Universidad de Oviedo

EN
English

School of Computer Science

Quality attributes

SOFTWARE ARCHITECTURE

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Jose E. Labra Gayo

Quality attributes

Also known as:

- Architecture characteristics
- Non-functional requirements

Types of requirements

Requirements can be categorized as:

- **Functional requirements**: state what the system must do, how it must behave or react to run-time stimuli.
- **Quality attribute requirements**. Annotate (qualify) functional requirements
  - Examples: Availability, modifiability, usability, security,...
  - Also called: non-functional requirements
- **Constraints**. A design decision that has already been made

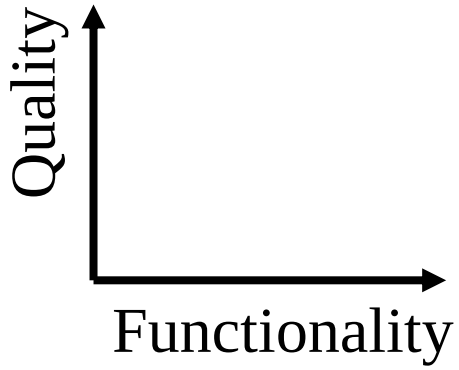
Functional requirements

Functionality = ability of the system to do the work for which it was intended

Functionality has a strange relationship to architecture:

- It does not determine architecture;
  - If functionality were the only requirement, the system could exist as a single monolithic module with no internal structure at all

Functionality and quality attributes are orthogonal



Quality attributes (QA)

Quality attributes annotate (qualify) the functionality

If a functional requirement is "when the user presses the green buttom an options dialog appears"

- A performance QA could describe how quickly
- An availability QA could describe this option could fail, or how often it will be repaired
- A usability QA could describe how easy is to learn this function

Quality attributes influence the architecture

What is Quality?

Degree to which a system satisfies the stated and implied needs of its stakeholders, providing value

- Degree (not Boolean)
- Quality = Fitness for purpose (*stakeholders* needs)
- Conform to requirements (stated and implied)
- Providing value

Several definitions of quality

`https://en.wikipedia.org/wiki/Software_quality`

Quality attributes and trade-offs

- QAs are all good
- ...but value depends on the project & stakeholder
  - *"Best quality"...for what?, for whom?*
- QAs are not independent
  - Some qualities can conflict
  - What matters most?
    - Example: A very secure system can be less usable
- There is always a price
  - What is your budget?

There is no single *perfect* system or architecture!

Specifying quality attributes

- 2 considerations:
  - QAs by themselves are not enough
    - They are non-operational
      - Example: It is meaningless to say that a system shall be modifiable or maintainable
  - The vocabulary describing QAs varies widely
    - It is necessary to describe each attribute separately
- QA scenarios: A common form to specify QA requirements

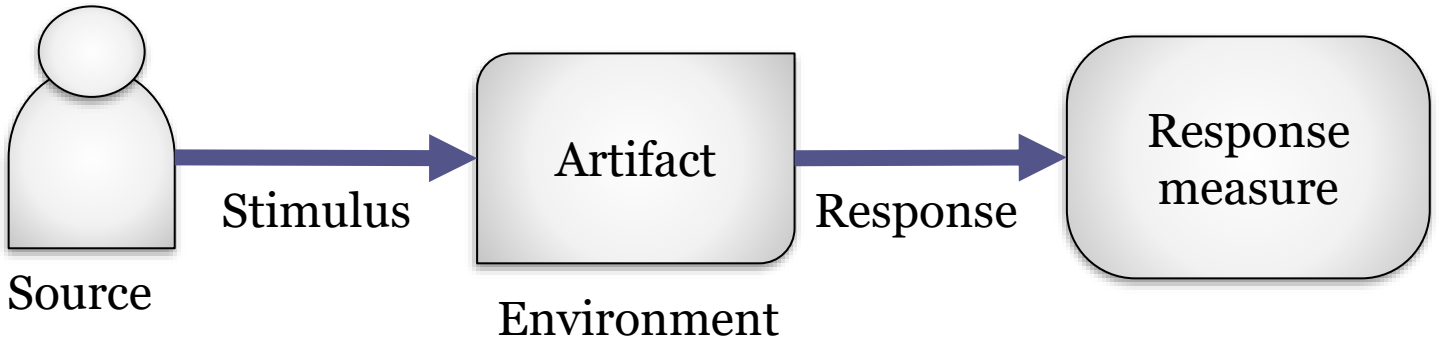
Quality attribute scenario

Describe a stimulus of the system and a measurable response to the stimulus

- Stimulus = event triggered by a person or system
- The stimulus generates a response

Must be testable

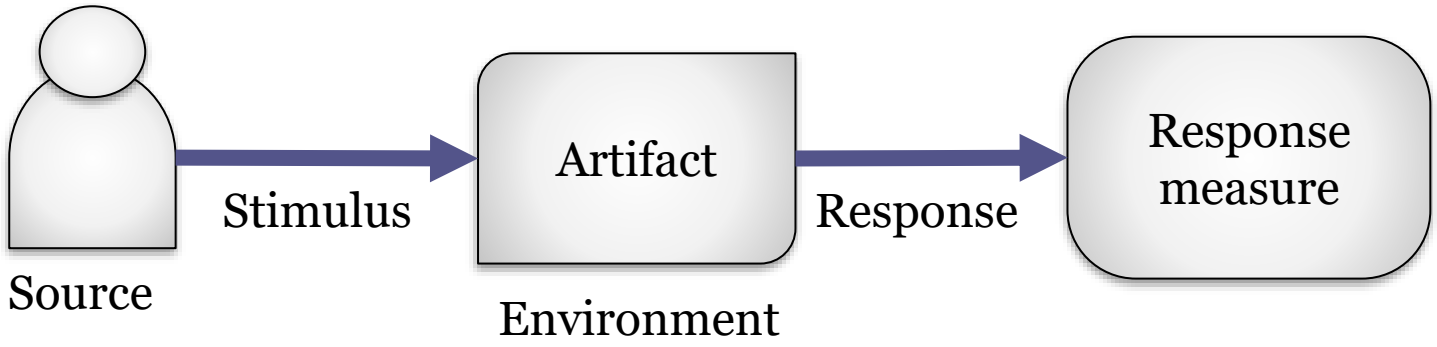
- Response must be externally visible and measurable



Components of QA scenario

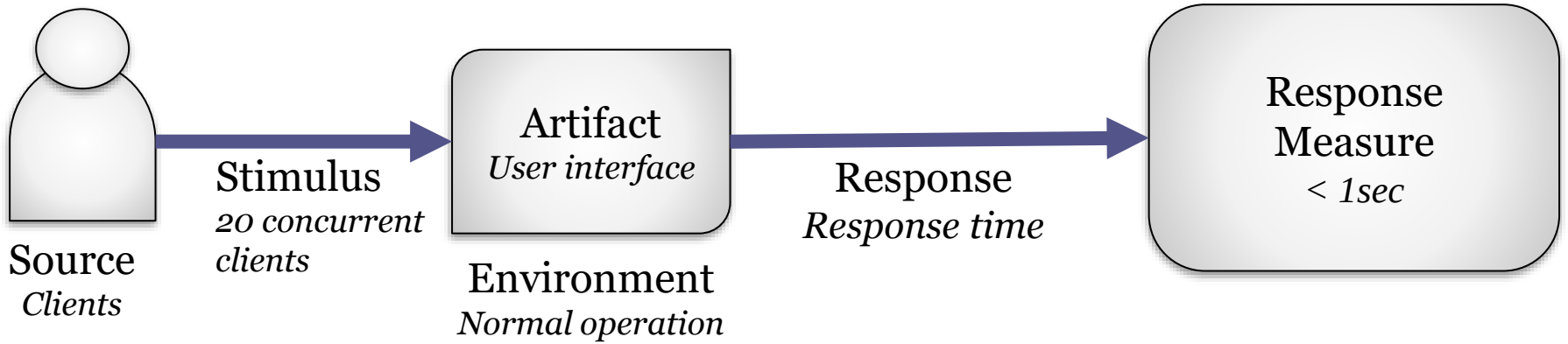
Source: Person or system that initiates the stimulus
Stimulus: Events that requires the system to respond
Artifact: Part of the system or the whole system
Response: Externally visible action
Response measure: Success criteria for the scenario
- Should be specific and measurable

Environment: Operational circumstances
- Should be always defined (even if it is "normal")



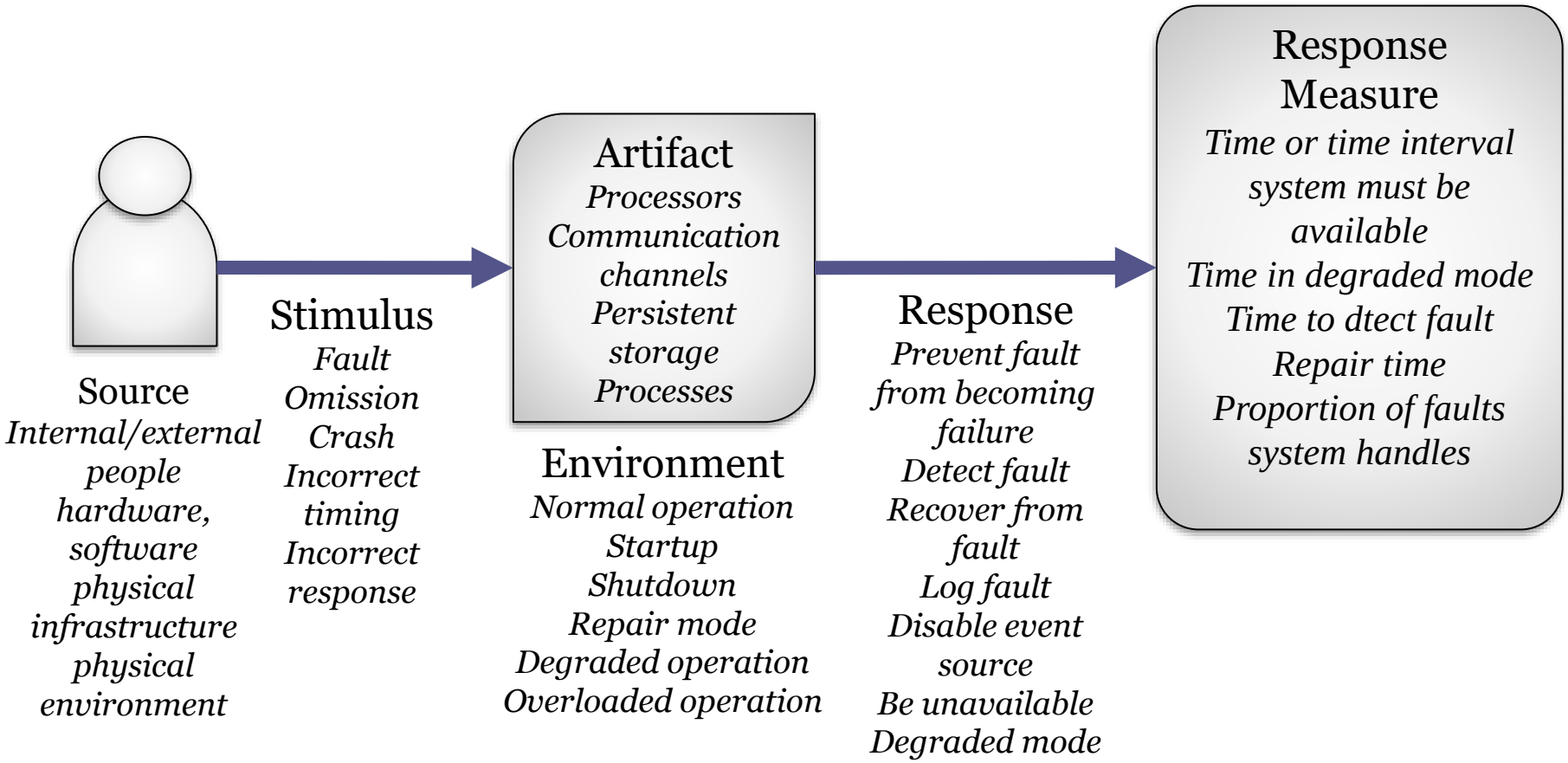
QA scenario, example 1

***Performance**: If there are 20 concurrent clients, the response time should be less than 1 sec. under normal operation*



Source of stimulus	Stimulus	Artifact	Environment	Response	Response measure
Clients	20 concurrent clients	User interface	Normal operation	Response time	<1sec
. . .	. . .	. . .	. . .	. . .	. . .

QA Scenario structure for availability



Types of QA scenarios

- Usage scenarios
  - The system is used (any use case or system function is executed)
    - Describe how the system behaves in these cases
      - Runtime, performance, memory consumption, throughput,...
- Change (or modification) scenarios
  - Any component within the system, its environment or its operational infrastructure changes
- Failure scenarios:
  - Some part of the system, infrastructure or neighbours fail

Prioritizing QA scenarios

- Scenarios should be prioritized
  - 2 values (Low/Medium/High)
    - How important it is for success (ranked by customer)
    - How difficult it is to achieve (ranked by architect)

Ref	Quality Attribute	Scenario	Priority
1	Availability	When the database does not respond, the system should log the fault and respond with stale data during 3 seconds	High, High
2	Availability	A user searches for elements of type X and receives a list of Xs 99% of the time on average over the course of the year	High, Medium
3	Scalability	New servers can be added during the planned maintainance window (less than 7 hours)	Low, Low
4	Performance	A user sees search results within 5 seconds when the system is at an average load of 2 searches per second	High, High
5	Reliability	Updates to external elements of type X should be reflected on the application within 24 hours of the change	Low, Medium
	. . .	. . .	. . .

Identifying quality attributes

- Finding QAs
  - Most of the time, QAs are not explicit
    - They're only verbally said alongside func. requirements
    - Usually implicit or said without much thought
  - Software architect must do educated guesses
- Quality Attribute Workshops
  - Meetings where stakeholders specify QAs
- Formal checklists
  - ISO25010
  - Wikipedia: https://en.wikipedia.org/wiki/List_of_system_quality_attributes

Typical quality attributes

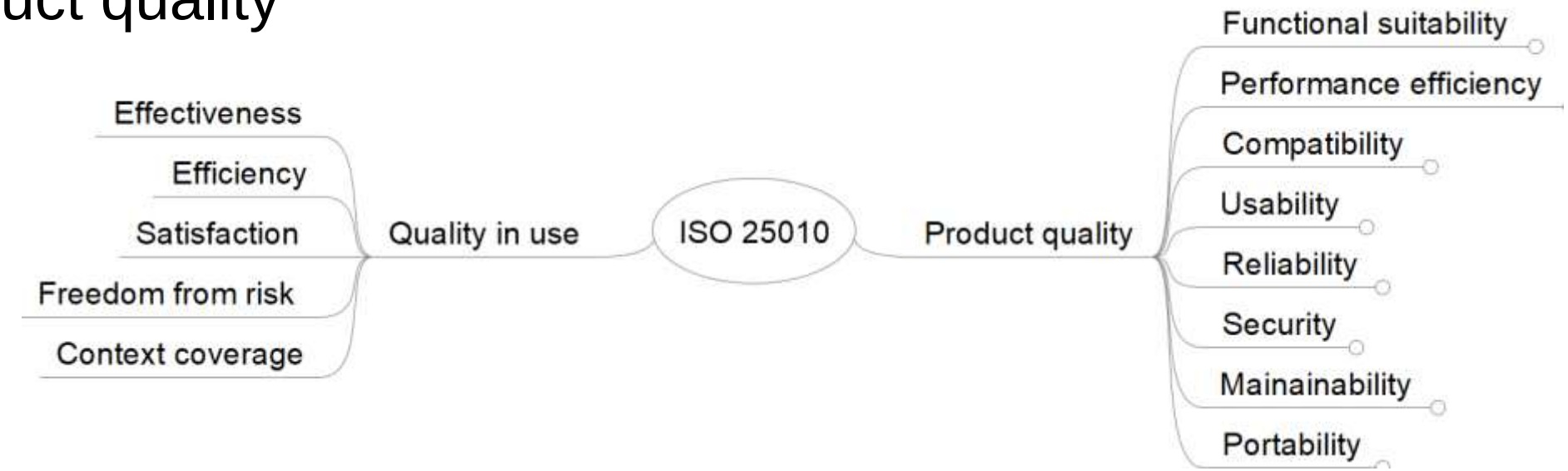
Availability
Modifiability
Performance
Security
Testability
Maintainability
Usability
Scalability
Interoperability
Portability
Changeability
. . .

ISO-25010 Software Quality Model

Systems and software Quality Requirements and Evaluation (SQuaRE)

2 parts:

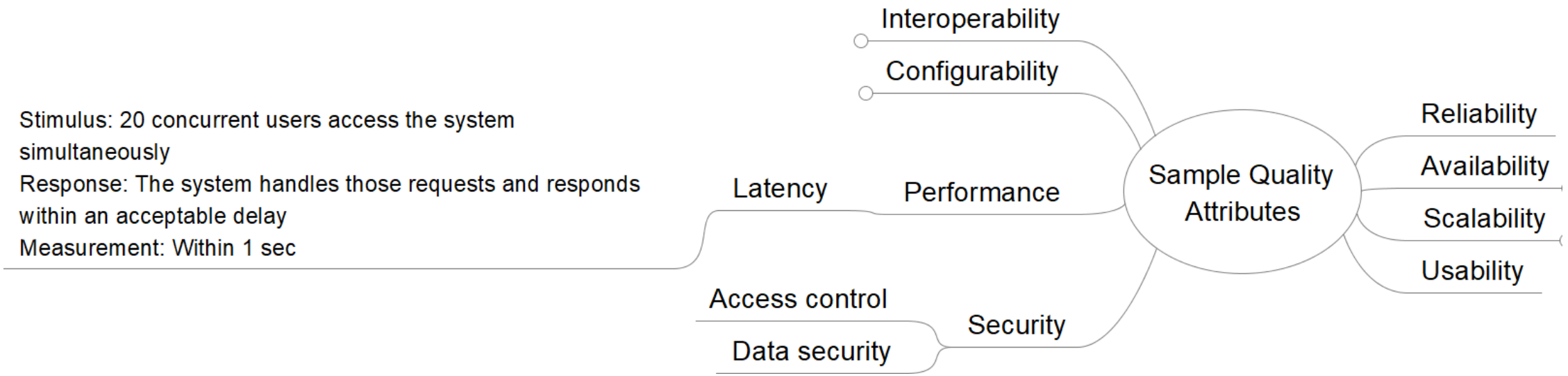
- Quality in-use
- Product quality



https://arquisoft.github.io/Iso25010QualityAttributes.html

Quality Attribute tree

Mindmap representations can be useful to visualize QA scenarios



Measuring quality attributes

QA scenarios require response measures

Common problems:

- Many QA have vague meanings
  - Example: deployability, scalability
- Wildly varying definitions
  - No universal definitions
- Too composite
  - Usually, a QA is composed of several features

Software metrics

Goal: Objective measures which can be automatically computed

Numerous metrics for different aspects

More information:

https://en.wikipedia.org/wiki/Software_metric

Operational measures

- Lots of metrics
  - Absolute values
    - Examples: Number of users, number of errors
  - Statistical values and models
    - Example

$$availability = \frac{MTBF}{MTBF + MTTR}$$ where $MTBF = mean\ time\ between\ failures\ (uptime)$, $MTTR = mean\ time\ to\ recover\ (downtime)$

Availability	Downtime/90days	Downtime/year
99,0%	21hours, 36 minutes	3 days, 15.6 hours
99,99%	12 minutes, 58secs	52min, 34 secs
99,9999%	8 secs	32 secs

Structural measures

Measure the structure of the modules

Examples:

Cyclomatic complexity (CC) from McCabe, 1976

Goal: Objective measure of complexity of code

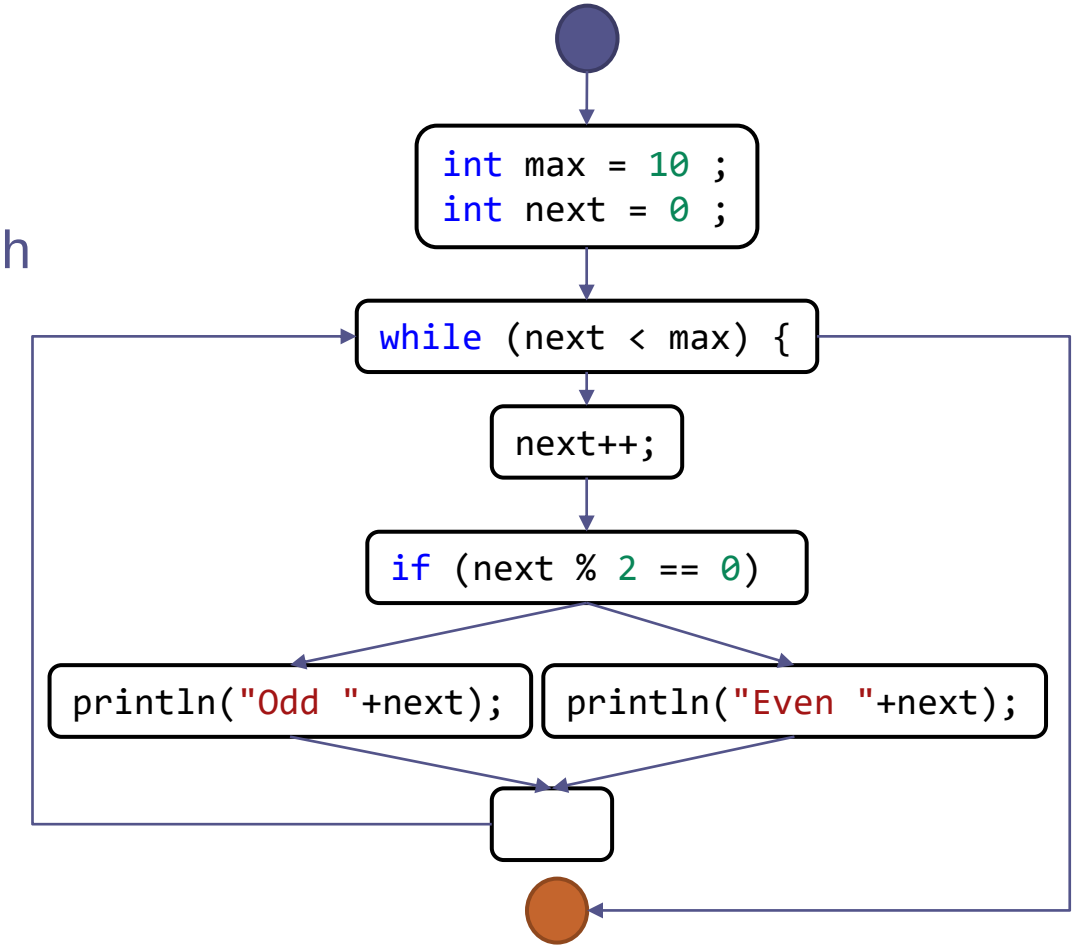
It is obtained from the program control flow graph

$CC = E - N + 2$ where $E = number\ of\ edges$, $N = number\ of\ nodes$

Example:

```
public static void main(String[] args) {
    int max = 10 ;
    int next = 0 ;
    while (next < max) {
      next++;
      if (next % 2 == 0)
       System.out.println("Even " + next);
      else
       System.out.println("Odd " + next);
     }
   }
```

$$CC = 10 - 9 + 2 = 3$$



Process measures

Measure process aspects like agility, testability, maintainability, etc.

Examples:

- Testability: Code-coverage during testing
  - Percentage of lines of code that have been run during the test phase
- Deployability:
  - % of successful to failed deploys
  - How long deployment takes
  - Issues/bugs in deployment
  - ...

4 key metrics or DORA metrics

Origin: State of DevOps report by DORA (DevOps Research and Assessment team)
Measure High delivery performance

1. Lead Time to change
   Time from code committed to code successfully running in production
2. Deployment frequency
   How often does an organization deploy code to production
3. Mean time to restore (MTTR)
   how long does it take to restore service after an incident
4. Change failure rate
   Percentage of changes to production that result in degraded service

https://www.devops-research.com/quickcheck.html

Governing quality attributes

Evolutionary architectures

- Fitness functions: mechanism that provides objective integrity assessment of some combination of quality attributes
- Make QA measures and evolve the architecture