**Guidelines:**

- Readable:  
Make text content readable and understandable.
- Predictable  
Make Web pages appear and operate in predictable ways.
- Input Assistance  
Help users avoid and correct mistakes.

**Advisory techniques for development and testing:**

- Make text that is not in the default human language of the web page visually distinct, giving the names of any languages used in foreign passages or phrases
- Provide language markup on proper names to facilitate correct pronunciation by screen readers
- Provide a mechanism for finding definitions for all words in text content
- Provide a mechanism to determine the meaning of each word or phrase in text content
- Avoiding unusual foreign words
- Use unique abbreviations in a web page
- Including content summaries in metadata
- Using the clearest and simplest language appropriate for the content
- Using sentences that contain no redundant words, that is, words that do not change the meaning of the sentence
- Using sentences that contain no more than two conjunctions

### **Principle 4 – Robust**

**Robust** – *Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.*

**Guidelines:**

- Compatible  
Maximize compatibility with current and future user agents, including assistive technologies.

**Advisory techniques for development and testing:**

- Provide labels for all form controls that do not have implicit labels
- Avoid deprecated features of W3C technologies
- Do not display content that relies on technologies that are not accessibility-supported when the technology is turned off or not supported.

*Assistive technologies and tools*

**Impairments that affect the access to IT**

The following impairments are some of the disabilities that affect communications and technology access, as well as many other life activities:

- communication disorders
- hearing impairments
- visual impairments
- mobility impairments
- a learning disability or impairment in mental functioning

## Assistive technologies

Impairment	Assistive technology
Communication impairment	Electronic speech synthesizer
Hearing impairment	<ul style="list-style-type: none"><li>• Earphones, headphones, headsets;</li><li>• Real-time closed captioning;</li><li>• Teletypewriter</li></ul>
Mobility impairment	<ul style="list-style-type: none"><li>• Page-turning device;</li><li>• Adaptive keyboards and computer mice (pointing devices such as trackballs, vertical mouse, foot mouse, or programmable pedal)</li></ul>
Physical or mental impairment, learning disability	Voice recognition software Talking textbooks
Visual impairment, learning disability	<ul style="list-style-type: none"><li>• Modified monitor interface, magnification devices;</li><li>• Reading service, E-text</li><li>• Braille note-taker;</li><li>• Braille printer;</li><li>• Screen magnifiers;</li><li>• Optical scanner</li></ul>

## Week 9 – Exploratory Testing

*Understanding the system to be tested – Think like the user!*

### Alternative definitions of computer programs:

- A Computer program = A set of instructions for a computer<sup>1</sup>
- A House = A set of building materials, arranged in the “House” design pattern.
- A House = Something for people to live in
- Kaner’s Definition of a Computer Program:
  - **A Computer program is:** a communication among several people and computer separated over distance and time that contains instructions that can be run on a computer.
  - **The purpose of a computer program is to provide value to the people**

### Alternative definition of quality

- A computer program is far more than its code
- A software product is far more than the instructions for the device
- Quality is far more than the absence of errors in the code (how many of you bought a wrong product just because it’s bug-free?)
- Testing is far more than writing code to assert that other code returns some “correct” result.
- **Testing is an investigation of code, systems, people, and the relationship between them.**
- **Quality is value to some person(s)**
- Think about the price while developing. Expensive = more frustration from small errors equal to cheap programs.

If you don’t have an understanding and an agreement on what is the mission of your testing, then just applying procedural testing would be pointless.

- So **know your mission** when practicing quality assurance and testing!

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<sup>1</sup> [http://en.wikipedia.org/wiki/Computer\\_program](http://en.wikipedia.org/wiki/Computer_program)

*Build quality, not only check it*

### **Testing vs checking**

Testing is a sapient; checking is not. Testing encompasses checking, not the other way round.

- Checking, in principle, can be done by a machine

### **Testing against customer's expectations**

Make sure:

- You build the right product
- You build it the right way, with the agreed level of quality

### **How to build quality – Understand the customer**

Questions to build quality:

- Who are my customers?
- Is the customer the same as the user?
- How would I describe the users?
- What do they use my product for?
- For how long have they been users of my product?
- How important is this feature to my customers?
- Can they live without this other feature?
- What is the time to market?
- How much can I invest in the development of the product?
- How much can my customers afford to pay for my product?
- What are the user's expectations? What are the customer's expectations?

*Testing is ~~boring~~ context-dependent*

### **Different software products**

- Because software systems **are** different
- They ask for different focus in testing, they are used in different ways, they pose **different risks**.

### **Context-dependent testing**

Testing depends on the following:

#### Supporting technologies:

New technology

Old technology

Someone else's technology

#### Product interfaces:

Batch system

GUI system

API-only system

#### Type of project

New project

Ongoing project

#### Project size:

Small project

Huge project

#### Development lifecycle:

“Agile” project

“Traditional” project

#### Project management:

Well managed project

Poorly managed

#### Type of product:

Experimental product

Mission-critical product

Life-critical product

Regulated product

#### Other product characteristic:

Embedded system

Real-time system

## Context-dependent testing

Even for the same product:

- It's different if it's the first release (more positive testing)
- Or subsequent release (more performance testing)
- Or a patch (more regression testing & negative testing)

*Testing is a sapient activity*

- Testing always happens under conditions of uncertainty
- Good testing is done in a way that stands up to scrutiny
  - o Without scrutiny, this would be easy to do. You could test badly, but no one would ever know or care.
  - o What makes testing hard is that someone, perhaps your employer, perhaps the users, or perhaps you yourself, will be judging your work.

How would you test this:

"The system shall operate at an input voltage range of nominal 100 - 250 VAC."

Poor answer:

- "Try it with an input voltage in the range of 100-250."

Good answer:

- One fundamental question here is what happens when the system receives voltage outside its rated range? Does it shut down? Blow up? Give erroneous results? Post an error message? If it's designed to pause and then recover when the power returns to normal range, what actually happens?
- Is there special gear that can supply voltage of different levels? If so, we could probably use it. What does it cost? What's the risk?
- Brownouts from the mains could be a risk. Run the system with varying output voltages, varying slowly, varying rapidly, as we run other tests.
- What happens if there's a power spike? Does the product need isolation from the mains?
- What happens if the input power drops suddenly and then recover? Does the product need an uninterruptable power supply? A line conditioner?
- How long can the product run above or below the rated levels?
- What does it mean "to operate" in this context?
- Run the product for a long time at the upper and lower ranges of voltage.
- What happens when we turn the product on or off? Does the product need time to reach some state before it can be used? How long is that?
- What can we observe in the output or in other aspects of the system that might be correlated to variances in the input voltage.

*Heuristics*

## Definition of heuristics

Heuristics is about structuring your problem-solving skills

Heuristics (Def.) refers to experience-based techniques for problem solving, learning, and discovery that give a solution which is not guaranteed to be optimal.



Where the exhaustive search is impractical, heuristic methods are used to speed up the process of finding a satisfactory solution via mental shortcuts to ease the cognitive load of making a decision. Examples of this method include using:

- a rule of thumb
- an educated guess,
- an intuitive judgment,
- stereotyping,
- or common sense.

**Guideword Heuristics** are words or labels that help you access the full spectrum of your knowledge and experience as you analyze something. They're often provided in the form of a **taxonomy**, a **classification system** in (typically) a hierarchical structure; or as a **checklist**.

## Try it and see if it works!

• Get it	• Choose where to look	• Read the spec
• Set it up	• See what is in there	• See if the product matches the spec
• Run it	• See what it's not there	• Find problems
• Run it again		• Find relevant problems
<b>Procedures</b>	<b>Coverage</b>	<b>Oracles</b>

### Guideword heuristics

1. Model the test space.
2. Determine coverage.
3. Determine oracles.
4. Determine test procedures.
5. Configure the system.
6. Operate the system.
7. Observe the system.
8. Evaluate the test results.
9. Apply a stopping heuristic.
10. Report test results.

### Example (Usability elements)

- Navigation
- Search and filter
- Grids
- Flow on page (top-left to bottom-right – in the western cultures)
- Placement of important buttons, like Save and Cancel (Windows/OX standard)
- Tab order
- Alignment
- Grouping (level of boxes, use and overuse)
- Active / inactive elements (the inactive elements must always be disabled)
- Destructive actions
  - Never put Save and Delete next to each other
  - Have confirmation for destructive actions
- Placement of checkboxes and radio buttons (Windows / OX standard)

### Trigger heuristics

Ideas associated with an event or condition that help you recognize when it may be time to take an action or think a particular way. Like an alarm clock for your mind. Emotions and feelings can be powerful sources of trigger heuristics.

Impatience → an intolerable delay?

Frustration → a poorly-conceived workflow?

Amusement → a threat to someone's image?

Surprise → inconsistency with expectations?

Confusion → unclear interface? Poor testability?

Annoyance → a missing feature?

Boredom → an uninteresting test?

Tiredness → time for a break?

### *Improve your exploratory testing*

#### **Mission of testing**

The mission of testing is **learning**

Testers help to defend the value of the product by learning on behalf of the users.

Testers do this by using:

1. Exploration methods (guided heuristics)
2. Creating mental models to represent and test the system
3. Checklists
4. Scripted test procedures

All these require continuous reviews and improvements

#### **Exploration**

Testers will explore:

- **The features:** Move through the application and get familiar with all the controls and features you come across.
- **The complexity:** Find the five most complex things about the application.
- **The configurations:** Find the ways you can change settings in a way that the application retains those settings.
- **The user:** Imagine five users for the product and the information they would want from the product or the major features they would be interested in.
- **The scenarios:** Imagine five realistic scenarios for how the users identified in the user tour would use this product.
- **The testability:** Find all the features you can use as testability features and/or identify tools you have available that you can use to help in your testing.
- **The variability:** Look for things you can change in the application – and then you try to change them.
- **The interoperability:** What does this application interact with?
- **The data:** Identify the major data elements of the application.
- **The structure:** Find everything you can about what comprises the physical product (code, interfaces, hardware, files, etc.)

#### **Mental models**

Create mental models of the system you are testing. Try to see more than one point of view

The mental models will be focused on one or a combination of the following:

- Program structure
- Data
- Program functions
- Platform
- Business risk
- Technical risk
- Operations

#### **Checklist**

Create checklist:

- On requirements
- On design specs / technical specs
- On the test strategy
- On the areas targeted by testing
- On the test methodologies

## Test scripting

Script the most important test scenarios.

Define your: Basic flow, Alternative flows, Exception flows.

- Represent them as a discrete unit of interaction between a user (human or machine) and the system.

This interaction has to be a single unit of meaningful work, such as Buy a set of e-books or View Account Details (assuming you test Amazon.com).

## Practicing exploratory testing

Do You Test Under Time Pressure?

- You have less time than you'd like.
- Faster is better.
- Your plans are often interrupted.
- You are not fully in control of your time.

When the ball comes to you:

- Do you know you have the ball?
- Can you receive the pass?
- Do you know what your role and mission is?
- Do you know where your teammates are?
- Are you ready to act, right now?
- Can you let your teammates help you?
- Do you know your options?
- Is your equipment ready?
- Can you read the situation on the field?
- Are you aware of the criticality of the situation?

A good sports team has to depend on the skills of the players, rather than on rote procedures. Professional sports teams begin with the skills of each player, and then work outwards from that. Skills get practiced offline, but every game is part of the practice too.

Strategy matters, plans matter, techniques matter, but the focus is on the player to choose the appropriate techniques and to execute them skillfully.

## Week 10 – Test Automation and Test Automation Frameworks

*Introduction and objectives for test automation*

### **Test automation – definition**

*In software testing, test automation is the use of special **software** to control the **setting up** of test preconditions, the **execution** of tests and the **comparison** of actual outcomes to predicated outcomes.*

- A key aspect to notice is that the software used for testing needs to be separate from the system under test (SUT) itself.
- Test automation is expected to help run many test cases consistently and repeatedly on different versions of the SUT.

But test automation is more than a mechanism for running a test suite without human interaction.

Test automation is a process of designing the testware, including the following:

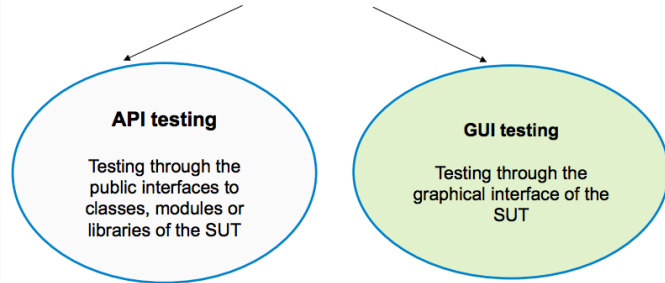
- Software (test tools)
- Documentation (for the tools, for running tests, etc.)
- Test cases
- Test environments
- Data

Necessary for the test activities:

- Implementing automated test cases
- Monitoring and controlling the execution of tests
- Interpreting, reporting and logging the test results

### Interfaces for automated tests

The test automation has two general ways for testing a SUT:



### Advantages and limitations of test automation

#### Advantages :

- More tests are run
- Tests that cannot be done manually are enabled (real-time, remote, parallel tests)
- Tests can be more complex
- Tests run faster
- Tests are less subject to operator error
- More effective and efficient use of testers
- Improved system reliability
- Improved quality of test

#### Limitations :

- One cannot automate all manual tests
- The automation can only check machine-interpretable results
- The automation can only check results that can be predicted or verified

### Major success factors for test automation

The SUT must be designed for testing.

Invariably, the SUT needs some changes to support automated testing or to allow new types of tests to be executed against it. This is an essential part of success with test automation.

- UI testing: the SUT should decouple as much as possible the GUI interaction data from the appearance of the graphical interface.
- API testing: more classes or modules may need to be exposed as public so that they can be tested.
- Good Test Automation Architecture (TA-A): The architecture of the test automation is just as the architecture of a software work product, and should be treated as such.
- Target the testable parts of the SUT first. Generally, a key factor in the success of the test automation lies in the ease of implementing automated test scenarios.
- Creation and maintenance of a test automation framework (TA-F): The framework should be easy to use, well documented, and maintainable.

### Approaches for automating test cases

#### Create automated test cases

A number of approaches can be used to create the sequence of actions of an automated test:

- A tool generates automated test procedures from models
- A tool translates an automated test procedure into an automated test script
- The TA-E transforms automated test procedures into automated test script
- The TA-E implements test cases directly into automated test scripts

#### Explanation of concepts:

Test cases translate into sequences of actions which are executed against an SUT. That sequence of action can be documented in an automated test procedure and/or can be implemented in an automated test script. The test script, besides the test procedure, also contains verification steps in it.

### Types of approaches for automating test cases

Well-established approaches for automating test cases include: **Capture replay**, Linear scripting, Structured scripting, **Data-driven approach**, **Keyword-driven approach**, Process-driven approach, Model-based approach

## Capture/replay

### Principle concept

In capture/replay approaches, tools are used to capture interactions with the SUT while performing the sequence of actions as defined by a test procedure. Inputs are captured; outputs may also be recorded for later checks.

- During the replay of events, there are various manual (the tester has to watch the SUT outputs for anomalies) and automated output checking possibilities:
  - Complete: all system output that were recorded during capture must be reproduced by the SUT
  - Exact: all system outputs that were recorded during capture must be reproduced by the SUT to the level of detail of the recording.
  - Checkpoints: only selected system outputs are checked at certain points for specified values.

### Pros

- The capture/replay approach can be used for SUTs on GUI and/or API level. Initially, it is easy to setup and use.

### Cons:

- Capture/replay scripts are hard to maintain and evolve. For example, when recording at the GUI level, changes in the GUI layout may impact the test scripts, even if it is only a change in the positioning of a GUI element. The test cases based on capture/replay are very fragile.
- Implementation of the test cases (scripts) can only start when the SUT is available.
- When the capture is done via the GUI, a GUI is needed. Not all software implementations have a GUI (e.g., embedded software).

## Data-driven approach

### Principle concept

The inputs are extracted from the scripts and put it into one or more separate files (typically called data files).

- This means we can reuse the main test script to implement a number of tests (rather than just a single test).
- Typically, the 'reusable' main test script is called a control script.
- The control script contains the sequence of instructions necessary to perform the tests but reads the input data from a data file.
- One control test may be used for many tests but it is usually insufficient to automate a wide range of tests.
- Thus, a number control scripts will be required but that is only a fraction of the number of tests that are automated.
- Ex: press "Login", enter username, enter password, press "submit" (1. script) 2.script has the data that you feed the first script, so you don't have to many scripts.

### Pros:

- The cost of adding new automated tests can be significantly reduced by this scripting technique. This technique is used to automate many variations of a useful test, giving deeper testing in a specific area rather than increasing coverage generally.

### Cons:

- A lot of irrelevant test scripts can be generated – it's hard to make those test scripts significant.

## Keyword-driven approach

### Principle concept

- The keyword-driven scripting technique builds on the data-driven scripting technique. This methodology uses keywords (or action words) to symbolize a functionality to be tested.
- The keywords are separated from data and the execution part of the script.
- Each keyword should represent a sequence of detailed actions that produce some meaningful result. For example, 'create account', 'place order', 'check order status' are all possible actions for an online shopping application that each involve a number of detailed steps.

### Pros:

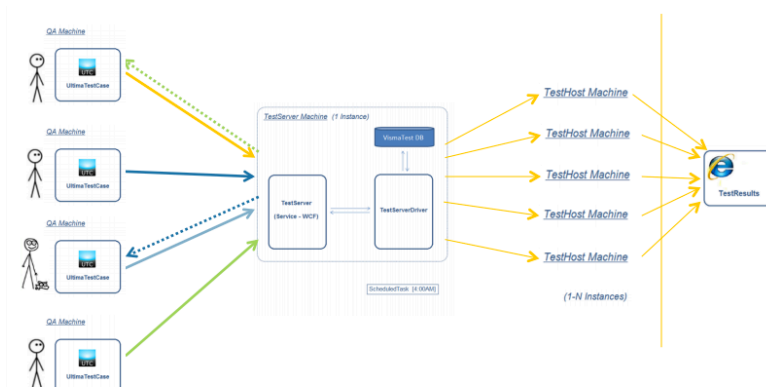
- Once the controlling script and supporting scripts for keywords have been written, the cost of adding new automated tests will be much reduced by this scripting technique.
- This method gives the non-technical testers more freedom to specify automated tests without as much dependency on the technical test analysts.
- These test cases are easier to maintain, read and write as the complexity can be hidden in the keywords (or in the libraries in case of a structured scripting approach). The keywords can offer an abstraction from the complexities of the interfaces of the SUT.

### Cons:

- Implementing the keywords remains a big task for Technical Test Analysts, particularly if using a tool that offers no support for this scripting technique.
- For small systems it may be too much of overhead to implement and the costs would outweigh the benefits.

## Architecture of a test automation framework

### Workflow with an automated test framework



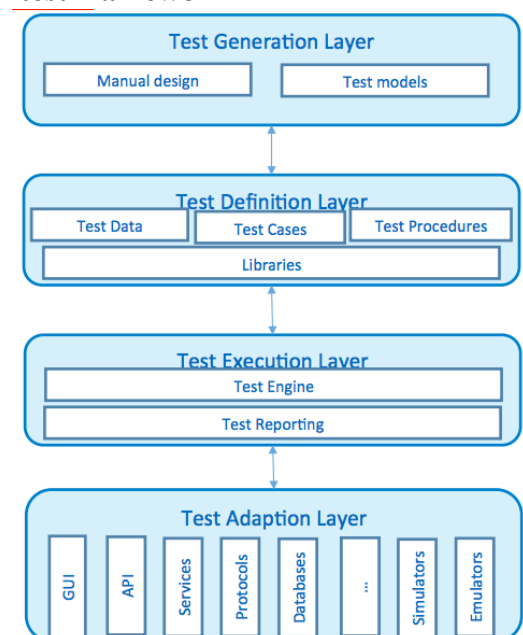
- ... tests are written by many testers
- ... they are managed by a test server
- ... tests are executed on different test environments
- ... test execution is logged
- ... an execution report is available

### Test generation layer

The test generation layers consist of tool support for the following:

- Developing manual test cases
- Automatically generating test cases from models that define the SUT and/or its environment.

### Typical architecture of an automated test framework



### **Test definition layer**

The test definition layer consists of tool support for the following:

- Defining test cases (at the abstract and/or concrete level)
- Defining test data for concrete test cases
- Defining test procedures for the execution of the test cases
- Access to test libraries as needed (for example in keyword-driven approaches)

### **Test execution layer**

The test execution layer consists of tool support for the following:

- Executing test cases automatically
- Logging the test case execution

### **Test adaption layer**

The test adaption layer consists of tool support for the following:

- Controlling the test harness
- Interacting with the SUT
- Monitoring the SUT
- Simulating or emulating the SUT environment

### *Transitioning manual to automated testing*

#### **Automated vs. manual tests**

Prior to commencing an automated testing effort, one needs to consider the applicability and viability of creating automated vs. manual tests. The suitability criteria may include, but is not limited to:

- Frequency of use
- Complexity to automate
- Compatibility of tool support
- Maturity of test process
- Suitability of automation
- Sustainability of the automated environment
- Controllability of the SUT

### **Preparing the automated test environment**

To adequately prepare for transitioning to an automated environment, the following need to be addressed:

#### **Test framework:**

- Availability of the automated tools in the test environment
- Test execution triggering
- Test execution time
- Test data and services (shared data or not)
- Automated test logging and reporting

#### **Test management:**

- Scope of the test automation effort
- Education of test team to the paradigm shift
- Cooperation between developers and automators

## Week 11 – Mobile Software Testing

### Mobile device categories

*Usability varies by mobile device category*

- Regular cellphones – with a tiny screen
- Smartphones – mid-size screen and a full A-Z keypad
- Full-screen phones (iPhone, Android, Windows phones)
- Large tablets (10 inch)
- Small tablets (7 inch)
- Smart watches

With regards to mobile development and testing, we are going to focus only on a full-screen phones and on tablets.

### Test:

- Each category of device has its own strategy and goals. Take this into account when planning your testing.
- Test first for the devices that your application is committed to support.

#### a) Mobile phones specific:

- Test answering calls and behavior during calls
- Test switching between mobile phone native apps (SMS service, contacts, phone) and your application

#### b) Tablet specific:

Tablets are most likely shared devices – so the design has to be for multiuser devices.

What does this translates into? Ex: the users might be reluctant to stay permanently signed into an app.

Also, it's important to design recognizable application icons so they will stand out in the crowded listing of several user's apps.

### Input devices for computers and mobile

- There are more input devices for both desktop computers and mobiles, but in the following example we analyzed the standard ones.
- Comparison between input devices:

Action	Mouse	Fingers
Precision	High	Low
Number of contact points	1	1 or 2-3 for multi-touch
Number of controls	3 (left, right, scroll)	1
Homing time	Yes	No
Signal states	Hover, mouse down, mouse-up	Finger-down, finger-up
Accelerated movements	Yes	No
Suitable for use with desktop monitors	Yes	No (arm fatigue)
Visible pointer / cursor	Yes	No
Obscures view of the screen	No (therefore allowing for continuous visual feedback)	Yes
Suitable for mobile	No	Yes
Direct engagement with screen	No	Yes
Accessibility support	Yes	No
Ease of learning	Fairly easy	Fairly easy



### **Test:**

- The application you are developing for desktop computers and mobile devices has to have a dedicated design for each, to allow interaction with these two different input devices (mouse and fingertips).
- The mobile app has to allow more space for commands than the desktop app, to compensate for the lack of precision of fingertips compared to mice.
- The mobile app has to simplify the interaction with the users, because there is no such thing as left and right-click with fingers.
- The mobile app has to offer a way for the user to interact with one control at a time and minimize accidental interaction (due to lack of visibility and space, the user is more prone or accidentally activating a certain feature).

### **Mobile tasks and user behavior**

#### *Mobile phones tasks*

“Killing-time” apps: Games, Weather, Social networking, Maps & navigation, Search, Music, News

The other “more productive” apps: Shopping/retail, Sport, Productivity, Communication, Travel, Health, Education/learning, Household/personal, etc.

### **Tablet tasks**

- Playing games, Checking email, Social networking sites, Watching movies and videos, Readings news, Shopping (but not so much)

### **Typical behavior for mobile phone users**

- They go to the mobiles when they want to “kill time” while waiting
- They are rushed and impatient
- The “killing time” activity is rather device-driven than user-driven. The users may have a very general goal (read something or play something). Then, they are happy to consume whatever content the device is offering.

### **Typical behavior for tablet users**

- A lot of users say that the tablet has replaced their laptop. This doesn’t mean they start making PowerPoint presentations on it, it means that the information-finding tasks are migrating from the laptop to the tablet.
- Tablet have dominated the media consumption
- The information production is mostly dominated by responding to the emails.
- Users feel it’s easier to shop on the desktop computers.
- Some users are worried about the security of e-commerce purchases on the tablet.

### **Comparison between mobile and tablet tasks**

- Generally, users perform more complex tasks on a tablet than on a phone.
  - o Ex: on an iPad the plan their vacation (destination, plane tickets)
    - But still they won’t buy on the spot. On phones, it’s just simple contextual needs – like finding the nearest hotel.
- Difference in usage sessions:
  - o Mobile phones: 3-5 minutes, very fragmented.
  - o Tablet: from several minutes, up to one hour (on the train, at home). The sessions are not rushed and not more fragmented than on a desktop computer.

### **Test:**

Test for each device type you are developing for:

- The typical session types for that specific device

- The user profile and behavior for that specific device

## **Designing software for mobile**

### *Design issues for mobile devices*

- **Low discoverability:**
  - o The interactive part is mostly hidden within the design.
- **Low memorability:**
  - o Gestures are not consistent across applications and are hard to remember. They can be confusing for both the users and the device (as are all recognition-based user interfaces).
- **Accidental activation:**
  - o This occurs when users touch by mistake some elements or make a gesture which unexpectedly initiates a feature.

### **Test:**

- Make it very clear which elements are interactive in your applications: have a clear separation between content and commands.
- Don't complicate the gestures that a user has to make to access your application. Stick to standard gestures as much as possible.
  - o Ex of standard gestures: tapping, dragging, swiping through the pages.
  - o Ex of non-standard gestures: double-tapping, touching and holding, pinching in and out (for zooming), scrolling with two fingers, three-finger tap or drag (to zoom and move within the zoomed area).
- Make sure you give the users the space to click only on the element that they need to activate. Make sure you provide a Back option or a way to undo the previous action.

## **Download times**

### *Download times dominates the user experience*

- Most pages take far too long to load.
- Even the high-end phones deliver much slower browsing than desktop computers.
- As result: users are reluctant to request additional pages and they give up easily.

### **Test:**

- Check the interaction cost. This cost depends on the type of device and the type of application. (interaction cost = number of atomic actions like clicks, scrolls, switching context – that a person needs to perform to fulfill a task on a computer or mobile device)
- Streaming the interaction so it involves as few page downloads as possible.
- Give users feedback about the state of the download (ex: by showing them a progress bar)

## **Scrolling**

Scrolling causes major usability problems, especially in the sites not optimized for mobiles

- The main problem is that the pages scroll to much.
- As result: people lose track of where they were and what info is in the page. Also people scroll right past something, without noticing it.

### **Test:**

- That users don't take too much time with the scrolling, thus degrading the short-term memory
- That it's easy to reacquire the previous location on the page.
- That the user attention is not diverted from the reading to the secondary task – which is scrolling

## **Zooming**

- Zooming into a page allows users to read more easily.
- Problem: users lose context. It is harder to know where they are on the page and what else is available.

## **Bloated pages**

- They make users lose context and feel lost.
- On computers these pages normally don't feel bloated, but rendered on a mobile they bloat.
- *Problem*: unnecessarily big images and long texts take a long time to load. Also, they bury the items the users wanted to see.

## **Test:**

- Include only needed information that is likely useful to your users and add value to the page.
- Don't abuse images on a page. Many images usually translate into slow download times. You have to choose smaller size images and edit them for mobile (zoom, focus on one detail, etc.).

## **Why mobile reading is harder**

- Users can see less at any given time. They have to rely on their short-term memory when they are trying to understand anything that is not fully explained within the viewable reading space.
- Users have to move around the page more, scrolling to refer to other parts of content, instead of simply glancing at the text.
- Mobile users are in a hurry and get visibly angry at sites that waste their time.
- Bullet points make information scan able on a small screen.

## **Test:**

- Cut the unnecessary paragraphs in the beginning of pages. Check if the text still makes sense without them.
- Stick to answering 2 questions: what and why.
- Old words are the best – check that you don't use too many neologisms or specialized terms that the readers might not understand.
- Defer secondary information to secondary screens (ex: progressive disclosure, like in Wikipedia; ex: summaries of the headlines in a list with articles).

## **Mobile optimized apps and sites**

- Cut features to eliminate functionalities that are not core to the mobile use case.
- Cut content to reduce word count.
- Defer secondary information to secondary pages.
- Enlarge interface elements to accommodate the “fat finger” problem.
- Here the challenge is to eliminate features and word count without limiting the selection of products. A mobile site should have less information about each product and support fewer tasks that user can do with the products, but the range of items should remain the same as on the full site.

If the users can't find a product on a mobile site, they assume the company doesn't sell it and go elsewhere.

## **Do's and don'ts in mobile design and testing**

### **Do's**

- Have a good startup screen: in a mobile world with little commitment or patience, a single bad screen can cost millions in lost revenue and brand value. Startup screens are the ones who make a good or bad user impression, this is why they are crucial.
- Focus the user's attention on the essential content. This is the main usability guideline for mobile content. The comprehension score on mobile devices is twice as low as Desktops (Cloze test).
- Have Back buttons, reliable search, homepages.
- Have direct access to content by touching headlines on the front page.
- Support standard navigation and gestures for users interacting with the mobile application you are developing.
- If you have to choose between scrolling and chop the content into linear sequences of pages, choose the first option (so that users don't have to wait for a page load every 20-30 seconds or so).

Also using the scroll makes it easier to go back to the parent-page, instead of tapping the "back" button many times. The only exception here are the books, which are not designed to be read in a single session. But be aware that book readers make moving between pages very easy and without time consumption.

- Get rid of the swiping ambiguity: using swipe gestures (for scroll page navigation, carousel browsing) together with tapping gestures in the same page may lead to the user either starting or ending the swiping gesture on an element that is interactive. This is called swipe overload.

Check that interactive elements that can be tapped do not interfere with the swiping gesture. In case they do, minimize the interference.

- Avoid offering the users too much navigation possibilities at the same time: scroll, carousel, thumbnail tapping, hyperlinks, tables of contents, etc.

### **Don'ts**

- Do not use early registration: don't make users pass through a registration screen as the first step.
- Do not have in the beginning of the app/webpage messages asking for the user's permission to push notifications or to access their current location.
- Do not present the users with lengthy instructions or user manuals. Most users are not motivated to read the instructions before getting any value from the app.
- Don't follow the "print metaphor" to the same degree as the desktop websites (print metaphor refers to designing a web page as close as possible to a printed magazine).

## **Week 12 – Intellectual property and licensing**

### *Forms of intellectual property*

#### **Categories of IP**

- Industrial property
  - o Patents (inventions), Trademarks, Industrial design, Geographic indications of source
- Copyright
  - o Literary and artistic works, Architectural designs

Rights related to copyright include those of performing artists in their performances and those of broadcasters in their radio and television programs.

#### **IP as intangible property**

- Tangible properties: land, houses, cars
- Intangible properties: intellectual property
- Intangible wealth is easily appropriated and reproduced.
- Once created, the marginal cost of reproduction is negligible.

#### **Why give IP protection**

- Capital expenditure for new products
- Research and Development
- Marketing and advertisement
- Maintaining loyal followers
- Profit

#### **What can be done with IP**

- Can be sold
- Can be bought
- Can be lease or rent
- Can pass under a will
- Can be assigned

#### **IP laws and regulations**

#### **The US Laws For Intellectual Property Protection**

- Copyright Act (1790; 2014)
- Trademarks Act (1870; 2006)
- Patent Act (1790, 2013)
- Industrial Design Act (1996)
- Geographical Indications Act (2000)
- Law of Tort (passing-off confidential information)

#### **Technology Innovation Legislation**

- Stevenson-Wydler Technology Innovation Act of 1980
- Bayh-Dole Act of 1980
- Small Business Innovation Development Act of 1982
- Cooperative Research Act of 1984
- Federal Technology Act of 1986

## ***Industrial Property***

- Trade secrets
- Trademarks (Trademark, Service Marks, Trade Name)
- Patents
  - o United States: Provisional, Full Application
  - o International
- Industrial design
- Geographical indication
- Confidential information

## **Trade Secrets**

- *Definition*: Confidential, unpatented information that is protected by keeping the information secret
- Factors in determining if it is a trade secret
  - o Extent information is known in industry
  - o Extent measures taken to safeguard secrecy
  - o Value of information to owner and competitors
  - o Ease/difficulty in independent development
- Advantages
  - o Easy to control
  - o Easy and inexpensive (relatively) to protect
  - o Indefinite term (determined by degree of protection)
  - o No patentability requirements to qualify
- Disadvantages
  - o Limited ability to exploit information
    - Competition can do reverse engineering
  - o No protection against independent development
  - o No statute law protecting trade secrets
- Remedy (middel)
  - o Injunction or damages
  - o Onus (byrde) is on owner to establish case

## **Trademarks**

- *Definition*
  - o Identifying mark, word, logo or symbol used by someone in commerce to identify or distinguish their goods and services from all others
  - o Sometimes confused with “trade name” which is the company name under which business is conducted.
- “mark” include a device, brand, heading, label, ticket, name, signature, word, letter, numeral or any combination.
- Does not include sound or smell
- Can either be registered or not registered
- Advantages of registered trade marks:
  - o Application can be made for goods and services
  - o Perform certain function such as indication of quality, identifying a trade connection

## **Patents**

- What is patentable?
  - o Any new and useful art, process, machine, manufacture or composition of matter or any new and useful improvement.

- Include software and mask works
- Patent can be applied for a product or a process. Patentable invention must be new, involves an inventive step and industrially applicable
- Key elements: Novelty, Utility, Non-obviousness
- First to invent vs. first to file
- Term is 20 years from date of application (USA)
- One-year grace period for prior disclosure
- Application published 18 months after filing

Software Patents are software-based inventions.

- Patentability criteria evolving and include:
  - Produces new/useful data interpretation
  - Controls device performing new/useful function
  - Solves computer-related problem
  - Improves existing computerized process

### **Industrial design**

- Protection for industrial designs that are new or original
- Design are feature of shape, configuration, pattern or ornament
- The design must be applied to an article
- The design must be applied by an industrial process.
- It has to appeal to the eye

### **Geographical indications**

- Geographical indication = an indication which identifies any goods as originating in a country or territory, or a region or locality where a given quality, reputation or other characteristic of the goods is essentially attributable to their geographical origin.
- Product must come from a particular geographical territory
- Uses a name link to the particular geographical nature of the territory
- Example: Swiss made, Swiss chocolate, Champagne, Sweet tamarind

### **Confidential information**

- Protection for confidential information under contract:
  - Employer-employee
  - Husband and wife
- To prove passing of confidential information, one needs to show:
  - That the information is confidential
  - Recipient who obtained the information uses it
  - Damages suffered by the owner
  - Example: Customers list, Secret recipes

### **What you need to test regarding the industrial property**

- Trade Secrets
  - You mark and distribute the documentation related to sensitive information appropriately: requirements, specifications, architecture overview, design, test, help files and other documentation.
- Trademarks
  - Check that you don't use other company's trademarks
  - Check if you must use your company's trademarks
- Patents, Industrial design

- Check that you don't use other company's patents or industrial design without prior agreement
  - Check if there is any part of the software product or process that needs to be patented.
- Geographical indications
  - Check that you don't misuse geographical indicators in your application or its outcomes
- Check if your application should contain information to be marked as confidential (as specified by the license type, contracts with customers, service level agreements).
- Check if the company's procedures to protect confidential information are respected and applied in the tested software product
  - Check that the confidential information of your application is encrypted or stored or deleted according to those specifications
- Test against unauthorized access to the confidential information contained by your application.

## **Copyright**

### *Definition and description*

- Copyright is a legal device that provides the creator of a work of art or literature, or a work that conveys information or ideas, the right to control how the work used
- Copyright is a law with the intent to advance the progress of knowledge by giving authors an economic incentive to keep on creating. It is a set of legal rights that the author has over his work for a limited period of time.
- Copyright insures that the person who created something is reimbursed for his intellectual work.
- These legal rights control everything from images to sound files and even whether or not you can photocopy – that protects the creator – gives creators the right to control how their works are used.
- There is no requirement for *novelty* or *uniqueness* as there is in patent law.
- Protects manner of expression; not the idea, process or concept
- Exists automatically on creation of work (Legal registration enhances protection)
- Term
  - Author's life + 70 years (USA)
  - Lesser of 95 years from first publication or 120 years from creation for works for hire (USA)
- Creations and works of art: drawings/prints, musical works, text, architectural plans, motion pictures, software, multimedia works, internet-distributed content
- Duration:
  - Depends on whether it is pre or post 1 Jan. 1978 (USA)
  - Pre – Depends on whether published?
    - Registered, first term, renewal etc.
  - Post –
    - Life of author + 50 years (USA)
    - Work-for-hire 75 years from publication, 100 years from creation which ever is first (USA)



## Public domain

- Most information is protected by copyright. The exception are works in the Public Domain. These can be reproduced or used by anyone.
- Example:
  - o Government publications
  - o Works where the author has waived copyright (freeware)
  - o Older works where the copyright has expired.
- You don't have to get permission to use it but you still must cite it. The only thing you don't have to cite is information known as common knowledge – info that everyone knows.

## Works for hire

- Employer is considered the author when:
  - o Work prepared by an employee within the scope of his/her employment
  - o Work specially ordered or commissioned for use as a contribution to a collective work
- Transfer of title vs Work-for-Hire
  - o Under a work for hire, employer is considered the owner.
  - o Duration 75 years from pub or 100 from creation (USA)
  - o Transfer of title – can be done after 45 years (USA)

## Fair use

- Fair use allows of a copyrighted work without seeking permission from the author. This is a law.
- Fair use is considered: criticism, comment, parody, news reporting, teaching, scholarship or research
- We look at these four factors to determine if a use is fair or not:
  1. Purpose/character of the use – this is where we fit in, educational use.  
**Has to be non-profit and educational**
  2. The nature of the copyrighted work **has to be published and factual**
  3. The portion of the work used **has to be relatively small and non-essential**
  4. The effect of the use on the market **won't prevent the owner from making money.**
- Allows:
  - o You to quote passages from a book or a journal article as long as it is credited/cited.
  - o You to reproduce short segments of songs and movies as long as it is cited/credited to the author.
  - o You to use an entire work depends on the circumstances.
- Examples:
  - o Professor giving you a copy of an article he wants you to read
  - o Photocopying selections of materials in the library for your own use
  - o Library Electronic Reserves
- Remember
  - o Just because you don't need permission, you still need to cite.

## Misuse of sources (When in doubt, just search (internet or library) for the answer)

- Misusing sources may result in unintentional plagiarism due to:
  - o Wrongly paraphrasing
  - o Paraphrasing without citing
  - o Copying & Pasting

### **What you need to test regarding copyrights**

- Check what external source of information you have used in developing your software product:
  - o Other code (libraries, routine, pieces of code)
  - o Images, videos, sounds, trademarks, text

Check for each of the sources if they are in the public domain or not.

For the information not in the public domain AND depending on the purpose of your software (educational, commercial, etc.), check that you have the permission of the author to use it.

Cite and reference the author of any external piece of information (in the public domain or copyrighted).

### *Licenses*

#### **What is a License?**

- A license = a contract between licensor and licensee.
- Licensor grants to licensee the right to practice the technology claimed in the licensed patent.
- Licensor agrees not to sue licensee for infringing licensor's patent.
- Licensing = In the broad sense, is a discipline that makes it possible to transfer technology from a proprietor (the licensor) to an interested purchaser (the licensee) in a well defined and effective manner.

#### **Why the need to have licenses**

- Knowledge moves quickly around the world
- Increase in industrial/academic espionage
- New trading blocks: EC, East Europe, North America
- Availability of R&D funds decreasing
- Competition for R&D funds increasing

#### **Link between IP and licenses**

- Idea >> concept >> reduction to practice >> prototype >> scale-up >> production
- Direct application by IP owner
- Sale of IP to another entity who then productizes
- License of IP to licensee(s)
- Public disclosure of IP

#### **Right under a license**

- To make
- To use
- To disclosure to others (by publication, in a marketed product, in a service manual, as a sub-license to a third party, to lease)
- To sell

#### **Types of licenses**

- Exclusive - there can only be one licensee; the licensor has no rights to exploit the technology/product
- Sole – exclusive but for the licensor, i.e., the licensor has rights to exploit the technology/product
- Non-exclusive – there is no limit to the number of potential licensees
- Irrevocable/Revocable for cause
- Territory: World-wide/Limited to named geographic regions

- Field of use: Market-specific
- Royalty-bearing/Royalty-free

#### Strategies for choosing a license

- Position in technology life-cycle
- Presence/absence of competition
- Technical, financial and marketing strengths of the parties
- Legal, political, and cultural environments
- Protection of proprietary information
- Remuneration hoped to be realized over the term of the license

#### Why license? – Licensor's reasons

- to make money
- to help sell products, services, equipment
- to secure a market
- to settle a patent dispute
- cross-licensing of other, existing technology
- rights to future technology
- to adapt a product to a local market
- to fulfill local laws
- to avoid antitrust/anti-competition or trade regulation problems
- to obtain rights to technology
- to supplement the licensee's R&D products
- to obtain continuing access to technical help
- to benefit from the good reputation of the licensor by gaining ability to use its trademark
- to obtain quick entry without cost and technology risks
- to obtain access to the licensor's facilities

#### What you need to test regarding licenses

1. Check that you are using the right license for the type of software that you are developing:
  - Check it for each local market in which you distribute your software
2. For the type of license that you are using
  - Check your duties according to the statement in the license:
    - Technical support
    - Support for new and legacy software
    - Backup / Availability (this can be comprised in a Service Level Agreement document too)
3. Check that you don't breach the license rules of other software (systems, libraries, routines or algorithms) you are using to develop your software – you need to check if you don't go over your rights to use other software or products (sell, use, disclose to others).

## What you need to test regarding licenses

GPL (general public license)

Q: Can any open source library be used in a commercial software or any specific licensed open source library?

- Yes, but you need to distinguish between commercial software used in-house/privately and commercial software bundled for sale or distribution.
- The GPL does not require you to release your modified version, or any part of it. You are free to make modifications and use them privately, without ever releasing them. This applies to organizations (including companies), too; an organization can make a modified version and use it internally without ever releasing it outside the organization.
- But *if* you release the modified version to the public in some way, the GPL requires you to make the modified source code available to the program's users, under the GPL.
- Thus, the GPL gives permission to release the modified program in certain ways, and not in other ways; but the decision of whether to release it is up to you.