Software Project Management

Lecture # 3

Outline

- Metrics for Process and Projects
  - Introduction
  - Software Metrics
    - Process metrics
    - Project metrics
    - Direct and Indirect software measures
  - Software Measurement
    - Size-oriented Metrics
    - Function-oriented Metrics
    - Object-oriented Metrics
    - Use-case-oriented Metrics
    - Software Quality Metrics

Introduction

- Software process and project metrics are *quantitative measures* that enable software engineers to gain insight into efficacy of the software process and projects that are conducted using the process as a framework.

Introduction (Contd.)

- Basic quality & productivity data (called measures) are collected.
- These data are then analyzed, compared against past averages (for similar projects) , and assessed to determine whether productivity & quality improvements have occurred.

Introduction (Contd.)

- Metrics also indicate problem areas in processes and projects which can then be rectified.
- Project metrics contribute to development of process metrics.

Introduction - Basic Terms

- What is Measurement?
  - It is the act of obtaining a *measure*.
  - It is a mechanism of objective evaluation.
  - It enables managers and practitioners to improve software process.
  - It assists in planning, tracking and controlling a software project and assessing product quality.

Introduction - Basic Terms (Contd.)

- What is a Measure?
  - To ascertain or appraise by comparing to a standard [1]

    OR
  - A standard or unit of measurement; the extent, dimensions, capacity, etc., of anything, especially as determined by a standard [2]

[1]IEEE Standard Glossary of Software Engineering Terminology, IEEE Std 729 1983.
[2]Engineering an Effective Measurement Program Course Notes, 1994.

Introduction - Basic Terms (Contd.)

- What is a Metric?
  - A metric is quantitative measure of the degree to which a system, component or process possesses a given attribute (IEEE definition)
  - A metric is the degree to which a particular subject possesses the quality that is being measured. It is based upon two or measures.

    (Ref: http://it.toolbox.com/blogs/dw-cents/measures-metrics-and-indicators-23543)

Introduction - Basic Terms (Contd.)

- Difference between terms:
- Measure
  - It is a value which does not provide enough information to make meaningful decisions
- Metric
  - A comparison of two or more measures, e.g., temperature values over time, errors per KLOC
- Indicator
  - Compares a metric against a baseline or expected result and helps in making decisions
- Reference:

http://www.stsc.hill.af.mil/crosstalk/1995/03/Measure.asp

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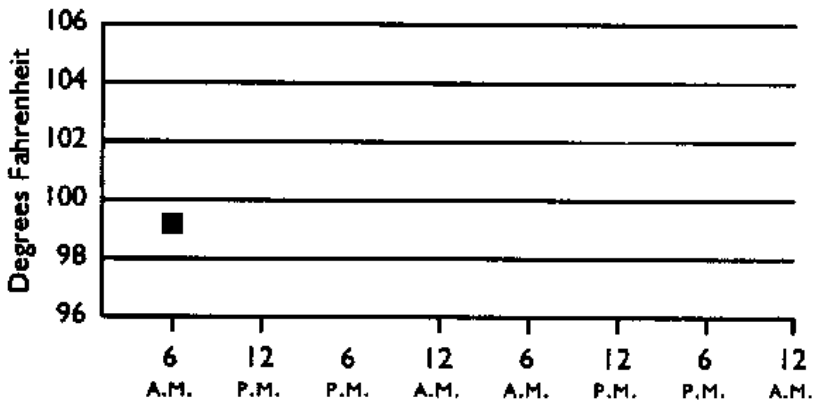


FIGURE 1: BODY TEMPERATURE (MEASURE).

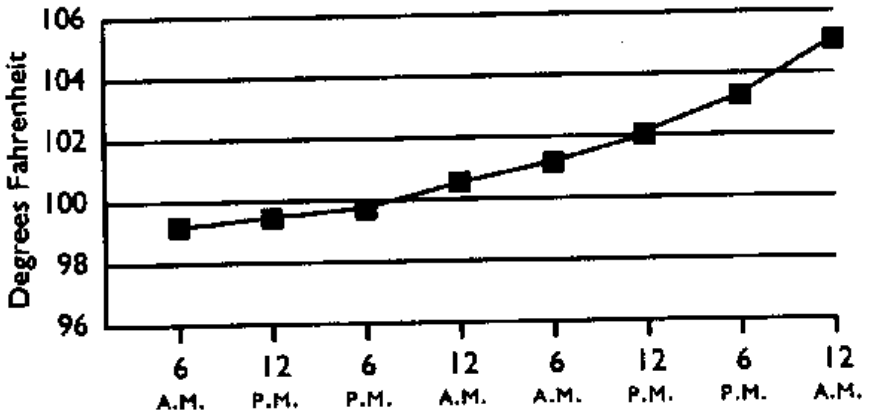


FIGURE 2: BODY TEMPERATURE (METRIC).

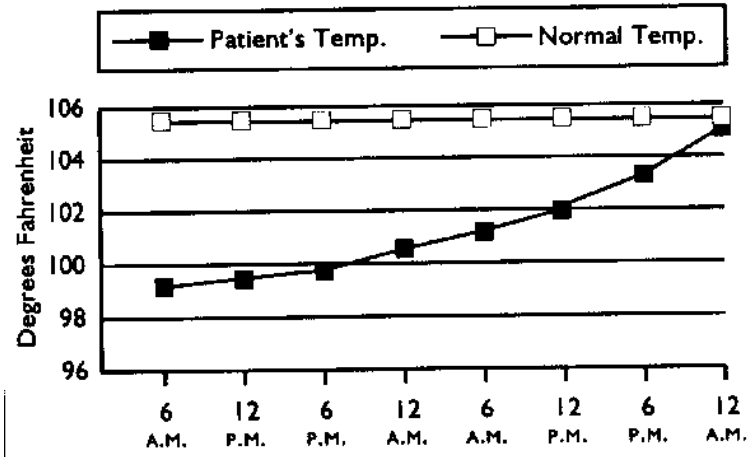


FIGURE 3: BODY TEMPERATURE COMPARED WITH NORMAL TEMPERATURE (INDICATOR).

Process Metrics & Software Process Improvement

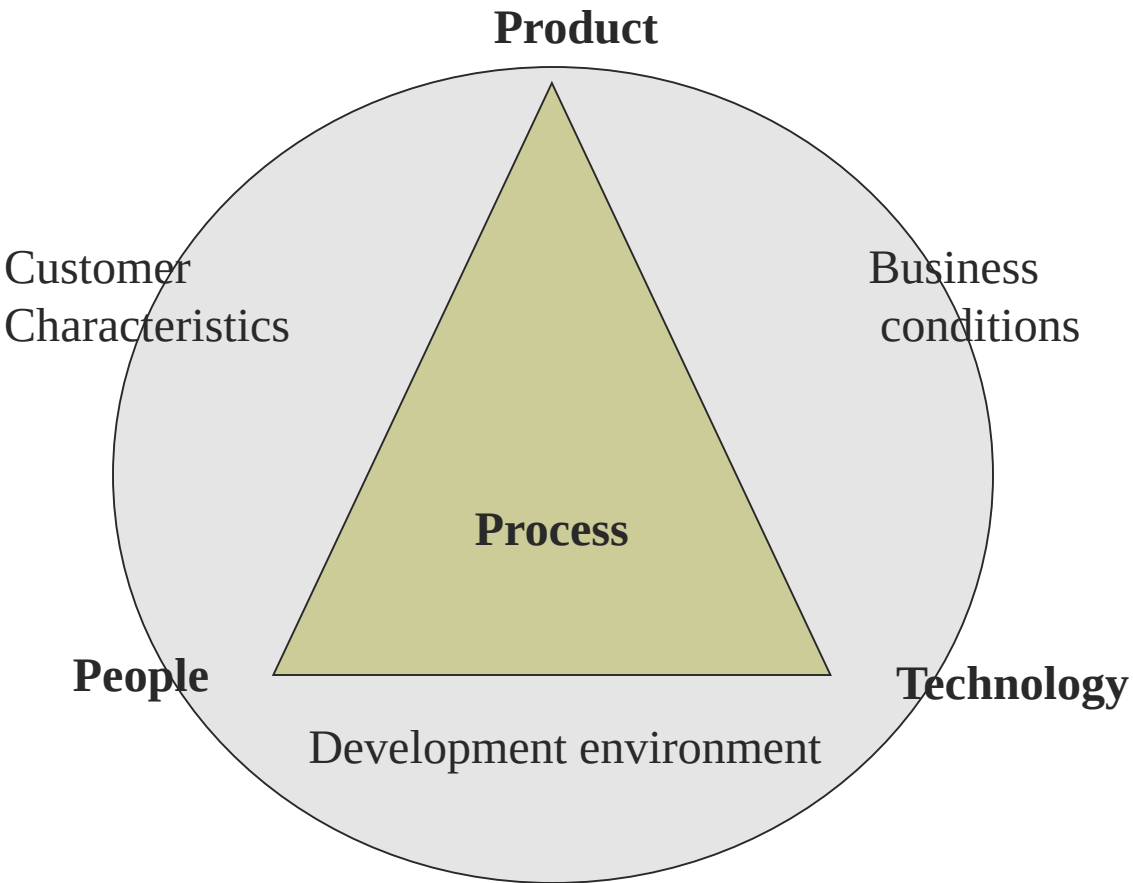
- To improve a process
  - Measure specific attributes of process
  - Develop meaningful metrics based on these attributes
  - These metrics provide indicators that lead to strategy for improvement
- Example
  - Metrics can be derived from the following process outcomes/attributes
    - Errors uncovered before software release,
    - defects delivered to & reported by end-user,
    - work products delivered,
    - Human efforts expended,
    - Calendar time expended,
    - Schedule conformance and other measures.

Improving Software Quality & Organizational Performance

- It is important to note that process is only one of the many controllable factors in improving software quality and organizational performance.
- The figure (on next slide) shows other factors connected with the ‘process’ that have significant influence on the same:
  - The skill and motivation of people
  - The complexity of the product
  - The technology

Improving Software Quality & Organizational Performance

Process connects 3 important factors that influence software quality and organizational performance



Project Metrics

- Used by project managers and software team to adapt project workflow and technical activities.
- Objective is
  - To minimize the development schedule by making adjustments that can avoid delays and mitigate potential problems.
  - To assess product quality on an ongoing basis and when necessary, modify technical approach to improve quality.
  - Most first application of project metrics on software projects occurs during estimation (of time, effort).
  - More project metrics are used as technical work of project commences.

Software Measurement

- Software measurement can be categorized in two ways
  - (1) direct measures of software process and product
  - (2) indirect measures of software product
- Direct Measures
  - of *software process* are
    - Cost and effort
  - of *software product* are
    - Line of Code (LOC)
    - Execution Speed
    - Defects over specified period of time

Software Measurement (Contd.)

- Indirect Measures
  - Of *product* are
    - Functionality
    - Quality
    - Complexity
    - Efficiency
    - Reliability
    - Maintainability
    - .. Other Abilities

Size Oriented Metrics

- These are derived by normalizing quality and/or productivity measures by considering the *size* of software that has been produced.
- Assume that an organization maintains record of the following size-oriented *measures* for each project completed:
  - Lines of code (LOC)
  - Effort in person-months

(see next slide)

Size Oriented Metrics (Contd.)

- Project cost (in dollars)
- Number of pages of documentation
- Number of errors
- Number of defects
- Number of people involved

- To develop metrics that can be incorporated with other similar projects, we choose LOC as a normalization factor.

Size Oriented Metrics (Contd.)

- Hence the following set of size-oriented metrics can be developed for each project:
  - Errors per KLOC (thousand lines of code)
  - Defects per KLOC
  - $ per KLOC
  - Pages of documentation per KLOC
- Other metrics can be:
  - Errors per person-month
  - KLOC per person-month
  - $ per page of documentation

Size Oriented Metrics - Pros and cons

- Size-oriented metrics are widely used but not universally accepted as best way to measure a software process
- Controversy lies in using LOC as a key measure
- Proponents claim
  - LOC is easy to count
  - Many existing estimation models use LOC or KLOC as key input
  - Large literature & data based on LOC exists

Size Oriented Metrics - Pros and cons

- But opponents argue that
  - LOC measures are programming language dependent
  - When considering productivity, LOC criteria penalizes well designed short programs
  - Can not accommodate non procedural languages
  - Planner must estimate LOC long before analysis and design

Function-oriented Metrics

- These use a measure of the functionality delivered by application as a normalization value.
- Most widely used function-oriented metric is function point (FP)
- FP’s computation is based on characteristics of software information domain and complexity.

Function-oriented Metrics: Function Point

- **Function points are** a measure of the size of computer applications and the projects that build them.
- The size is measured from a functional or user, point of view.
- It is independent of the computer language, development methodology, technology or capability of the project team used to develop the application.

Reference URL: http://ourworld.compuserve.com/homepages/softcomp/fpfaq.htm

Function-oriented Metrics: Function Point (Contd.)

- First proposed by Albrecht; can be used to measure functionality delivered by a system.
- Using historical data, FP can be used to:
  - Estimate cost and effort required to design, code and test the software,
  - Predict no. of errors that will be encountered during testing,
  - Forecast the no. of components and/or project source lines in the implemented system.

Computing function points (cont..) (Contd.)

- Following empirical relationship is used to compute Function Point (FP)

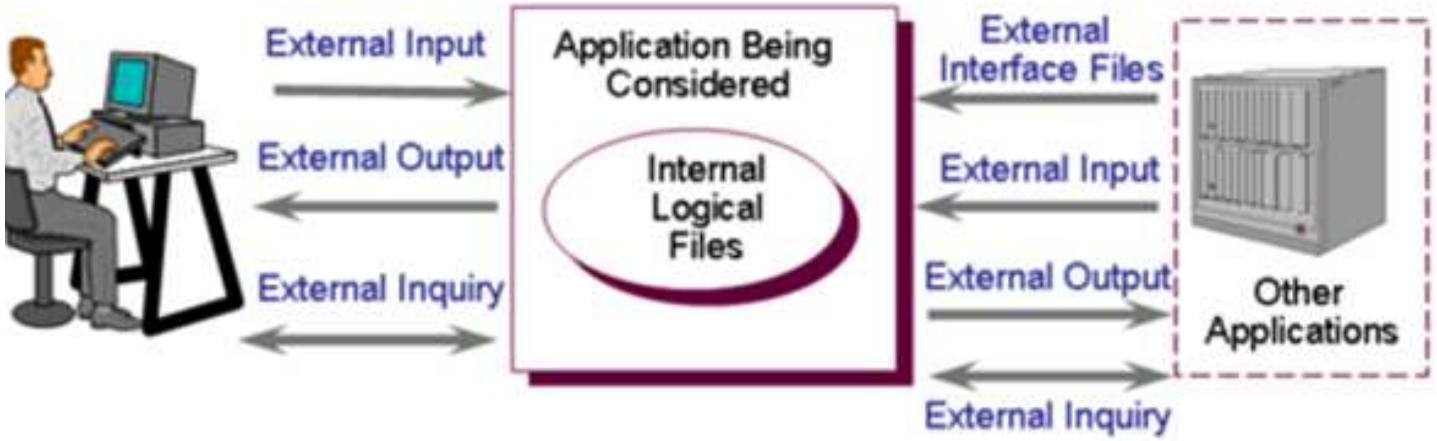
$$FP = \text{count total} \times [0.65 + 0.01 \times \Sigma(F_i)]$$

- F_j (i=1 to 14) are VAF (Value adjustment factors) or simply ‘adjustment values’ based on answers to some questions (See list of 14 Qs on Page 473 from book 6th edition)

- Answer to these questions are on a scale of 0 (not applicable) to 5 (absolutely essential)

Function-oriented Metrics: Function Point (Contd.)

- *Count total* is calculated using the following information domain values:
  - External inputs (EIs)
  - External outputs (EOs)
  - External inquiries (EQs)
  - Internal logic files (ILFs)
  - External interface files (EIFs)



Function-oriented Metrics: Function Point (Contd.)

- Each information domain value is multiplied by a weighting factor (simple, average or complex) and all values are added to get count total.
- See example in book (Roger Pressman page 473)

Function-oriented Metrics: Function Point (Contd.)

- Like LOC, FP is also controversial
  - Proponents claim
    - It is prog. Language independent, hence ideal for conventional and non-procedural languages
    - Based on data that can be known early phases of projects
  - Opponents claim
    - Computation is based on subjective rather than objective data
    - counts of information domain may be difficult to collect
    - FP is just a number and has no physical meaning

Object-oriented Metrics

- FP and LOC can be used to estimate OO software projects but these metrics do not address all aspects of such projects.
- Hence OO metrics are used for object-oriented projects
- Set of metrics for OO projects:
  - Number of scenario scripts
    - These are detailed sequence of steps about user and application interaction
    - These are directly correlated to application size and no. of test cases

Object-oriented Metrics (Contd.)

- Number of key classes
  - Key classes are independent components
  - They Indicate amount of development effort and potential reuse
- Number of support classes
  - Required to implement the system but not directly related to problem domain, e.g., UI classes, DB access, etc.
  - These indicate amount of development effort and potential reuse

Object-oriented Metrics (Contd.)

- Average number of support classes per key class
  - If these are known then estimation (based on total no. of classes) would be much simplified.
- Number of sub systems (aggregation of classes)
  - If identified, it is easier to lay out the schedule in which work on subsystems is partitioned among project staff.

Use-case oriented Metrics

- Use-cases describe user visible functions and features.
- They are defined early in software process and can be used as normalization measure before significant activities are initiated.
- They are independent of programming language
- No. of use cases directly proportional to
  - size of application in LOC &
  - no. of test cases that will be designed
- There is no standard size of a use case as they are created at different levels of abstraction
  - For this reason, it is a suspect as a normalization measure

Web Engineering Project Metrics

- Reading assignment, pages 559, 660, 661

Software Quality Metrics

- Measuring quality through
  - Correctness
    - It is degree to which software performs its required function
    - Common measure= defects per KLOC
    - For quality assessment defects are counted typically for 1 year
  - Maintainability
    - It is the ease with which a program can be
      - corrected if an error is found
      - Adapted if environment changes or
      - Enhanced if customer desires
    - Measured indirectly, e.g., Mean-time-to change (MTTC)
    - Maintainable programs -> lower MTTC

Software Quality Metrics

- Integrity
  - System's ability to withstand (accidental & intentional) attacks
  - Two more attributes that help determine integrity
    - threat = probability of attack within a given time (that causes failure)
    - security = probability that an attack will be repelled
  - Integrity = Σ [1 – (threat * (1 – security))]
- Usability
  - It quantifies ease of use and learning (time)

References

- Today's lecture taken from
  - Roger Pressman's "Software Engineering a practitioner's approach"
    - Chapter 22 - "Metrics for Process & Projects"
    - Chapter 15 - For details of FP computation, 15.3.1, page 472
- For more in-depth study of function points, see http://devdaily.com/fpa/fpa-borland/what-are-fps.shtml