

# Empirical Methods in Software Engineering (01 OPJIU)

---

## Measurement

<http://softeng.polito.it/EMSE/>



**SoftEng**  
<http://softeng.polito.it>

© Marco Torchiano, 2013



### Attribution-NonCommercial-NoDerivs 2.5

- You are free: to copy, distribute, display, and perform the work

Under the following conditions:



**Attribution.** You must attribute the work in the manner specified by the author or licensor.



**Noncommercial.** You may not use this work for commercial purposes.



**No Derivative Works.** You may not alter, transform, or build upon this work.

- For any reuse or distribution, you must make clear to others the license terms of this work.
- Any of these conditions can be waived if you get permission from the copyright holder.

**Your fair use and other rights are in no way affected by the above.**

This is a human-readable summary of the Legal Code (the full license) found at the end of this document

# Contents

---

- Introduction to measurement
- Theory of measurement
- Measurement scales
- Common metrics

# Measurement

---

*the process of empirical  
**objective** assignment of  
numbers to **entities**, in order  
to characterize a specific  
**attribute** thereof*

# Measurement

---

- Entity:
  - ◆ an object or event
- Attribute:
  - ◆ a feature or property of an entity
- Objective:
  - ◆ the measurement process must be based on well-defined rules and procedures whose results are repeatable

## Examples of measures

Entity	Attribute	Measure
Person	Age	Year of last birthday
Person	Age	Months since birth
Source code	Length	# Lines of Code (LOC)
Source code	Length	# Executable statements
Testing process	Duration	Time in hours from start to finish
Tester	Efficiency	Number of faults found per KLOC
Testing process	Fault frequency	Number of faults found per KLOC
Source code	Quality	Number of faults found per KLOC
Operating system	Reliability	Mean Time to Failure

# Guidelines

---

- Specify both entity and attribute
  - ♦ The entity must be defined precisely
- You must have a reasonable, even intuitive understanding of the attribute before you propose a measure.
- You must not re-define an attribute to fit in with an existing measure.

# Common mistake

---

- Mistake: propose a ‘measure’ if there is no consensus on what attribute it characterizes.
- Results of an IQ test
  - ♦ Intelligence?
  - ♦ or verbal ability?
  - ♦ or problem solving skills?
- # defects found / KLOC
  - ♦ quality of code?
  - ♦ quality of testing?

# Type and use

---

- Types
  - ◆ Direct measurement
  - ◆ Indirect measurement
- Uses of measurement:
  - ◆ for assessment
  - ◆ for prediction
    - Measurement for prediction requires a prediction system/model

## Direct measures

---

- **Length** of source code
  - ◆ E.g. measured by LOC
- **Duration** of testing process
  - ◆ E.g. measured by elapsed time in hours
- **Number of defects** discovered during the testing process
  - ◆ E.g. measured by counting defects
- **Effort** of a programmer on a project
  - ◆ E.g. measured by person months worked

# Indirect measures

---

$$\text{Programmer productivity} = \frac{\text{LOC produced person}}{\text{months of effort}}$$

$$\text{Module defect density} = \frac{\text{number of defects module}}{\text{size}}$$

$$\text{Defect detection efficiency} = \frac{\text{number of defects detected}}{\text{total number of defects}}$$

$$\text{Requirements stability} = \frac{\text{\# of initial requirements}}{\text{total \#of requirements}}$$

$$\text{Test effectiveness ratio} = \frac{\text{number of items covered}}{\text{total number of items}}$$

$$\text{System spoilage} = \frac{\text{effort spent fixing faults}}{\text{total project effort}}$$

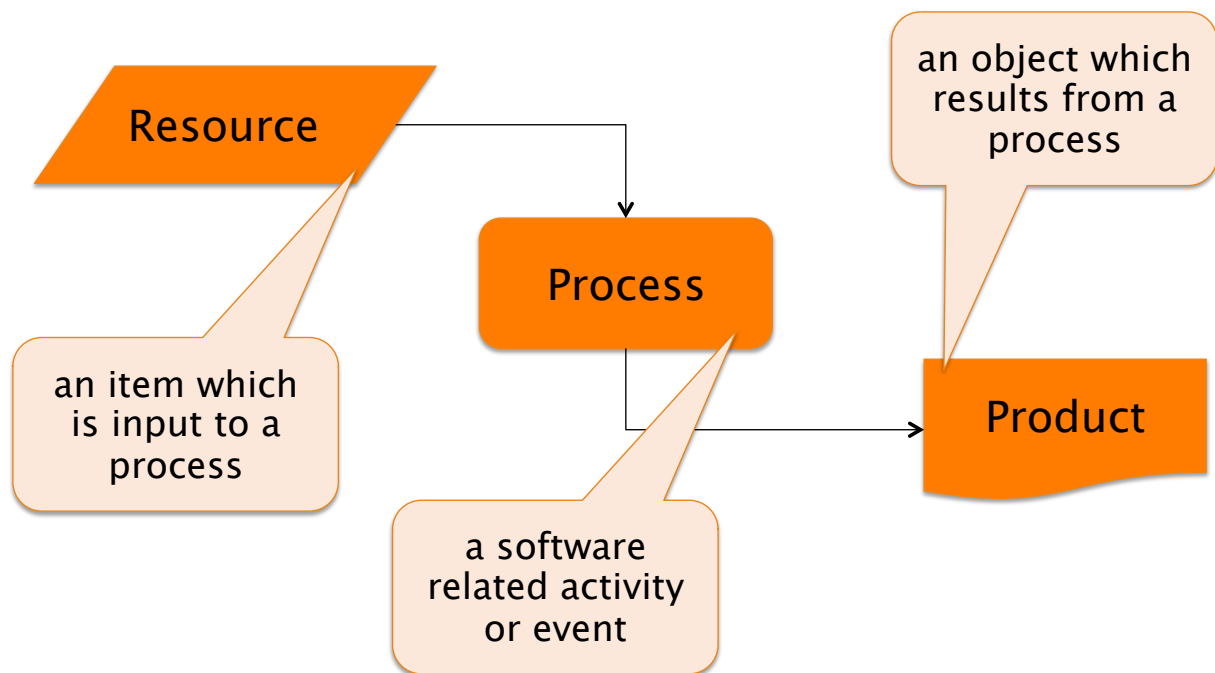
# Predictive measurement

---

- Requires a *prediction system*
  - ♦ Mathematical model
    - e.g. ‘ $E=as^b$ ’ where  $E$  is effort in person months (to be predicted),  $S$  is size (LOC), and  $a$  and  $b$  are constants.
  - ♦ Procedures for determining model parameters
    - e.g. ‘Use regression analysis on past project data to determine  $a$  and  $b$ ’.
  - ♦ Procedures for interpreting the results
    - e.g. ‘Use Bayesian probability to determine the likelihood that your prediction is accurate to within 10%’

# Entity classes

---



## Internal vs. External

---

Given an entity (process, product, or resource)

- Internal attributes can be measured purely in terms of the entity itself
  - ♦ e.g. length or complexity of source code (product)
- External attributes can only be measured with respect to how the entity relates to its environment
  - ♦ e.g. reliability or maintainability of source code (product)

# Metrics

	Attributes	
Entities	Internal	External
<b>PRODUCTS</b> <i>Specification</i> <i>Source Code</i> ....	Length, functionality modularity, structuredness, reuse ....	maintainability reliability .....
<b>PROCESSES</b> <i>Design</i> <i>Test</i>	time, effort, #spec faults found ....	stability cost- effectiveness .. ..
<b>RESOURCES</b> <i>People, Tools</i>	age, price, CMM level price, size ....	productivity usability, quality ....

15

## BASIC MEASUREMENT THEORY

16



# Evolution of measures

---

- More sophisticated measures can be defined as understanding of an attribute grows
- E.g. temperature of liquids:
  - ♦ 200BC: rankings, “hotter than”
  - ♦ 1600: first thermometer still “hotter than”
  - ♦ 1720: Fahrenheit scale
  - ♦ 1742: Centigrade scale
  - ♦ 1854: Absolute zero, Kelvin scale

# Measurement theory

---

- Scientific basis to determine formally:
  - ♦ When we have really defined a measure
  - ♦ Which statements involving measurement are meaningful
  - ♦ What the appropriate scale type is
  - ♦ What types of statistical operations can be applied to measurement data

# Empirical relation system

---

- The **relations** about entities, observed in the real world, which characterize our understanding of the attribute under consideration
  - ♦ e.g. 'Fred taller than Joe'
    - Entity: people
    - Attribute height

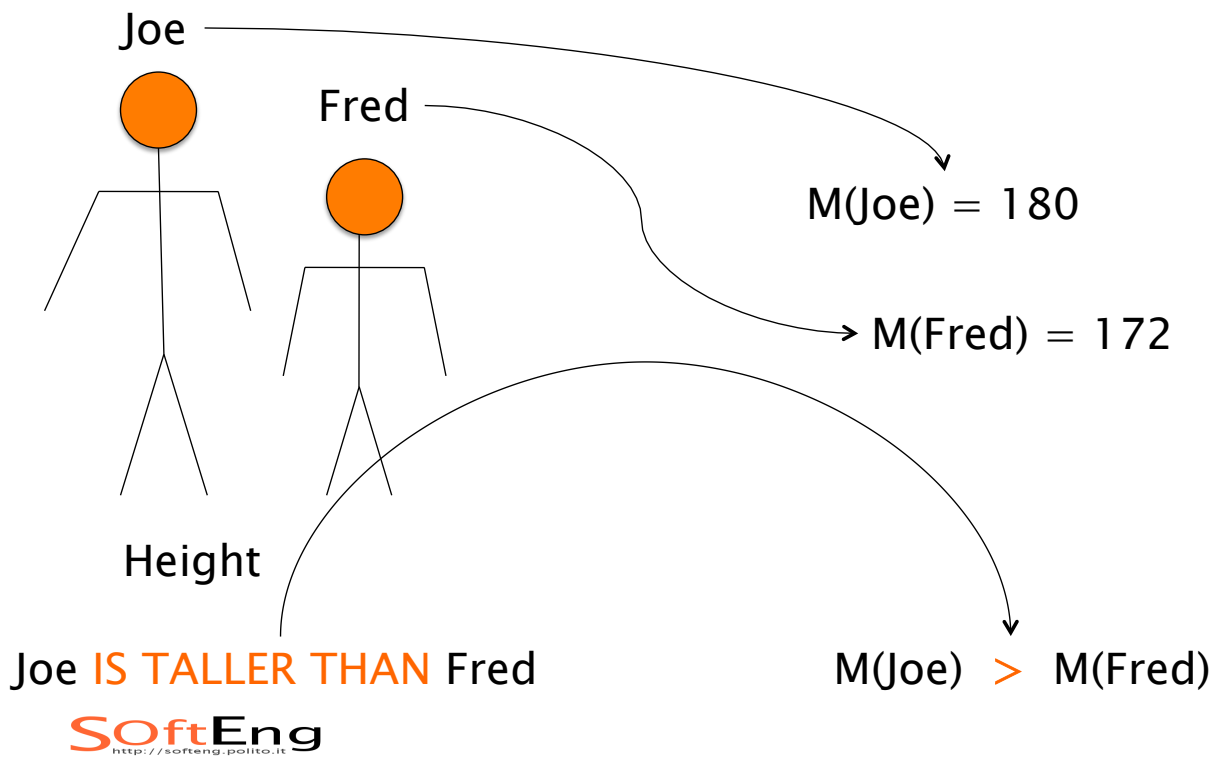
# Measurement mapping

---

- Mapping from the empirical world to the formal world
  - ♦ Measure
  - ♦ Relation mapping
- A.k.a. representation, homomorphism
- Measure: the quantity assigned to an entity in order to characterize an attribute

# Measurement mapping

---



21

# Representation condition

---

- Measurement mapping implies that all empirical relations are preserved in numerical relations and no new relations are created
  - ♦ e.g.  $M(\text{Fred}) > M(\text{Joe})$  precisely when Fred is taller than Joe

22

---

# MEASUREMENT SCALES

## Issues

---

- Representation problem
  - ◆ How do we know if a particular empirical relation system has a representation in a given numerical relation system?
- Uniqueness problem
  - ◆ How do we deal with several possible alternative representations (scales) in the same numerical relation system?
- Pragmatic problem
  - ◆ Which is the preferred numerical relation system for a given empirical relation system?

# Relation system richness

---

- RS A is richer than RS B if at least all relations in RS B are contained in RS A
- The richer the empirical system the more sophisticated the scale

# Scale types

---

- Nominal
- Ordinal
- Interval
- Ratio
- Absolute



# Admissible measure

---

- Measure that is able to represent all the empirical relations
  - ♦ There may exist several admissible measure
    - E.g. Length: inch, cm, feet, meter, miles
- Admissible transformation
  - ♦ Mapping between two admissible measures
  - ♦ The more sophisticated the scale the more restricted the class of admissible transformation
    - E.g. Admissible Length transformation:  $M' = a * M$
    - Inadmissible transformation:  $M' = a * M + b$


# Nominal scale

---

- Places elements in classification schema
- Empirical scale: different classes
  - ♦ No ordering relation
- Any representation based on a set of distinct numbers or symbols is acceptable
  - ♦ No notion of magnitude

# Nominal scale example

---

- Empirical system
  - ♦ Entity: fault
  - ♦ Attribute: artifact type
    - Specification, design, code
- Admissible mapping
  - ♦  $M(x) =$ 
    -  S if x is a specification fault
    - D if x is a design fault
    - C if x is a code fault

# Ordinal scale

---

- Empirical system: classes ordered wrt the attribute
- Acceptable mapping: any mapping preserving the order
  - ♦ Measure represent ranking only
  - ♦ Acceptable transformations are the set of all monotonic mappings
  - ♦  $\langle C_1, C_2, \dots, C_n \rangle \rightarrow \langle a_1, a_2, \dots, a_n \rangle$
  - ♦ Where  $\forall i > j, a_i > a_j$

# Ordinal scale example

---

- Empirical system
  - ♦ Entity: code
  - ♦ Attribute: size class
    - Small, medium, large
- Admissible mapping
  - ♦  $M(x) =$ 
    - 1 if x is small
    - 2 if x is medium
    - 3 if x is large

# Interval scale

---

- Empirical system: order and differences between classes
- Acceptable mappings: preserve order and difference
  - ♦ Addition and subtraction make sense
  - ♦ The ratio makes no sense
- Acceptable transformations are affine transformations
  - ♦  $M' = a * M + b$



# Interval scale example

---

- Empirical system
  - ♦ Entity: project activity
  - ♦ Attribute: time of start
    - Months since the beginning of the project
    - Years since funding available
- Admissible transformation
  - ♦ PM counts month since project start:
    - April 1, 2010
  - ♦ CEO counts years since received funds:
    - January 1, 2011
  - ♦  $M_{PM} = 12 * M_{CEO} + 9$

# Ratio scale

---

- Preserves ordering, size of intervals, and ratios between entities
- There is a **zero** element
  - ♦ Represents total lack of attribute
  - ♦ Measurement starts at zero and increases at equal intervals: called **units**
  - ♦ All arithmetic can be applied meaningfully to classes in the range of the mapping
- Admissible transformation
  - ♦ Ratio transformation
  - ♦  $M' = a * M$

# Ratio scale example

---

- Empirical system
  - ♦ Entity: code
  - ♦ Attribute: length
    - LOC
- Admissible transformation
  - ♦  $M_{LOC} = \text{lines of code}$
  - ♦  $M_{Char} = \text{characters of code}$
  - ♦  $M_{Char} = a * M_{LOC}$ 
    - Where a = average chars per line of code

# Absolute scale

---

- Measurement made simply counting items in the entity set
  - ♦ Number of occurrences
  - ♦ Only one possible mapping
  - ♦ All arithmetic analysis is meaningful

# Absolute scale (counter)examples

- Empirical system
  - ♦ Entity: project
  - ♦ Attribute: full time staff
    - Number of full time developers
- The attribute definition implies the items to be counted!
  - ♦ Length is not measurable on an absolute scale, # of lines it is
  - ♦ Age is not measurable on absolute scale

## Scales

Scale	Admissible Transformations	Example
Nominal	1-to-1 mapping	Labeling, classifying entities
Ordinal	Monotonic increasing function	Preference, hardness
Interval	$M' = a * M + b$ With: $a > 0$	Relative time, temperature
Ratio	$M' = a * M$ With: $a > 0$	Time interval, length
Absolute	$M' = M$	Counting entities

# Meaningful statements

---

- A statement involving measurement is meaningful if its truth is invariant of transformation of allowable scales

# Meaningful statements

---

- Statements
  - ✓ The number of errors discovered during the integration testing was at least 100
  - ◆ The cost of fixing each error is at least 100 ?
  - ✓ A semantic error takes twice as long to fix as a syntactic error
  - ◆ A semantic error is twice as complex as a syntactic error

# Meaningful statements?

---

- Fred is twice as tall as Jane
- The temperature in Tokyo today is twice that in London
- The difference in temperature between Tokyo and London today is twice what it was yesterday

# Statistical operations

---

- Central tendency

Type	Mean	Median	Mode
Nominal	✗	✗	✓
Ordinal	✗	✓	✓
Interval	✓	✓	✓
Ratio	✓	✓	✓
Absolute	✓	✓	✓

# Objective vs. Subjective

---

- Objective measures do not depend on the environment or the person collecting the measure
  - ♦ A small portion of subjectivity cannot be avoided
- Subjective measures depend on the context where they are collected
  - ♦ Can change according to the person
  - ♦ They reflect the perception and judgment of the person performing the measurement

---

## SOFTWARE MEASURES

# Process measures

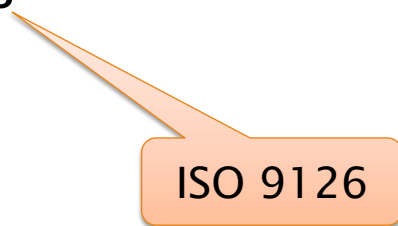
---

- Duration
  - ◆ Of process or one of its activities
- Effort
  - ◆ Of process or one of its activities
- Number of events
  - ◆ Of a given type
  - ◆ Arising during process or one of its activities
- Subjective measures

# Product measures

---

- External attributes
  - ◆ Reliability
  - ◆ Understandability
  - ◆ Usability
  - ◆ Integrity
  - ◆ Efficiency
  - ◆ Testability
  - ◆ Reusability
  - ◆ Portability



ISO 9126

# Quality myth

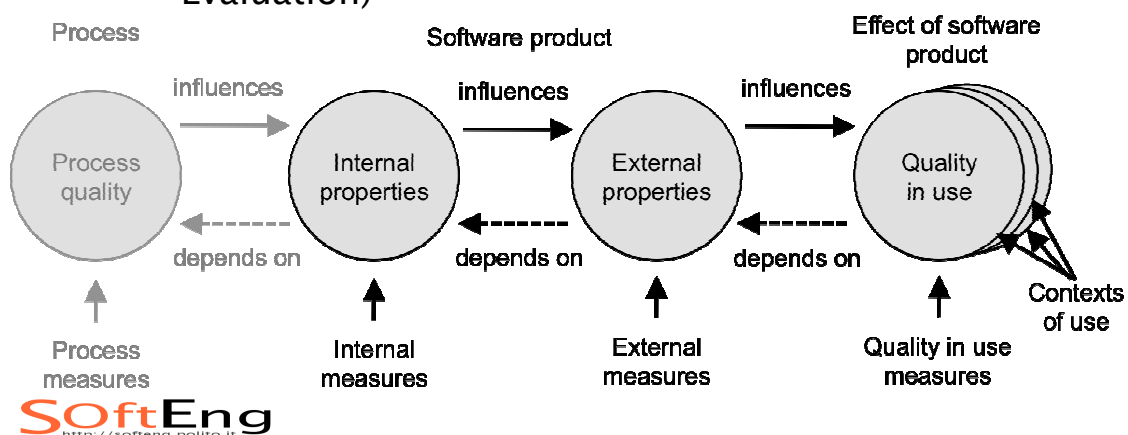
---

- Term used to describe an internal attribute
- Inherently multidimensional
  - ♦ There are several aspects to quality
  - ♦ A single aggregate (indirect) measure of quality implies weighting all different aspects

# ISO 9126

---

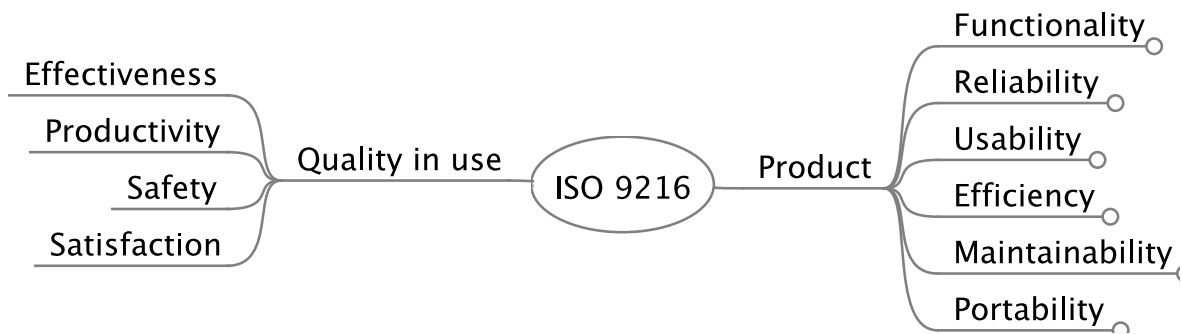
- Software product quality
  - ♦ Issued 1991, revised 2001
  - ♦ Being replace by ISO/IEC 250xx
    - SQuARE (Software product Quality Requirements and Evaluation)





# ISO 9126

---



**SoftEng**  
http://softeng.polito.it

---

## ISO 9126 – External measure

---

### ▪ Breakdown avoidance

Purpose	How often can user avoid breakdown of system, even if critical failures occurred?
Method of application	Count the number of breakdowns occurrence with respect to number of failures. If it is under operation, analyze log of user operation history.
Definition	Breakdown avoidance ratio $X = 1 - (A / B)$ A= Number of breakdowns B= Number of failures NOTE: 1.The breakdown means executing of any user task is suspended until system is restarted up, or its control is lost until system is enforced to be shut down. 2. When none or a few failures observed, time between breakdown may be more suitable.
Interpretation	$0 \leq X \leq 1$ The closer to 1.0 is the better.

---

# ISO 9126 – Internal measure

---

- Test coverage

<b>Purpose</b>	How much of the required test cases are covered by the test plan?
<b>Method of application</b>	Count the number of test cases planned and compare it to the number of test cases required to obtain adequate test coverage.
<b>Definition</b>	$X=A/B$  A=Number of test cases designed in test plan and confirmed in review B= Number of test cases required
<b>Interpretation</b>	$0 \leq X$ Where X is the greater the better adequacy

---

## Product measures

---

- Internal attributes
  - ◆ Few simple and easy to measure
    - E.g. size
  - ◆ Other controversial
    - E.g. complexity
  - ◆ Automated measurement

# Internal Product Attributes

---

- Methodologies address structuring and improvement of software products in terms of
  - ◆ Development process
  - ◆ Products
    - Typically characterized by internal attributes
- Quality assurance
  - ◆ Internal attributes can be measured during development to predict and control external ones

# Resources

---

- Input for sw development
  - ◆ Personnel
    - Individuals and teams
  - ◆ Materials
    - E.g. office supplies
  - ◆ Tools
    - Both HW and SW
  - ◆ Methods

# Resource metrics

---

- Magnitude
  - ♦ E.g. How many staff?
- Cost
  - ♦ E.g. Payments for testing tools
- Quality
  - ♦ E.g. Experience of developers

- Productivity =  $\frac{\text{Amount of output}}{\text{Effort input}}$ 
  - ♦ Indirect measure

Product

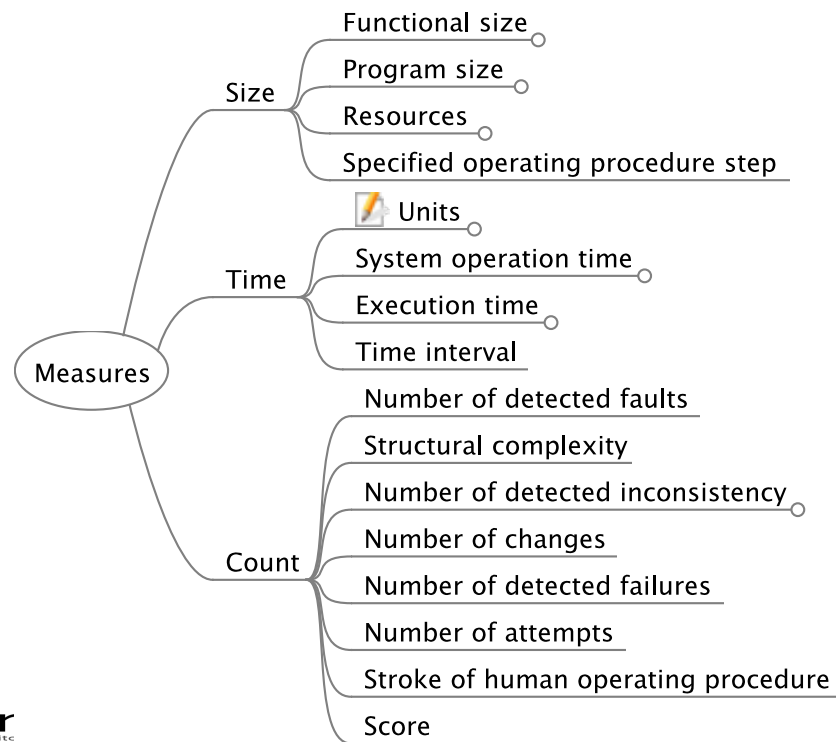
Process

---

## COMMON METRICS

# Common measures

---



## Lines Of Code (LOC)

---

- Most intuitive
  - ♦ Count the number of lines of code
- Operational aspects
  - ♦ What to include/exclude in the count?
  - ♦ How to deal with complex lines?

# LOC – Operational aspects

---

- Inclusion/exclusion
  - ♦ Executable lines
  - ♦ Declarations
  - ♦ Comments
  - ♦ COTS
  - ♦ Automatically generated code
  - ♦ Reused code
- Multiple instructions on a line
  - ♦ Number of statements
  - ♦ Number of lines

## LOC: Pros & Cons

---

- Easy to understand 😊
- Hard to measure precisely 😞
  - ♦ Easy of an approximate measure 😊
    - e.g. `wc -l *.c`
- Very widely used 😊
  - ♦ Several predictive models use LOC 😊
- If measures productivity it does not favors well structured programs 😞

# Mc Cabe Cyclomatic Complexity

---

- Complexity of the control flow
- Control flow is represented as a Control Flow Graph (CFG)
- $V(G)$  is the number of base paths in  $G$ 
  - ♦ The number of linearly independent paths from initial node to final node

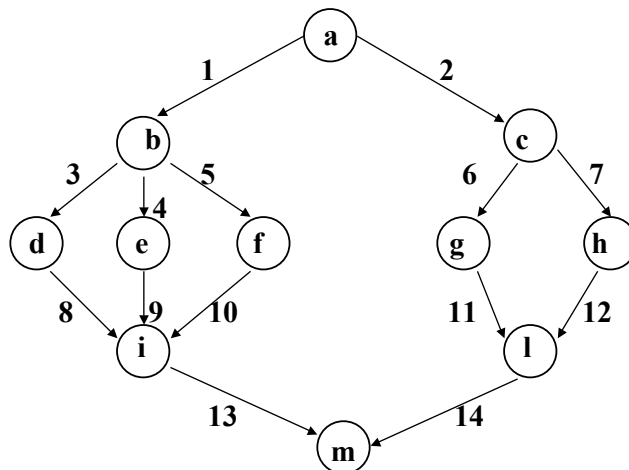
# Cyclomatic number

---

- If  $G$  is a strongly connected graphs
  - ♦  $V(G) = \#E - \#N + 1$
- A typical CFG is not strongly connected, unless we add an edge from the final to the initial node
  - ♦  $V(G) = \#E - \#N + 2$

# Cyclomatic complexity

---



$$V(G) = E - N + 2 = 14 - 11 + 2 = 5$$

C1: 1,3,8,13
C2: 1,4,9,13
C3: 1,5,10,13
C4: 2,6,11,14
C5: 2,7,12,14

## McCabe Pros & Cons

---

- Well defined from a mathematical point of view
- Typically strongly correlated with LOC
- Focus on code complexity
  - ◆ Disregards data-related complexity



# Design Metrics – CK

---

- Chidamber and Kemerer [TSE94]:
- Weighted Methods per Class (WMC)
  - ♦ count of methods in each class
- Number Of Children per class (NOC)
  - ♦ number of immediate sub-classes of a class
- Depth of Inheritance Tree (DIT):
  - ♦ maximum inheritance path from the class to the root class
- Coupling Between Object classes (CBO)
  - ♦ number of classes to which a class is coupled

# Design Metrics – CK

---

- Response For a Class (RFC)
  - ♦ Sum of cardinalities of
    - methods in the class
    - remote methods directly called by methods of the class
- Lack of Cohesion in Methods (LCOM)
  - ♦  $LCOM = P - Q$ , if  $P > Q$   
= 0 otherwise
  - ♦ Where
    - $Q = \#$  pairs of methods sharing attributes
    - $P = \#$  pairs of methods not sharing attributes

# LCOM – Henderson–Sellers

---

- Alternative definition of LCOM

$$LCOM2 = 1 - \frac{\sum mA_i}{m \cdot a}$$

- Where
  - ♦ m: number of methods in class
  - ♦ a: number of attributes in class
  - ♦ mA<sub>i</sub>: num. of methods using attribute A<sub>i</sub>

# CK – Pros & Cons

---

- Theoretical validation lacking ☹️
- Empirical validation lacking ☹️
- Not all metrics can be easily computed
  - ♦ RFC e LCOM need implementation details
    - Design or code metrics?

# Bibliography

---

- N. Fenton, S. Pfleeger. “Software Metrics: A Rigorous Approach”. PWS Publishing, 1998.
- S.R. Chidamber, C.F. Kemerer. “A Metrics Suite for Object-Oriented Design” IEEE Transactions on Software Engineering 20(6), 1994.
- T. McCabe “A complexity measure” IEEE Transactions on Software Engineering 2(4), 1976.
- V. Basili, L. Briand, W. Melo. “A Validation of Object-Oriented Design Metrics as Quality Indicators” IEEE Transactions on Software Engineering 22(10), 1996

## License (1)

---

- THE WORK (AS DEFINED BELOW) IS PROVIDED UNDER THE TERMS OF THIS CREATIVE COMMONS PUBLIC LICENSE (“CCPL” OR “LICENSE”). THE WORK IS PROTECTED BY COPYRIGHT AND/OR OTHER APPLICABLE LAW. ANY USE OF THE WORK OTHER THAN AS AUTHORIZED UNDER THIS LICENSE OR COPYRIGHT LAW IS PROHIBITED.
- BY EXERCISING ANY RIGHTS TO THE WORK PROVIDED HERE, YOU ACCEPT AND AGREE TO BE BOUND BY THE TERMS OF THIS LICENSE. THE LICENSOR GRANTS YOU THE RIGHTS CONTAINED HERE IN CONSIDERATION OF YOUR ACCEPTANCE OF SUCH TERMS AND CONDITIONS.
- **1. Definitions**
  - **“Collective Work”** means a work, such as a periodical issue, anthology or encyclopedia, in which the Work in its entirety in unmodified form, along with a number of other contributions, constituting separate and independent works in themselves, are assembled into a collective whole. A work that constitutes a Collective Work will not be considered a Derivative Work (as defined below) for the purposes of this License.
  - **“Derivative Work”** means a work based upon the Work or upon the Work and other pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which the Work may be recast, transformed, or adapted, except that a work that constitutes a Collective Work will not be considered a Derivative Work for the purpose of this License. For the avoidance of doubt, where the Work is a musical composition or sound recording, the synchronization of the Work in timed-relation with a moving image (“synching”) will be considered a Derivative Work for the purpose of this License.
  - **“Licensor”** means the individual or entity that offers the Work under the terms of this License.
  - **“Original Author”** means the individual or entity who created the Work.
  - **“Work”** means the copyrightable work of authorship offered under the terms of this License.
  - **“You”** means an individual or entity exercising rights under this License who has not previously violated the terms of this License with respect to the Work, or who has received express permission from the Licensor to exercise rights under this License despite a previous violation.
- **2. Fair Use Rights.** Nothing in this license is intended to reduce, limit, or restrict any rights arising from fair use, first sale or other limitations on the exclusive rights of the copyright owner under copyright law or other applicable laws.
- **3. License Grant.** Subject to the terms and conditions of this License, Licensor hereby grants You a worldwide, royalty-free, non-exclusive, perpetual (for the duration of the applicable copyright) license to exercise the rights in the Work as stated below:
  - a. to reproduce the Work, to incorporate the Work into one or more Collective Works, and to reproduce the Work as incorporated in the Collective Works;
  - b. to distribute copies or phonorecords of, display publicly, perform publicly, and perform publicly by means of a digital audio transmission the Work including as incorporated in Collective Works;The above rights may be exercised in all media and formats whether now known or hereafter devised. The above rights include the right to make such modifications as are technically necessary to exercise the rights in other media and formats, but otherwise you have no rights to make Derivative Works. All rights not expressly granted by Licensor are hereby reserved, including but not limited to the rights set forth in Sections 4(d) and 4(e).

# License (2)

---

- **4. Restrictions.** The license granted in Section 3 above is expressly made subject to and limited by the following restrictions:
  - a. You may distribute, publicly display, publicly perform, or publicly digitally perform the Work only under the terms of this License, and You must include a copy of, or the Uniform Resource Identifier for, this License with every copy or phonorecord of the Work You distribute, publicly display, publicly perform, or publicly digitally perform. You may not offer or impose any terms on the Work that alter or restrict the terms of this License or the recipients' exercise of the rights granted hereunder. You may not sublicense the Work. You must keep intact all notices that refer to this License and to the disclaimer of warranties. You may not distribute, publicly display, publicly perform, or publicly digitally perform the Work with any technological measures that control access or use of the Work in a manner inconsistent with the terms of this License Agreement. The above applies to the Work as incorporated in a Collective Work, but this does not require the Collective Work apart from the Work itself to be made subject to the terms of this License. If You create a Collective Work, upon notice from any Licensor You must, to the extent practicable, remove from the Collective Work any credit as required by clause 4(c), as requested.
  - b. You may not exercise any of the rights granted to You in Section 3 above in any manner that is primarily intended for or directed toward commercial advantage or private monetary compensation. The exchange of the Work for other copyrighted works by means of digital file-sharing or otherwise shall not be considered to be intended for or directed toward commercial advantage or private monetary compensation, provided there is no payment of any monetary compensation in connection with the exchange of copyrighted works.
  - c. If you distribute, publicly display, publicly perform, or publicly digitally perform the Work, You must keep intact all copyright notices for the Work and provide, reasonable to the medium or means You are utilizing: (i) the name of the Original Author (or pseudonym, if applicable) if supplied, and/or (ii) if the Original Author and/or Licensor designate another party or parties (e.g. a sponsor institute, publishing entity, journal) for attribution in Licensor's copyright notice, terms of service or by other reasonable means, the name of such party or parties; the title of the Work if supplied; and to the extent reasonably practicable, the Uniform Resource Identifier, if any, that Licensor specifies to be associated with the Work, unless such URI does not refer to the copyright notice or licensing information for the Work. Such credit may be implemented in any reasonable manner; provided, however, that in the case of a Collective Work, at a minimum such credit will appear where any other comparable authorship credit appears and in a manner at least as prominent as such other comparable authorship credit.
  - d. For the avoidance of doubt, where the Work is a musical composition:
    - i. **Performance Royalties Under Blanket Licenses.** Licensor reserves the exclusive right to collect, whether individually or via a performance rights society (e.g. ASCAP, BMI, SESAC), royalties for the public performance or public digital performance (e.g. webcast) of the Work if that performance is primarily intended for or directed toward commercial advantage or private monetary compensation.
    - ii. **Mechanical Rights and Statutory Royalties.** Licensor reserves the exclusive right to collect, whether individually or via a music rights agency or designated agent (e.g. Harry Fox Agency), royalties for any phonorecord You create from the Work ("cover version") and distribute, subject to the compulsory license created by 17 USC Section 115 of the US Copyright Act (or the equivalent in other jurisdictions), if Your distribution of such cover version is primarily intended for or directed toward commercial advantage or private monetary compensation.
  - **Webcasting Rights and Statutory Royalties.** For the avoidance of doubt, where the Work is a sound recording, Licensor reserves the exclusive right to collect, whether individually or via a performance-rights society (e.g. SoundExchange), royalties for the public digital performance (e.g. webcast) of the Work, subject to the compulsory license created by 17 USC Section 114 of the US Copyright Act (or the equivalent in other jurisdictions), if Your public digital performance is primarily intended for or directed toward commercial advantage or private monetary compensation.

# License (3)

---

- **5. Representations, Warranties and Disclaimer**
- UNLESS OTHERWISE MUTUALLY AGREED BY THE PARTIES IN WRITING, LICENSOR OFFERS THE WORK AS-IS AND MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND CONCERNING THE WORK, EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING, WITHOUT LIMITATION, WARRANTIES OF TITLE, MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, NON-INFRINGEMENT, OR THE ABSENCE OF LATENT OR OTHER DEFECTS, ACCURACY, OR THE PRESENCE OF ABSENCE OF ERRORS, WHETHER OR NOT DISCOVERABLE. SOME JURISDICTIONS DO NOT ALLOW THE EXCLUSION OF IMPLIED WARRANTIES, SO SUCH EXCLUSION MAY NOT APPLY TO YOU.
- **6. Limitation on Liability.** EXCEPT TO THE EXTENT REQUIRED BY APPLICABLE LAW, IN NO EVENT WILL LICENSOR BE LIABLE TO YOU ON ANY LEGAL THEORY FOR ANY SPECIAL, INCIDENTAL, CONSEQUENTIAL, PUNITIVE OR EXEMPLARY DAMAGES ARISING OUT OF THIS LICENSE OR THE USE OF THE WORK, EVEN IF LICENSOR HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.
- **7. Termination**
  - a. This License and the rights granted hereunder will terminate automatically upon any breach by You of the terms of this License. Individuals or entities who have received Collective Works from You under this License, however, will not have their licenses terminated provided such individuals or entities remain in full compliance with those licenses. Sections 1, 2, 5, 6, 7, and 8 will survive any termination of this License.
  - b. Subject to the above terms and conditions, the license granted here is perpetual (for the duration of the applicable copyright in the Work). Notwithstanding the above, Licensor reserves the right to release the Work under different license terms or to stop distributing the Work at any time; provided, however that any such election will not serve to withdraw this License (or any other license that has been, or is required to be, granted under the terms of this License), and this License will continue in full force and effect unless terminated as stated above.
- **8. Miscellaneous**
  - a. Each time You distribute or publicly digitally perform the Work or a Collective Work, the Licensor offers to the recipient a license to the Work on the same terms and conditions as the license granted to You under this License.
  - b. If any provision of this License is invalid or unenforceable under applicable law, it shall not affect the validity or enforceability of the remainder of the terms of this License, and without further action by the parties to this agreement, such provision shall be reformed to the minimum extent necessary to make such provision valid and enforceable.
  - c. No term or provision of this License shall be deemed waived and no breach consented to unless such waiver or consent shall be in writing and signed by the party to be charged with such waiver or consent.
  - d. This License constitutes the entire agreement between the parties with respect to the Work licensed here. There are no understandings, agreements or representations with respect to the Work not specified here. Licensor shall not be bound by any additional provisions that may appear in any communication from You. This License may not be modified without the mutual written agreement of the Licensor and You.