Software Metrics

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Software Engineering

- What is Software Engineering?
- “Solution to a Crisis”
- SE – development of methods to build Quality software.
- How are the methods accessed ?

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Overview

- Motivation
- Types -- Process vs. Product
- Process Metrics
- Product Metrics
- Object Oriented Metrics
- Validation of Metrics

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Metric

- "You can't Manage if you cannot Measure"

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Objectives to Software Measurement

- Management Objectives
  - Cost of Software Production
  - Productivity of Staff
  - Quality of the Software
  - Access new software techniques or tools

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Objectives to Software Measurement

- Engineering Objectives
  - Monitor the quality of evolving systems
  - Quality and performance requirements
  - Need to predict quality of future products

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Scope of Software Measurement

- Cost Estimation
- Productivity Measures
- Reliability Models
- Quality assurance
- Algorithmic complexity
- Data Collection
- Structural and Complexity metrics

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Metrics

- Measurement of code quality
- Measurement of design quality
- Measurement of maintenance activity

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What do we measure?

- How do you measure designs?
- How do you measure “qualities” like Readability?

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History

- Management Needs
- Programmer Needs
- User Needs

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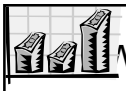

What are those Needs? (Management)

- How long will it take?
- How much will it cost?
- Is it worth the effort?
- Will metrics assist with scheduling difficulties
- Will metrics assist with prediction of error prone software?
- Where can metrics be used?

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What are those needs? (Programmers)

- Will this improve my development time?
- Will I create a better product?
- Will I be given a raise based on these metrics?

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Types of Metrics

- Resource Metrics
- Process Metrics
  - SEI
  - ISO 9000
  - TQM
- Product Metrics
  - Type of Metrics
  - Validation

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Capable Maturity Model

- Key Process Areas (KPA)
  - Goal to perform
  - Commitment to perform
  - Group responsibility and ability to perform
  - Activities

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Process Metrics--SEI (Capability Maturity Model)

- Level 1 – INITIAL (ad hoc Process)
- Level 2 – REPEATABLE (Disciplined Process)
- Level 3 – DEFINED (Standard Consistent Process)
- Level 4 – MANAGED (Predictable Process)
- Level 5 – OPTIMIZING (Continuously Improving Process)

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Product Metrics

- Qualities
  - Automatable
  - Robust
  - Consistent
  - Repeatable
  - Objective
  - **Predictive**
  - **Measures some code quality**

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Product Metrics

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Product Metrics

- Code Metrics (Procedural)
  - Measurement of the code
  - Measurement of the code's style
- Structure Metrics
  - Measurement of the interconnectivity
  - Measurement of the interactions among components
- OO Metrics
- 4GL Languages

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Code Metrics

- Lines of Code (LOC)
- How do YOU count a line of code?

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Code Metrics

- Lines of Code (LOC)
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McCabe's Cyclomatic Complexity

- Based on Graph Theory
- Assume each program is a strongly connected graph

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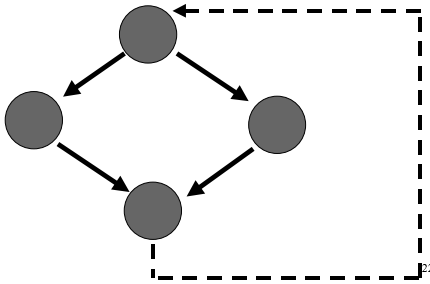
McCabe's Cyclomatic Complexity



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McCabe's Cyclomatic Complexity

- CC = Edges – Nodes + 2
- CC = Decisions + 1

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Halstead's Software Science

- Basic Quantities
  - Number of unique operators **n1**
  - Number of unique operands **n2**
  - Total number of occurrences of operators **N1**
  - Total number of occurrences of operands **N2**

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Halstead's Software Science Derived Equations

Vocabulary Size $n = n1 + n2$

Length $N = N1 + N2$

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Halstead's Software Science Derived Equations

Program Volume $V = N * \log_2 n$

Program level $L = \frac{2}{n1} * \frac{n2}{N2}$

Effort $E = \frac{V}{L}$

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Structure Metrics

- Difficult to collect
- Based on the Interconnectivity of the Components
  - Calling structure
  - Shared Data
  - Indirect information (side-effect)

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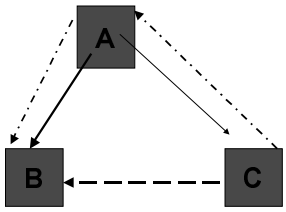
Structure Metrics Information Flow



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Information Flow Metric

- C = (code metric) * (Fan-in * Fan-out) ^{2}
- Fan-in – number of flows into a component
- Fan-out – number of flows out of a component

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Procedural

- First Metrics available
- Combination of metrics
- Which Metric is best?
  - Environment
  - Language
  - Type of product

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Object Oriented Metrics (Chidamber and Kemerer)

- DIT – Depth in the tree
- NOC – Number of Children
- CBO – Coupling Between Objects
- RFC – Response for a class
- LCOM – Lack of Cohesion of the Method
- WMC – Weighted Methods per Class

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Problems with MOOSE

- Definitions were not clear
- Metrics were based on Theory and not on a validation
- Metrics lack completeness

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Additions/Modifications to MOOSE

- Interface Metric
  - Number of Methods per class
- Cohesion
  - Through inheritance
  - Through Message Passing
  - Through data abstraction

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Additions/Modifications to MOOSE

- Size metric
  - Number of semicolons (LOC)
  - Number of Data Attribute + number of Method attributes

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Which metric is BEST?

- Balancing effect
- Measure different properties
- Ease of collection

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Validation of Metrics

- How do we know if they work?
- What do they measure?

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Process of Validation

- Decide which product to measure
- Configuration Control for product
- Which attributes to measure
- Select quantifiable scales (time, errors)
- Design forms for this collection
- Design process for handling forms, analysis

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Validation Data

- Collect error data
  - Severity of error
  - Effect of that “fix”
- Collect timing data
  - Time to design
  - Time to code
  - Time to fix an error

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Metric Results

- Prediction equations with a confidence interval greater than 95% (Regression)
- Correlations of 99%
- Predictions are available at design time
- Cross validation of metric equations with a confidence of 99%

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Metric Results

- Reduce the cost of Maintainability
- Locate problem areas earlier in the life cycle
- Provide direction on re-design
- Insight into REUSE

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Setting up a Measurement program

1. Define company objective for the program
2. Assign responsibility
3. Do research
4. Define initial collection of metrics
5. Sell the initial collection of those metrics

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Setting up a Measurement program

6. Get tools for automatic data collection and analysis
7. Establish a training class in measurement
8. Publicize success stories

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Setting up a Measurement program

9. Create a Metrics Database
10. Establish a mechanism for changing the standard.

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Questions?

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Thank You

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