Software Process Improvement

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Software Process Improvement I

- Management of the software process identified as important economic concern
- Growing pains: avoid project failures, stay within budget
- 1980s: The USAF funds the Software Engineering Institute (SEI) at Carnegie Mellon to address these issues
- SEI develops a process maturity framework – used by DoD to evaluate software contractors

Software Process Improvement II

- Key contribution of SEI: development of the capability maturity model (CMM) initiative.
- Insight: organizations mature processes in stages, staged evolution to software practices
- Related efforts include the ISO 9000-series standards of the International Organization for Standardization, and ISO/IEC 15504, an international software development improvement initiative.

Capability Maturity Model (CMM)

Overview

- A set of strategies for improving the software process.
- *Not* a life-cycle model.
- CMM developed for various different aspects:
    - SW-CMM for software
    - P-CMM for human resources
    - SE-CMM for systems engineering
    - IPD-CMM for integrated product development
    - SA-CMM for software acquisition
- These strategies are unified into CMMI (capability maturity model integration).

SW-CMM I

A strategy for improving the software proces, developed in 1986 by W. Humphrey (SEI).

Fundamental premise

- Use of new software techniques $\neq$ increased productivity and profitability.
- Management of the software process is the key underlying problem.

SW-CMM II

Fundamental strategy

- Induce change incrementally from one level of *maturity* to another.
- Maturity is a measure of the goodness of the process itself.
- Five levels of maturity are defined:

  Level 1. Initial level
  Level 2. Repeatable level
  Level 3. Defined level
  Level 4. Managed level
  Level 5. Optimizing level
- An organization advances from level to level over time.

SW-CMM III

Level 1. Initial Level

- Ad hoc approach to software engineering management
- Time and cost overruns
- Unpredictability in the entire software process
- Crisis oriented development rather than planned development
- Lack of measurements

- Most organizations world-wide are at level 1

SW-CMM IV

Level 2. Repeatable Level

- Use of basic software management
- Planning and management based on experience with similar products
- Use of various measurements to aid cost and duration estimation
- Identification and correction of problems
- Use of measurement data from previous projects

SW-CMM V

Level 3. Defined Level

- Fully documented software process
- Clearly defined managerial and technical aspects
- Continuous effort to improve quality and productivity
- Improve/focus on software quality
- Usage of computer-aided software engineering (CASE) tools, e.g. configuration control, data modeling, refactoring, source code generation, UML, etc.

SW-CMM VI

Level 4. Managed Level

- Set quality and productivity goals for each project
- Continual monitoring of quality and productivity
- Measurement and correction of process
- Use of statistical quality controls

SW-CMM VII

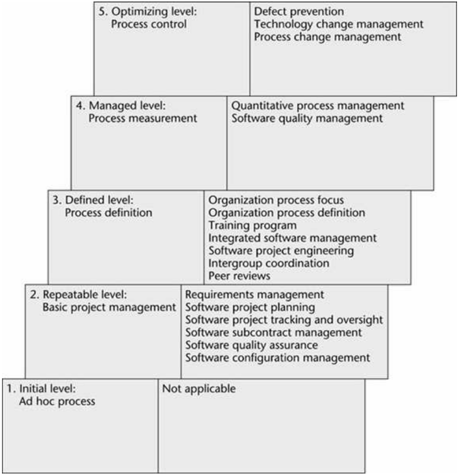
Level 5. Optimizing Level

- Continuous process improvement
- Statistical quality and process controls used for guidance
- Feedback of knowledge from each project to the next

SW-CMM VIII

Reaching the next maturity level

- SEI highlights a series of key process areas (KPA) to reach next maturity level:



5. Optimizing level: Process control	Defect prevention Technology change management Process change management
4. Managed level: Process measurement	Quantitative process management Software quality management
3. Defined level: Process definition	Organization process focus Organization process definition Training program Integrated software management Software project engineering Intergroup coordination Peer reviews
2. Repeatable level: Basic project management	Requirements management Software project planning Software project tracking and oversight Software subcontract management Software quality assurance Software configuration management
1. Initial level: Ad hoc process	Not applicable

SW-CMM IX

Remarks

- 3 to 5 years to go from level 1 to level 2.
- 1.5 to 3 years to go from level 2 to level 3.

- 1998 - US Air Force: contractors must have attained SW-CMM level 3.
- DOD followed with similar directives.

- Many companies worlwide not associated with the military have committed to SW-CMM compliance.

CMMI History I

- CMM developed from 1987 to 1997
- CMMI v.1.1 released in 2002
- CMMI v.1.2 released in 2006
- CMMI v.1.3 released in 2010 (support of agile soft. development)

The ISO 9000-series I

- Five related standards applicable to a variety of industrial activities, i.e. design, development, production, installation, and servicing
- ISO 9001 is most applicable to software

Features

- Documentation of the process in words and pictures
- Adherence to standards does not guarantee high-quality product, only reduces risk of poor-quality product
- Management commitment to quality, intensive worker training, goals for continual quality improvement

The ISO 9000-series II

Remarks

- Adopted by over 60 countries, including US, EU, Japan, Canada, etc.
- Must be ISO 9000 compliant to do business with international clients

Costs & Benefits of Software Process Improvement I

Some examples

- Hughes Aircraft (Fullerton, CA) spent $500K (1987-90) moving from level 2 to 3.
  - Resulting savings estimated at $2M / year
- Equipment Division at Raytheon moved from level 1 in 1988 to level 3 in 1993
  - Productivity doubled
  - Return of $7.70 per dollar invested in process improvement

Costs & Benefits of Software Process Improvement II

- Tata Consultancy Services (India) used ISO 9000 and CMM (1996-2000)
  - Errors in estimation decreased from 50% to 15%
  - Effectiveness of reviews increased from 40% to 80%
  - Effort devoted to reworking projects dropped from 12% to <6%
- Motorola GED has used CMM since 1992 with CMM level from 1 to 5, resulting in
  - Decrease in relative duration of software projects
  - Higher quality of software
  - Higher productivity

Software Quality

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- *Definition?*
  - Functional: How well it conforms to a given design and specifications
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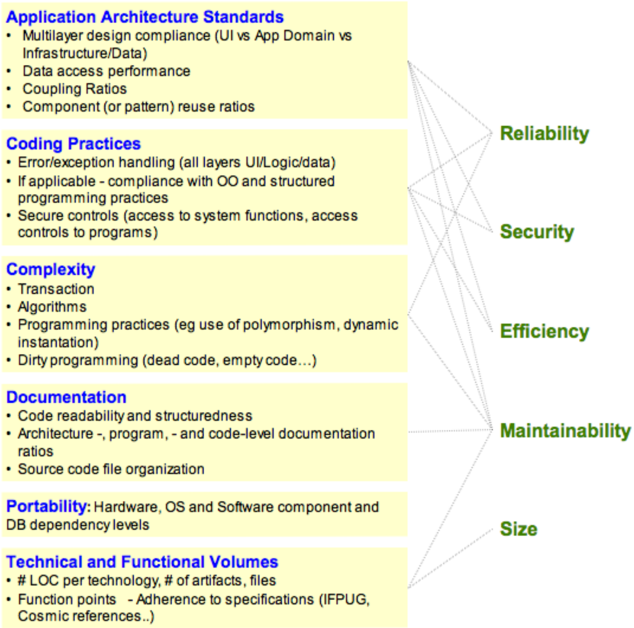
- *How to measure?*
  - Measurable attributes
  - Desirable characteristics

Software Quality Measurement



Application Architecture Standards
- Multilayer design compliance (UI vs App Domain vs Infrastructure/Data)
- Data access performance
- Coupling Ratios
- Component (or pattern) reuse ratios

Coding Practices
- Error/exception handling (all layers UI/Logic/data)
- If applicable - compliance with OO and structured programming practices
- Secure controls (access to system functions, access controls to programs)

Complexity
- Transaction
- Algorithms
- Programming practices (eg use of polymorphism, dynamic instantation)
- Dirty programming (dead code, empty code...)

Documentation
- Code readability and structuredness
- Architecture -, program, - and code-level documentation ratios
- Source code file organization

Portability: Hardware, OS and Software component and DB dependency levels

Technical and Functional Volumes
- # LOC per technology, # of artifacts, files
- Function points - Adherence to specifications (IFPUG, Cosmic references..)

Analysis of Quality Attributes

- Number of Critical programming errors:

  Reliability:

  - Uninitialized variables, null pointers, etc
  - Error management in insert, update, delete, create, select functions
  - Thread safe applications

  Efficiency:

  - Network traffic, non-index DB access

  Security:

  - data access w/o error management
  - return codes and error handling mechanisms
  - Input validation – SQL injection flaws

  Maintainability:

  - Deep inheritance trees and nesting
  - Tightly coupled components
  - Ad-hoc naming conventions

Software Size

- Non-trivial problem

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- Common approaches:
  - Number of lines of code (#LOC)
  - Function points (FP): identify and weight user inputs, outputs and data stores
  - Development cost / FP
  - Delivered defects / FP
  - FP / Staff month
- Manual and cost-intensive process → Automated FP