The University of Western Australia
School of Computer Science and Software Engineering

CITS5502 Software Processes

Lecture 4

Revision of Measurement Theory

Key concepts

- What is a Metric?
  - Measurement of some abstract property of a system or process
  - Relationship of *Precision*, *Accuracy*, and *Relevance*
  - Mathematical axioms for a metric
  - Desirable properties of a metric
- Purpose of Metrics
  - Prediction; Control; Improvement; Optimization
- Aspects of definition of a metric
  - Measurement leads to improvement
  - Non-measurement leads to deterioration
  - Metrics must be aligned with organizational objectives

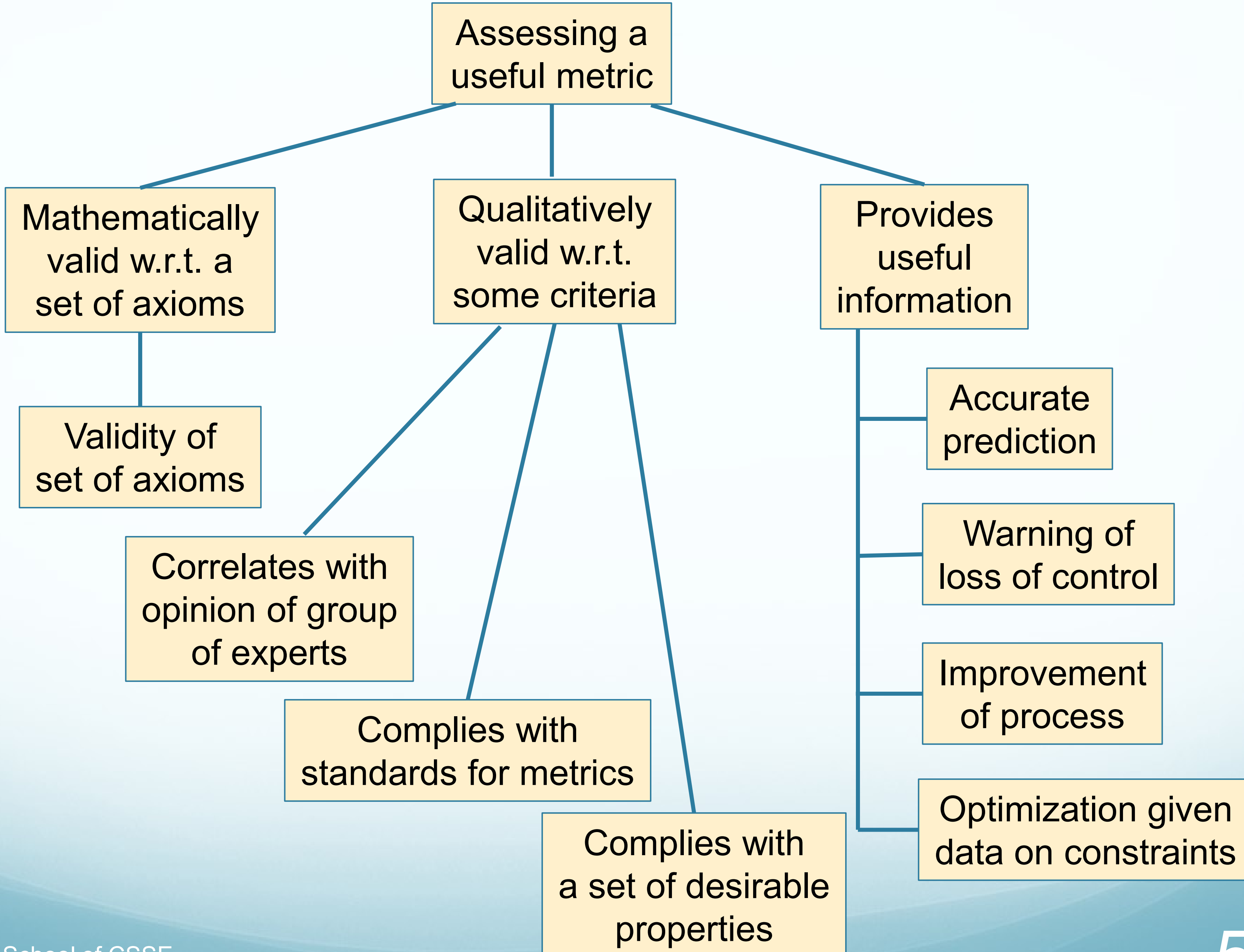
Key concepts (cont.)

- Type of measurement and use – statistical methods
- Validation of metrics
  - Mathematically, Qualitative, Provides information
- Simple taxonomy of software metrics
  - Quality; Product; Process; Organization and Drivers

What is a Metric?

- A metric is a formal measurement designed to associate a number with some characteristic of the things you want to assess.

  - It is not always straightforward to define a metric on what you want to measure, e.g., *How would you measure the size of a system?*


Assessing a useful metric
Mathematically valid w.r.t. a set of axioms
Qualitatively valid w.r.t. some criteria
Provides useful information
Validity of set of axioms
Correlates with opinion of group of experts
Complies with standards for metrics
Complies with a set of desirable properties
Accurate prediction
Warning of loss of control
Improvement of process
Optimization given data on constraints

Examples

- Suppose that we want to estimate how long (in *months*) it would take to do a project, we can use the formula below to estimate the error:

$$\text{Error} = \frac{|\text{Estimate} - \text{Actual}|}{\text{Actual}}$$

  This is the **relative error** of our estimate.

- If we have n projects, then we can compute the **mean magnitude of relative error** (MMRE):

$$\text{MMRE} = \frac{1}{n}\sum_{i=1}^{n} \text{Error}_i$$

Types of Measurement

Scale Name	Operations	Examples
Nominal	Comparison	Companies Languages
Ordinal	Ranking	Preferences Relative sizes
Interval	Addition Subtraction	Time Temperature
Ratio	Multiplication Division	Length Size
Absolute		Census

Nominal and Ordinal data items may (for convenience) have numeric labels (e.g., Aboriginal=1, Caucasian=2, Mongoloid=3, Negro=4) but this does not imply that one is twice as great as another!

Examination of Data

- For statistical purposes, the distribution of a data item may be inspected by means of
  - a histogram with a mode for nominal data
  - a histogram with a median for ordinal data
  - a continuous distribution with a mean for interval, ratio, or absolute data
- Two data items of the same type may be compared by means of
  - a contingency table for nominal or ordinal data
  - a scattergram for interval, ratio, or absolute data

Examination of Data (cont.)

- Combining data items of different types produces an item with the characteristics of the lower type.
  - For example, Size (in lines of code [ratio]) multiplied by Complexity (judged on a 1 to 5 scale [ordinal]) of a piece of computer code produces a data item that looks like a ratio number but only has the precision of an ordinal number.

Desirable Properties for Software Metrics

- **Conforming to the needs of people**

1. Understandable – the measurement mechanism is easily understood by all affected parties
2. Non-threatening – focused on the artefact and not people

- **Conforming to measurement theory**

3. Objective – is independent of anyone's opinion
4. Reproducible – can be consistently repeated
5. Standardized – uses a mathematically appropriate scale
6. Formally valid – conforms to sets of mathematical axioms
7. Informally valid – is clearly related to the feature being measured – it monotonically increases as the feature rises
8. Precise – discriminates between levels of the feature measured (i.e., it is sensitive to changes at the required level of granularity)

Desirable Properties for Software Metrics (cont.)

- **Conforming to measurement theory**

  9. Robust – is not easily manipulated nor sensitive to extraneous factors
  10. Comparable – is highly correlated with other metrics purporting to measure the same feature
  11. Useful – provides information which reduces uncertainty

- **Conforming to the needs of management**

  12. Sustainable over time – is likely to be valid in the future so that trend forecasts based on the metric will be useful
  13. Scalable – can be translated into metrics for macro or micro parts of the product or process
  14. Timely – can be obtained in time for action to be taken on its message

Desirable Properties for Software Metrics (cont.)

- **Conforming to the needs of management**
  15. Effective – clearly identifies significant areas for improvement
  16. Efficient – does not consume significant resources (preferably a by-product of other activities)
  17. Relevant – supports the goals of the organization

Recommended Reading

- Royce: Appendix C “Change Metrics”
- Wysocki: Appendix J “Project Performance Reporting”
- Pressman: Sections on “FURPS” or “ISO 9126 Quality Factors”
- Sommerville: Sections “Analysis of Measurements”, “Interface Evaluation”