Software Metrics

SE 611

Outline of The Course

- **Module 1:** Measurement theory
- **Module 2:** Software product and process measurements
- **Module 3:** Measurement management

Measurement Theory

- The basics of measurement
- Overview of software measurement metrics
- Framework for software measurement
- Empirical investigation
- Analyzing software measurement data

Software Measurement

- Measuring Internal Product Attributes: Size and Structure
- Measuring External Product Attributes
- Making Process Predictions: estimate effort, size, release date
- Software Reliability: Measurement and Prediction

Measurement Management

- Planning measurement
- Resource management: productivity, teams, and tool
- Support for measurement

End of This Course…

- What is software measurement about?
- Why software measurement is important
- What does empirical investigation mean in the SE context
- What is software measurement metrics
- What is software measurement process
- How to implement a software measurement plan
- Challenges and difficulties of applying software metrics

Chapter 1: Measurement

- Measurement: What Is It and Why Do It?
- What is Software Metrics
- Scope of Software Metrics

Measurement

- *Measurement* is the process by which numbers or symbols are assigned to *attributes of entities* in the real world in such a way so as to describe them according to clearly defined rules.
- Thus, measurement captures information about *attributes* of *entities*.
- An *Entity* is an object or event in the real world
- An *attribute* is a feature or property of an *entity*
- Two general types of attributes in SE*: Internal (e.g., code, size, and modularity)* and *External (e.g., reliability, maintainability)*
- The accuracy depends on the measuring instrument (or metrics)

Measurement in Software Engineering

- *Measurement* in SE is selecting, measuring, and putting together many different attributes of the software and adding our subjective interpretation in order to get a whole picture of the software
- A good software must be reliable, user-friendly, and maintainable
- So? Is measurements necessary?
- What are the effect of neglecting proper measuring in SE?

Neglecting of Measurement in SE

- Failure to set measurable targets for the product (e.g., how user-friendly, reliable, and maintainable a product is)
- Failure to understand and quantify the component costs of a software project, e.g., difference between design cost, coding cost, testing cost
- Failure to quantify or predict the quality of product. Thus potential user can not be informed how reliable a product is.

Metrics

- Metrics are standards (i.e., commonly accepted scales, measurements or quantifiable indicators) that define measurable attributes of entities, their units, and their scopes.
- *Software Metrics* are measures that are used to quantify software, software development resources, and/or the software development process
- Common Software metrics: size metrics, effort metrics, quality metrics, productivity metrics, maintainability, and reliability metrics.
- *"What is Not Measurable Make Measurable"*

Mathematical Perspective of Metrics

- A metrics is a function m defined on pairs of objects x and y such that $m(x,y)$ represent the distance between x and y. Such metric must satisfy certain properties
  - $m(x, x) = 0$ for all x
  - $m(x, y) = m(y, x)$
  - $m(x, z) <= m(x, y) + m(y, z)$ for all x, y, and z

Software Metrics Challenges

- SE Metrics are mostly non-physical
  - *Reliability, maturity, portability, flexibility, maintainability, etc., and relations are unknown*
    - Choosing the right metrics can be challenging.
    - Gathering accurate and reliable data for metrics can be a challenge.
    - Tracking too many metrics can overwhelm teams and make it difficult to focus on the most important aspects.
    - Metrics may not capture all relevant aspects of software development, and they can be influenced by subjective judgments and biases.
    - There is a risk of metric manipulation, where individuals or teams may intentionally or unintentionally manipulate metrics to present a favourable picture
    - Software projects and technologies evolve rapidly, and metrics that were once effective may become outdated or less relevant over time.

Objective of Software Measurement

- From manager perspective
  - *How does each process cost?*
  - *How productive is the staff?*
  - *How good is the code being developed?*
  - *Will the user be satisfied with the product?*
  - *How can we improve?*
- From developer perspective
  - *Are the requirements testable?*
  - *Have we found all the faults?*
  - *Have we meet product or process goals?*
  - *What will happen in the future?*

Scope of Software Metrics

- Cost and effort estimation models and measures
- Data collection
- Quality models and measures
- Reliability models
- Security metrics
- Structural and complexity metrics
- Capability maturity assessment
- Evaluation of methods and tools

Scope of Software Metrics/1

Cost and effort estimation models and measures

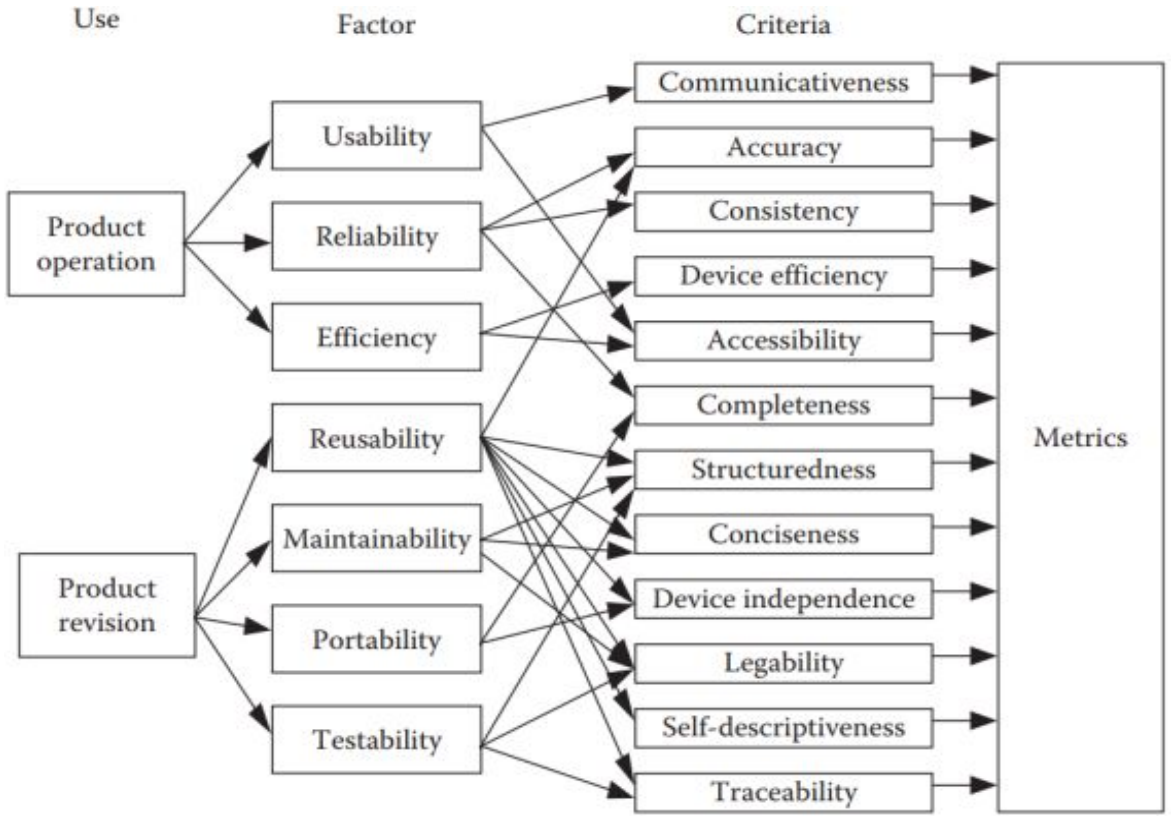
- Software cost estimation is the process of predicting the amount of effort required to build a software system.
- Estimates for project cost and time requirements are derived during the planning stage of a project.
- Models used to estimate cost can be categorized as either cost models (e.g., Constructive Cost Model COCOMO) or constraint models (e.g., SLIM).
- Experience is often the only guide used to derive these estimates, but it may be insufficient if the project breaks new ground.
- Many models are available as automated tools.

Scope of Software Metrics/2

- Data collection
  - Very critical and very hard step.
    - What data should be collected?
    - How it should be collected?
    - Is collected data reproducible?
  - **Example:** software failure data collection
    1) Time of failure
    2) Time interval between failures
    3) Cumulative failure up to a given time
    4) Failures experienced in a time interval

Scope of Software Metrics/3

- Quality models and measures



Scope of Software Metrics/4

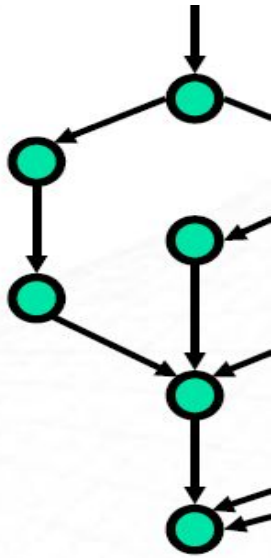
- Reliability models
  - Plot the change of failure intensity (λ) against time.
  - Many models are proposed. The most famous ones are basic exponential model and logarithmic Poisson model.
  - The basic exponential model assumes finite failures in infinite time; the logarithmic Poisson model assumes infinite failures.
  - Automated tools such as CASRE are available.

Scope of Software Metrics/5

- Security metrics
  - Security depends on both the internal design of a system and the nature of the attacks that originate externally.
  - To assess security risks in terms of impact, likelihood, threats, and vulnerabilities.

Scope of Software Metrics/6

- Structural and complexity metrics



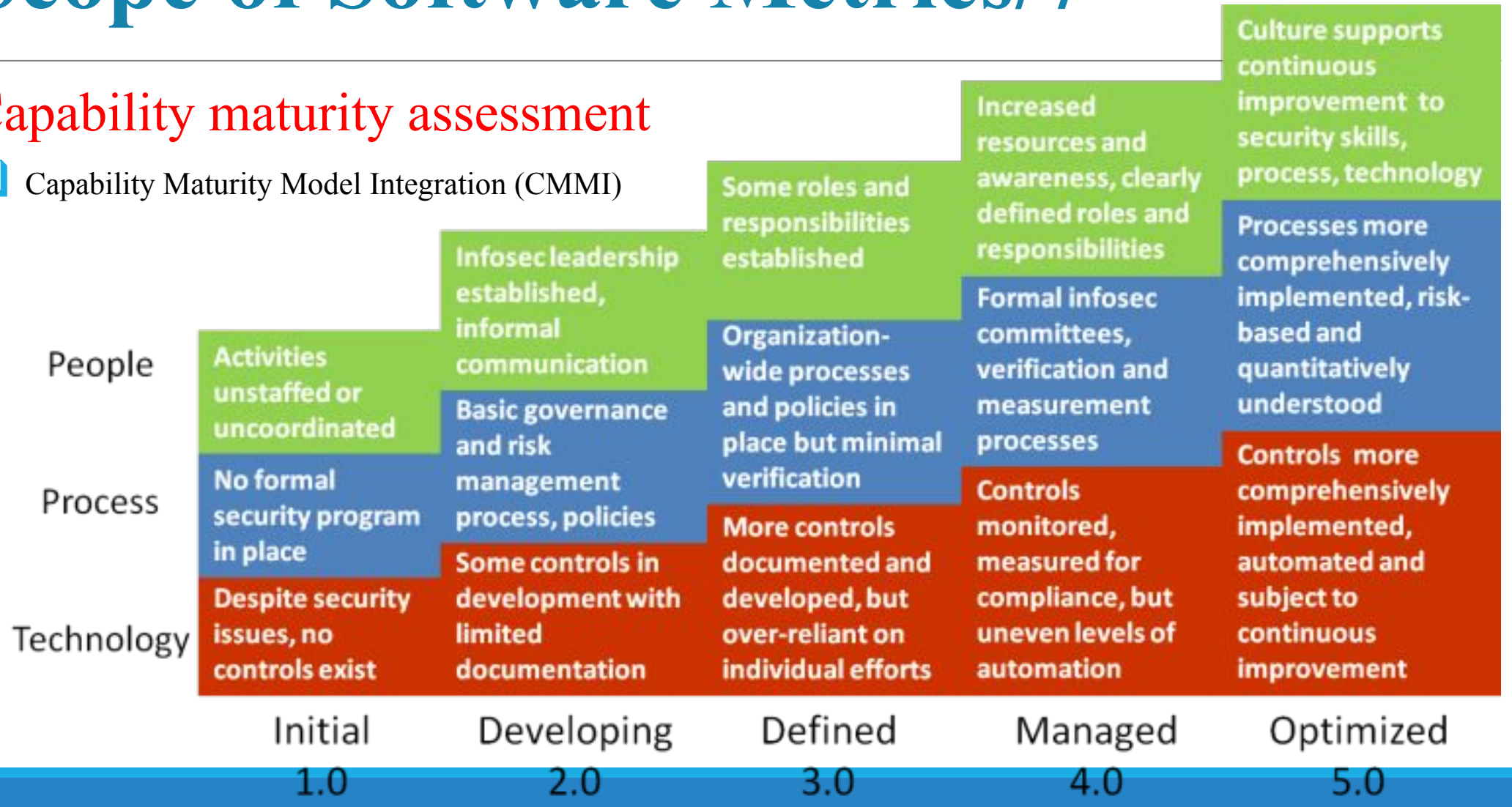
- Control-flow structure
- Data-flow structure
- Data structure
- Information flow attributes

Complexity metrics (1979~)

- Cyclomatic complexity (McCabe 1989) defining number of independent paths in execution of a program

Scope of Software Metrics/7

- Capability maturity assessment
  - Capability Maturity Model Integration (CMMI)



Scope of Software Metrics/8

- Evaluation of methods and tools
  - Efficiency of methods (1991~)
  - Efficiency and reliability of tools
  - Certification test of acquired tools and components
  - Benchmarking

Eight Steps of Measurement Program

The eight steps required to implement a software measurement program are:

- Document the software development process
- State the goals
- Define metrics required to reach goals ← GQM
- Identify data to collect
- Define data collection procedures
- Assemble a metrics toolset
- Create a metrics database
- Define the feedback mechanism

End of Chapter 1