Department of Computer Engineering and Sciences



CSE 4621 / SWE 5620 Software Metrics

Introduction to Software Metrics

Chapter -1-

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Measurement in our Lives



 Measurement lies at the heart of many systems that govern our lives

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|----------------|-----|-------|-----------|
| | | 11 .1 | |

| Field | Concern | Metric |
|----------------------|-------------------------------|----------------------|
| Medicine | Likelihood of stroke | Blood pressure |
| Econometrics | Future inflation rate | Prime interest rate |
| Automotive mechanics | Likelihood of engine overhaul | Oil consumption rate |

Managerial

| Field | Concern | Metric |
|-------------------|--------------------------|-------------------|
| Economics | National economic health | Unemployment rate |
| Automotive design | Engine efficiency | Miles per gallon |

Evaluative

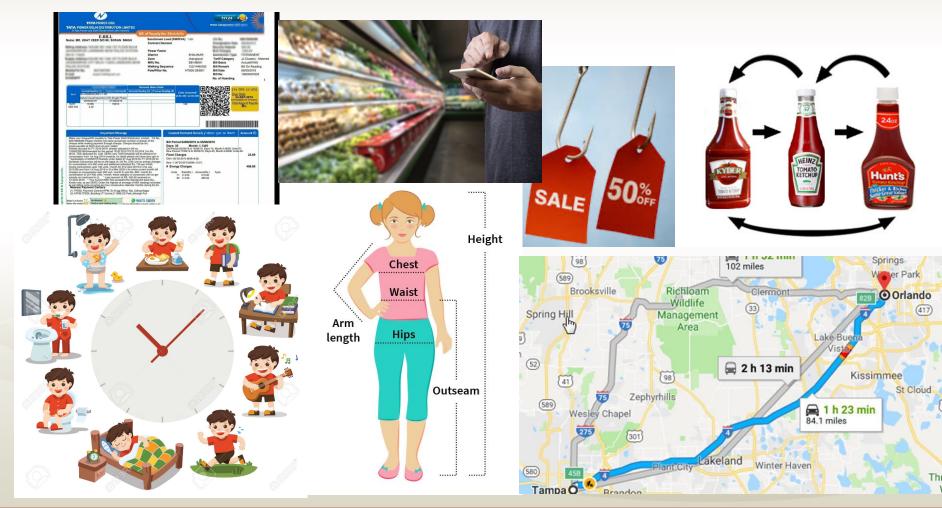
| Field | Concern | Metric |
|-------------|-----------------|--------------------------|
| Agriculture | Food production | Yield (Bushels per acre) |

Note that any metric should have an associated unit of measurement

Measurement in our Lives



 But measurement is not solely the domain of professional technologists. Each of us uses it in everyday life



Measurement: Definition



- Measurement is the process by which numbers or symbols are assigned to attributes of entities in the real world in such a way as to describe them according to defined rules
 Fenton&Bieman
- Measurement captures information about attributes of entities.

Entities & Attributes



- An entity is an object (such as a person or a room) or an event (such as a journey or the testing phase of a software project) in the real word
- An attribute is a feature, property or characteristic of an entity
 - e.g., blood pressure of a person, fuel cost of a journey, duration of the software testing phase, length of code, etc.

We measure attributes of entities

Entities & Attributes



- We describe entities by using attributes
- We often define the attributes using numbers or symbols
 - price is designated as a number of dollars
 - height is defined in terms of inches or centimeters
 - clothing size may be "small," "medium," or "large,"
 - fuel is "regular," "premium," or "super."

These numbers and symbols are abstractions that we use to reflect our perceptions of the real world.

We can make judgments about entities solely by knowing and analyzing their attributes.

Measurement: Phrases



"When you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot measure, when you cannot express it in numbers, your knowledge is of a meager and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science."

— Lord Kelvin

"What Is Not Measurable Make Measurable"

- Galileo

Measurement is Complex



- Measurement is a process whose definition is far from clear-cut
 - In a room with blue walls, is "blue" a measure of the color of the room?
 - What about other attributes of people, such as intelligence? Does an IQ test score adequately measure intelligence? Can a drink quality be measured using the ratings of experts?
 - Some measures are not likely to be accurate, either because the measurement is imprecise or because it depends on the judgment of the person doing the measuring (e.g., human intelligence)

Measurement is Complex, cont.



- Measurement is a process whose definition is far from clear-cut
 - There is often margin for error in measuring the best understood physical attributes (person's height)
 - Different scales to measure the same attribute (height)
 - Once we obtain measurements, we want to analyze them and draw conclusions about the entities from which they were derived. What kind of manipulations can we apply to the results of measurement?

Fred is twice as tall as Joe it is twice as hot today as it was yesterday average height of a London building is 200 m average of football team jersey numbers

Software Measurement



- Software engineering describes the collection of techniques that apply engineering approaches to the construction and support of software products.
- Software engineering activities include managing, costing, planning, modeling, analyzing, specifying, designing, implementing, testing, and maintaining.

By "engineering approaches," we mean that each activity is understood and controlled

Software Measurement



- Software measurements are measures that are used to quantify software products, software development resources, and/or the software development process.
- This includes items which are directly measurable, such as thousands of lines of code (LOC), as well as items which are calculated from measurements, such as car average speed or software quality.

Software Measurement



 Measurement in SE is selecting, measuring and putting together many different attributes of the software, and adding our subjective interpretations in order to get a whole picture of the software.

This is not a trivial task!

500+ metrics have been defined





Neglect of Measurement in SE



- Science and engineering can be neither effective nor practical without measurement
- measurement has been considered a luxury in software engineering. For many development projects:
 - We fail to set measurable targets for our software products.
 - We fail to understand and quantify the component costs of software projects.
 - We do not quantify or predict the quality of the products we produce.

Software Measurement?



- Software measurement is an essential component of good software engineering.
- How can you tell if your project is healthy if you have no measures of its health?
- Some best software developers measure characteristics /attributes of their software to get some sense of:
 - whether the requirements are consistent and complete
 - whether the design is of high quality
 - whether the code is ready to be released
 - whether the developers are productive
- Effective project managers measure attributes of processes and products to be able to tell when software will be ready for delivery, whether a budget will be exceeded, and whether users will be satisfied with the delivered product

Software Measurement?



- Organizations use process evaluation measurements to select software suppliers.
- Informed customers measure the aspects of the final product to determine if it meets the requirements and is of sufficient quality.
- Maintainers must be able to assess the current product to see what should be upgraded and improved.

Software Measurement is for **Understanding**, **Control**, and **Improvement**

"You cannot control what you cannot measure"

— De Marco

Software Metrics



 In software development, measurements are conducted by using metrics

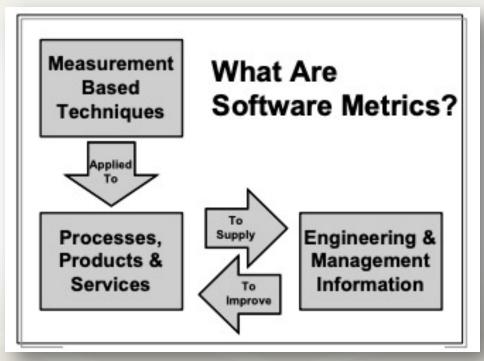
"A metric is an empirical assignment of a value to an entity aiming to describe a specific characteristic of this entity." - Michalis Xenos

- A metric is not a measurement
 - (metrics are functions, while measurements are the numbers obtained by the application of metrics)
- Metrics play a key role in good software engineering
 - Lines of code in a program
 - Number of person-days required to develop a component
 - Code complexity (McCabe's Cyclomatic)
 - Software quality

Software Metrics



 In software development, measurements are conducted by using metrics



A metric should

- Measure the right things
- Deliver more value than it costs

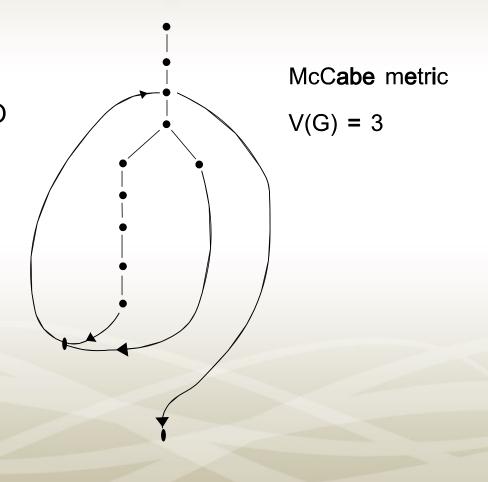
- Linda Westfall

McCabe Cyclomatic Metric



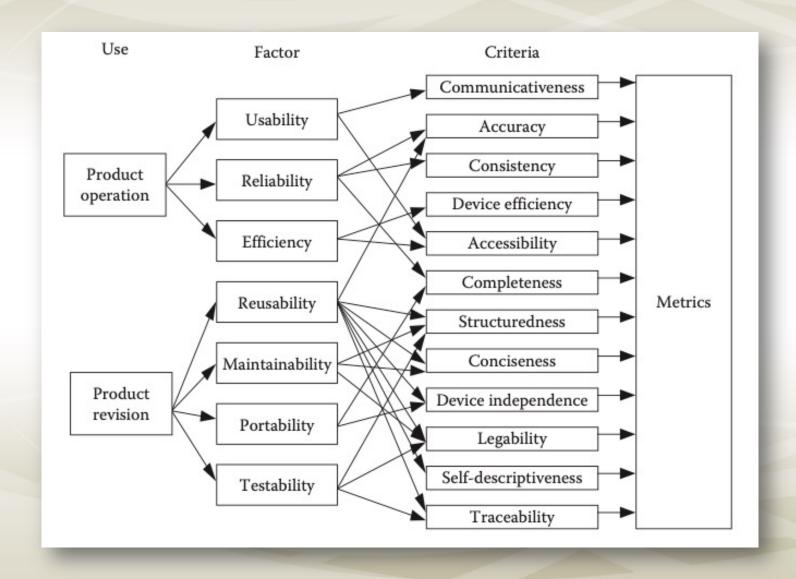
Definition: 1 plus the number of decisions in the control flow

```
J:=I-1;
SWAPPING:= true;
WHILE J>=1 AND SWAPPING DO
 BEGIN
  IF A[J] > A[J+1] THEN
    BEGIN
      TEMP:=A[J];
       A[J] := A[J+1];
       A[J+1]:=TEMP;
       J := J - 1
    END;
   ELSE SWAPPING:= FALSE
 END
```



Software Quality Model





Sources of Project Cost



Project Cost

Cost of Quality

Cost of Performance

Cost of Conformance

| Appraisal Costs | Prevention | Costs |
|-----------------|------------|-------|
|-----------------|------------|-------|

- o Reviews
 - system
 - réquirements
 - design
 - test

o Methodology

o Training

- in
- o Inspections o Planning
- o Audits o Quality improvements
- o Testing (first time) o Data gathering & analysis
- 0 IV&V (1st time) o Fault analysis
 - o Root cause analysis

o Policy & procedures

o Quality reports

- Cost of Nonconformance
 - o Re-reviews
 - o Re-test
 - o Fixing defects
 - code
 - documentation
 - o Reworking any document
 - o CCB
 - o Engineering changes
 - o Lab equipment, cost of retest
 - o Patches to internal code, delivered code
 - o External failures

- Generation of plans ,documentation
- Development of requirements ,design, code
- Integration

Metrics and the Cost of Quality



- Where you are spending your time? ...coding? ...testing?
- What percentage of your work is actually re-work?
- How effective your methods are in finding errors?
- How many errors are left in your code at completion?
- What kind of errors you are likely to make?
- How your customer is going to judge the quality of the product?
- Etc...

Scope of Software Metrics



- Several software activities all of which involve some degree of software measurement
 - Cost and effort estimation models and measures
 - Data collection
 - Quality models and measures
 - Reliability models
 - Security metrics
 - Structural and complexity metrics
 - Capability maturity assessment
 - Management by metrics
 - Evaluation of methods and tools