Software Engineering

Lecture-16

Process and Project Metrics

Topics Covered

- Introduction
Metrics in the Process Domain
Metrics in the Project Domain
Software Measurement
Integrating Metrics within the Software Process

Introduction

What are Metrics?

- Software process and project metrics are quantitative measures
- They are a management tool
- They offer insight into the effectiveness of the software process and the projects that are conducted using the process as a framework
- Basic quality and productivity data are collected
- These data are analyzed, compared against past averages, and assessed
- The goal is to determine whether quality and productivity improvements have occurred
- The data can also be used to pinpoint problem areas
- Remedies can then be developed and the software process can be improved

A Quote on Measurement

“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 WILLIAM KELVIN (1824 – 1907)

Uses of Measurement

- Can be applied to the software process with the intent of improving it on a continuous basis
- Can be used throughout a software project to assist in estimation, quality control, productivity assessment, and project control
- Can be used to help assess the quality of software work products and to assist in tactical decision making as a project proceeds

Reasons to Measure

- To characterize in order to
  - Gain an understanding of processes, products, resources, and environments
  - Establish baselines for comparisons with future assessments
- To evaluate in order to
  - Determine status with respect to plans
- To predict in order to
  - Gain understanding of relationships among processes and products
  - Build models of these relationships
- To improve in order to
  - Identify roadblocks, root causes, inefficiencies, and other opportunities for improving product quality and process performance

Metrics in the Process Domain

METRICS IN THE PROCESS DOMAIN

- Process metrics are collected across all projects and over long periods of time
- They are used for making strategic decisions
- The intent is to provide a set of process indicators that lead to long-term software process improvement
- The only way to know how/where to improve any process is to
  - Measure specific attributes of the process
  - Develop a set of meaningful metrics based on these attributes
  - Use the metrics to provide indicators that will lead to a strategy for improvement

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METRICS IN THE PROCESS DOMAIN (CONTINUED)

- We measure the effectiveness of a process by deriving a set of metrics based on outcomes of the process such as
  - Errors uncovered before release of the software
  - Defects delivered to and reported by the end users
  - Work products delivered
  - Human effort expended
  - Calendar time expended
  - Conformance to the schedule
  - Time and effort to complete each generic activity

Etiquette of Process Metrics

- Use common sense and organizational sensitivity when interpreting metrics data
- Provide regular feedback to the individuals and teams who collect measures and metrics
- Don’t use metrics to evaluate individuals
- Work with practitioners and teams to set clear goals and metrics that will be used to achieve them
- Never use metrics to threaten individuals or teams
- Metrics data that indicate a problem should not be considered “negative”
  - Such data are merely an indicator for process improvement
- Don’t obsess on a single metric to the exclusion of other important metrics

Metrics in the Project Domain

Metrics in the Project Domain

- Project metrics enable a software project manager to
  - Assess the status of an ongoing project
  - Track potential risks
  - Uncover problem areas before their status becomes critical
  - Adjust work flow or tasks
  - Evaluate the project team’s ability to control quality of software work products
- Many of the same metrics are used in both the process and project domain
- Project metrics are used for making tactical decisions
  - They are used to adapt project workflow and technical activities

Use of Project Metrics

- The first application of project metrics occurs during estimation
  - Metrics from past projects are used as a basis for estimating time and effort
- As a project proceeds, the amount of time and effort expended are compared to original estimates
- As technical work commences, other project metrics become important
  - Production rates are measured (represented in terms of models created, review hours, function points, and delivered source lines of code)
  - Error uncovered during each generic framework activity (i.e, communication, planning, modeling, construction, deployment) are measured

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USE OF PROJECT METRICS (CONTINUED)

- Project metrics are used to
  - Minimize the development schedule by making the adjustments necessary to avoid delays and mitigate potential problems and risks
  - Assess product quality on an ongoing basis and, when necessary, to modify the technical approach to improve quality
- In summary
  - As <u>quality improves</u>, defects are minimized
  - As <u>defects go down</u>, the amount of rework required during the project is also reduced
  - As <u>rework goes down</u>, the overall project <u>cost is reduced</u>

Software Measurement

Categories of Software Measurement

- Two categories of software measurement
  - Direct measures of the
    - Software process (cost, effort, etc.)
    - Software product (lines of code produced, execution speed, defects reported over time, etc.)
  - Indirect measures of the
    - Software product (functionality, quality, complexity, efficiency, reliability, maintainability, etc.)
- Project metrics can be consolidated to create process metrics for an organization

SIZE-ORIENTED METRICS

- Derived by normalizing quality and/or productivity measures by considering the size of the software produced
- Thousand lines of code (KLOC) are often chosen as the normalization value
- Metrics include
  - Errors per KLOC - Errors per person-month
  - Defects per KLOC - KLOC per person-month
  - Dollars per KLOC - Dollars per page of documentation
  - Pages of documentation per KLOC

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Size-oriented Metrics (continued)

- Size-oriented metrics are not universally accepted as the best way to measure the software process
- Opponents argue that KLOC measurements
  - Are dependent on the programming language
  - Penalize well-designed but short programs
  - Cannot easily accommodate nonprocedural languages
  - Require a level of detail that may be difficult to achieve

FUNCTION-ORIENTED METRICS

- Function-oriented metrics use a measure of the functionality delivered by the application as a normalization value
- Most widely used metric of this type is the function point:

  FP = count total * [0.65 + 0.01 * sum (value adj. factors)]

- Material in Chapter 15 covered this in more detail
- Function point values on past projects can be used to compute, for example, the average number of lines of code per function point (e.g., 60)

Function Point Controversy

- Like the KLOC measure, function point use also has proponents and opponents
- Proponents claim that
  - FP is programming language independent
  - FP is based on data that are more likely to be known in the early stages of a project, making it more attractive as an estimation approach
- Opponents claim that
  - FP requires some “sleight of hand” because the computation is based on subjective data
  - Counts of the information domain can be difficult to collect after the fact
  - FP has no direct physical meaning…it’s just a number

Reconciling LOC and FP Metrics

- Relationship between LOC and FP depends upon
  - The programming language that is used to implement the software
  - The quality of the design
- FP and LOC have been found to be relatively accurate predictors of software development effort and cost
  - However, a historical baseline of information must first be established
- LOC and FP can be used to estimate object-oriented software projects
  - However, they do not provide enough granularity for the schedule and effort adjustments required in the iterations of an evolutionary or incremental process
- The table on the next slide provides a rough estimate of the average LOC to one FP in various programming languages

LOC Per Function Point

Language	Average	Median	Low	High
Ada	154	--	104	205
Assembler	337	315	91	694
C	162	109	33	704
C++	66	53	29	178
COBOL	77	77	14	400
Java	55	53	9	214
PL/1	78	67	22	263
Visual Basic	47	42	16	158

Object-oriented Metrics

- Number of scenario scripts (i.e., use cases)
  - This number is directly related to the size of an application and to the number of test cases required to test the system
- Number of key classes (the highly independent components)
  - Key classes are defined early in object-oriented analysis and are central to the problem domain
  - This number indicates the amount of effort required to develop the software
  - It also indicates the potential amount of reuse to be applied during development
- Number of support classes
  - Support classes are required to implement the system but are not immediately related to the problem domain (e.g., user interface, database, computation)
  - This number indicates the amount of effort and potential reuse

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Object-oriented Metrics (continued)

- Average number of support classes per key class
  - Key classes are identified early in a project (e.g., at requirements analysis)
  - Estimation of the number of support classes can be made from the number of key classes
  - GUI applications have between two and three times more support classes as key classes
  - Non-GUI applications have between one and two times more support classes as key classes
- Number of subsystems
  - A subsystem is an aggregation of classes that support a function that is visible to the end user of a system

METRICS FOR SOFTWARE QUALITY

- Correctness
  - This is the number of defects per KLOC, where a defect is a verified lack of conformance to requirements
  - Defects are those problems reported by a program user after the program is released for general use
- Maintainability
  - This describes the ease with which a program can be corrected if an error is found, adapted if the environment changes, or enhanced if the customer has changed requirements
  - Mean time to change (MTTC) : the time to analyze, design, implement, test, and distribute a change to all users
    - Maintainable programs on average have a lower MTTC

Defect Removal Efficiency

- Defect removal efficiency provides benefits at both the project and process level
- It is a measure of the filtering ability of QA activities as they are applied throughout all process framework activities
  - It indicates the percentage of software errors found before software release
- It is defined as $DRE = E / (E + D)$
  - E is the number of errors found before delivery of the software to the end user
  - D is the number of defects found after delivery
- As D increases, DRE decreases (i.e., becomes a smaller and smaller fraction)
- The ideal value of DRE is 1, which means no defects are found after delivery
- DRE encourages a software team to institute techniques for finding as many errors as possible before delivery

Integrating Metrics within the Software Process

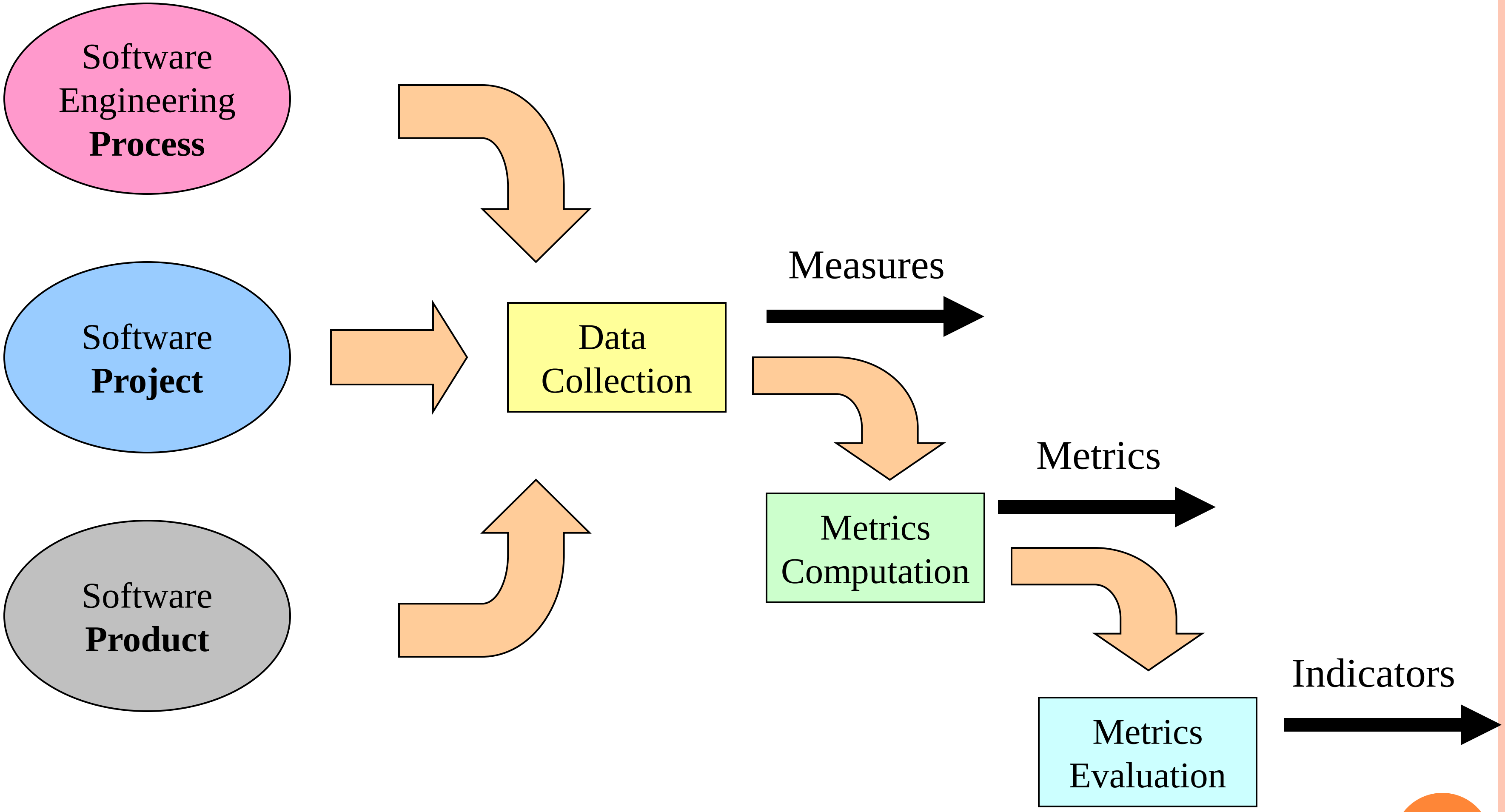
Arguments for Software Metrics

- Most software developers do not measure, and most have little desire to begin
- Establishing a successful company-wide software metrics program can be a multi-year effort
- But if we do not measure, there is no real way of determining whether we are improving
- Measurement is used to establish a process baseline from which improvements can be assessed
- Software metrics help people to develop better project estimates, produce higher-quality systems, and get products out the door on time

ESTABLISHING A METRICS BASELINE

- By establishing a metrics baseline, benefits can be obtained at the software process, product, and project levels
- The same metrics can serve many masters
- The baseline consists of data collected from past projects
- Baseline data must have the following attributes
  - Data must be reasonably accurate (guesses should be avoided)
  - Data should be collected for as many projects as possible
  - Measures must be consistent (e.g., a line of code must be interpreted consistently across all projects)
  - Past applications should be similar to the work that is to be estimated
- After data is collected and metrics are computed, the metrics should be evaluated and applied during estimation, technical work, project control, and process improvement

Software Metrics Baseline Process



Software Engineering **Process**

Software **Project**

Software **Product**

Data Collection

Measures

Metrics Computation

Metrics

Metrics Evaluation

Indicators

Getting Started with Metrics

1) Understand your existing process
2) Define the goals to be achieved by establishing a metrics program
3) Identify metrics to achieve those goals
    - Keep the metrics simple
    - Be sure the metrics add value to your process and product
4) Identify the measures to be collected to support those metrics

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Getting Started with Metrics (continued)

5) Establish a measurement collection process
   - a) What is the source of the data?
   - b) Can tools be used to collect the data?
   - c) Who is responsible for collecting the data?
   - d) When are the data collected and recorded?
   - e) How are the data stored?
   - f) What validation mechanisms are used to ensure the data are correct?
6) Acquire appropriate tools to assist in collection and assessment
7) Establish a metrics database
8) Define appropriate feedback mechanisms on what the metrics indicate about your process so that the process and the metrics program can be improved

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