SOFTWARE QUALITY

CPTS 583

Value and Cost of Software Quality

Outline

- Value of software quality
  - Process value
  - Business value
- Cost of software quality (CoSQ)
  - Cost model
  - Prevention
  - Failure cost
- Quality cost estimation
  - Application of a CoSQ model
- Software cost estimation
  - COCOMO

Value of software quality

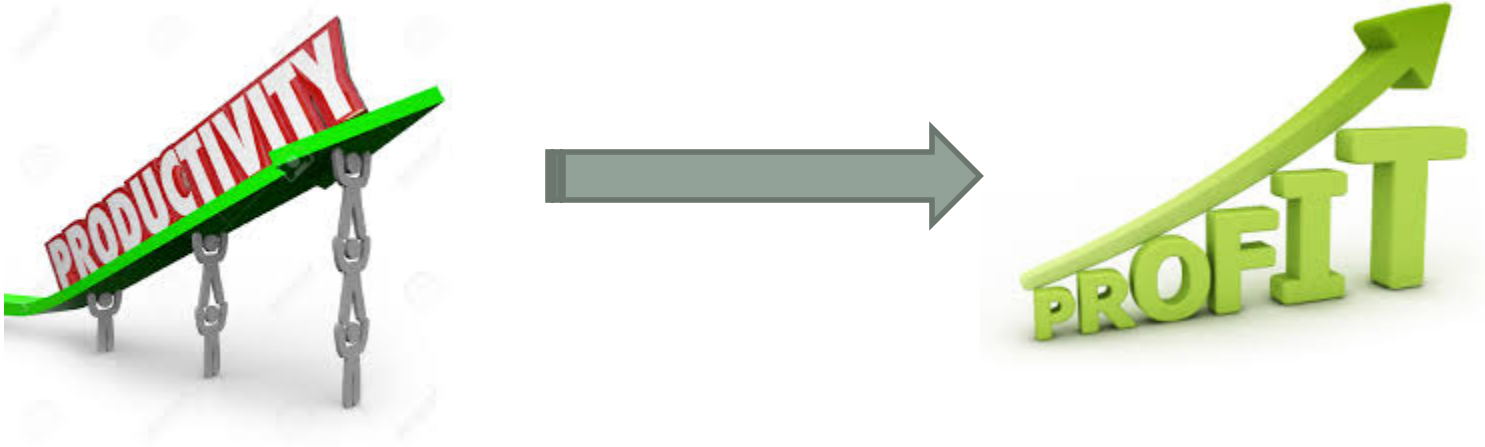
- Process value
  - Value to software process

Reduce cost
(time and money)

Less rework

Value of software quality

- Business value
  - Leaders see quality as luxury
  - Actually power source for improved productivity
  - Improved productivity -> improved profit



Value of software quality

- Business value
  - Longer-term value
    - Enabling responsiveness and innovation
    - A market differentiator
    - Key to survival

Cost of software quality

- Balancing cost and quality

Cost of software quality

- Why should we estimate the cost?
  - Put the quality cost under control
  - Plan and manage budget
  - Adjust quality assurance methodology and/or plan

Cost of software quality

- What are the costs?

15-40%

Traditional Costs of Quality (CoQ)

- Cost of defect prevention
  - E.g., process improvement, root-cause analysis, training, etc.
- Cost of defect detection
  - E.g., inspection, testing
- Cost of failures
  - Internal (pre-release)
  - External (post-release)

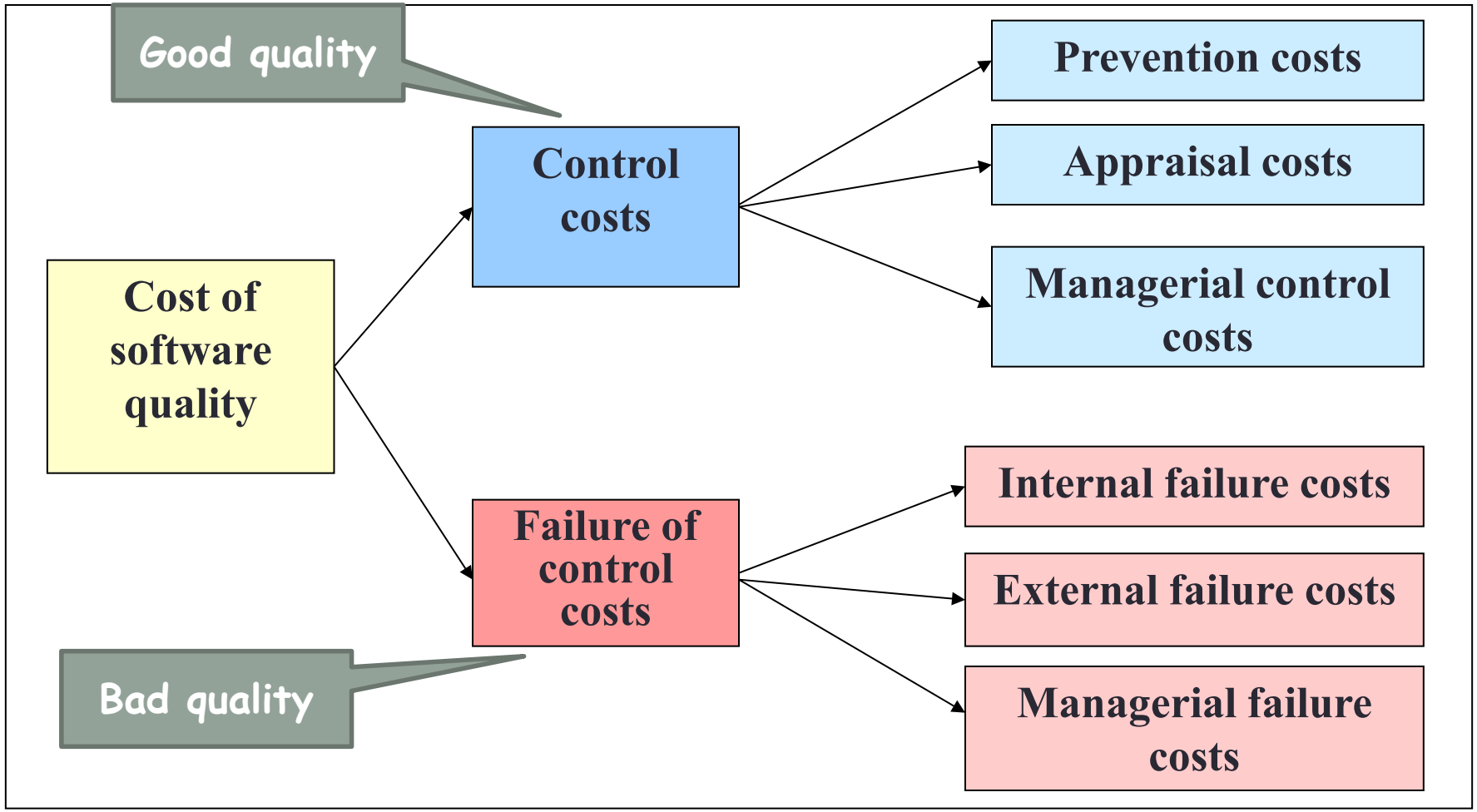
Cost of software quality

- What are the costs?

Costs of **Software** Quality (**CoSQ**)

- CoQ
  - Defect Detection -> Appraisal
- Additional costs specific to *Software* quality
  - Managerial control costs
  - Managerial failure costs

CoSQ model

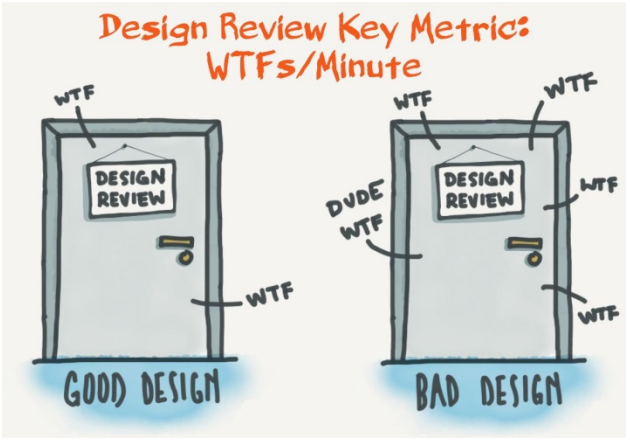

Good quality
Control costs
Prevention costs
Appraisal costs
Managerial control costs
Cost of software quality
Failure of control costs
Internal failure costs
External failure costs
Managerial failure costs
Bad quality

CoSQ model

- Prevention costs
  - Training and consulting
    - Instruction, certification, consultation
  - Infrastructure investments
    - Process improvement
    - Configuration management
  - Technical costs
    - Root cause analysis
    - Reviews, audits

CoSQ model

- Appraisal costs
  - Inspection and Reviews
    - Design review, code review
  - Software testing
    - Verification
      - unit, integration, system testing
    - Validation
      - acceptance testing

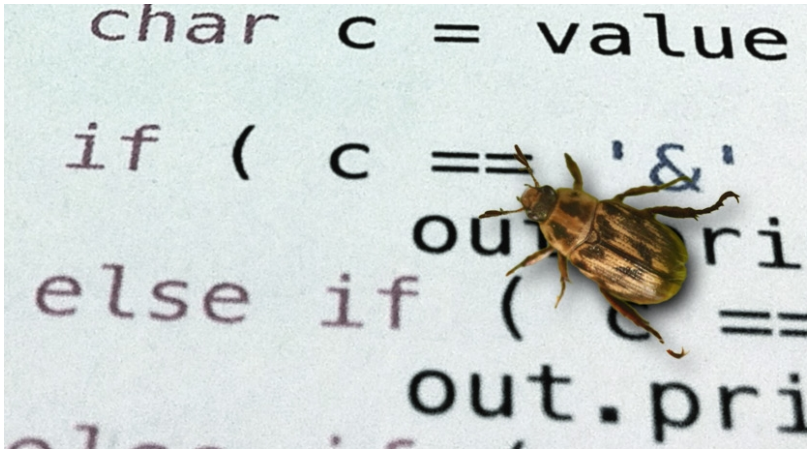


CoSQ model

- Managerial control costs
  - Prepare and maintain project and quality plans
  - Progress management

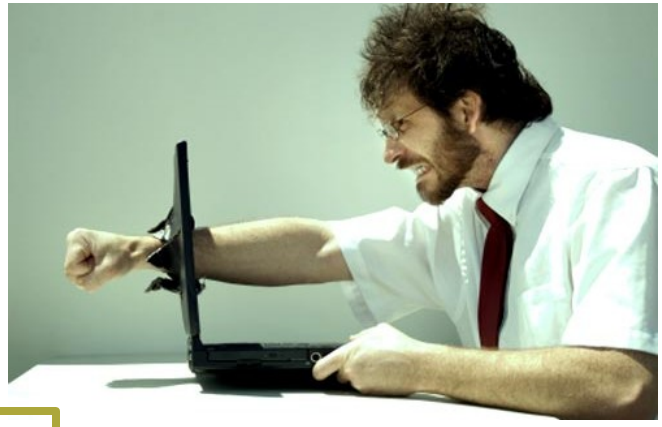
CoSQ model

- Internal failure costs
  - Design problems
    - Correct/redo design
  - Program defects
    - Bug fixing, re-program
  - Re-review/re-testing



CoSQ model

- External failure costs



Overt

- Correction of failures
- Compensations
  - Resolution of user complaints
  - Insurance
  - Reimbursement

CoSQ model

- External failure costs

Hidden

- Sales reduction
  - Lower price
  - Fewer sales
- Extra sale investments
  - Additional promotion

CoSQ model

- Managerial failure costs
  - Underestimated/insufficient resources
  - Late project completion
  - Domino effects

How much is the CoSQ

Total Software Development Project Cost

From 40 - 67 % of costs are for Software Quality!

Example of good and bad quality cost

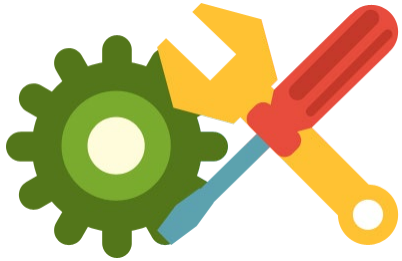
Case 0	Case 1	Case 2	Case 3
Good Quality cost of zero dollars	Good Quality cost increased to 50,000 dollars	Good Quality cost increased to 100,000 dollars	Good Quality cost increased to 150,000 dollars
Bad quality costs of 1,000,000 dollars	Bad quality costs decreased to 900,000 dollars	Bad quality costs decreased to 700,000 dollars	Bad quality costs decreased to 500,000 dollars
Total cost of $1,000,000	Total cost of $950,000	Total cost of $800,000	Total cost of $650,000

Estimate CoSQ

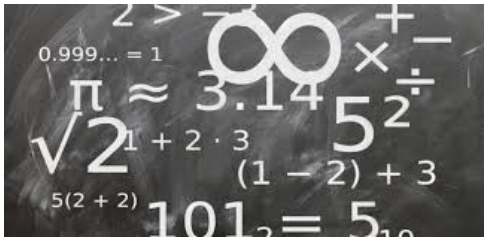
- Estimate
- When?
  - Start after requirements
    - Initial estimation
  - Throughout entire software process
    - Keep adjusting

Estimate CoSQ

- How?
  - Applying a CoSQ model



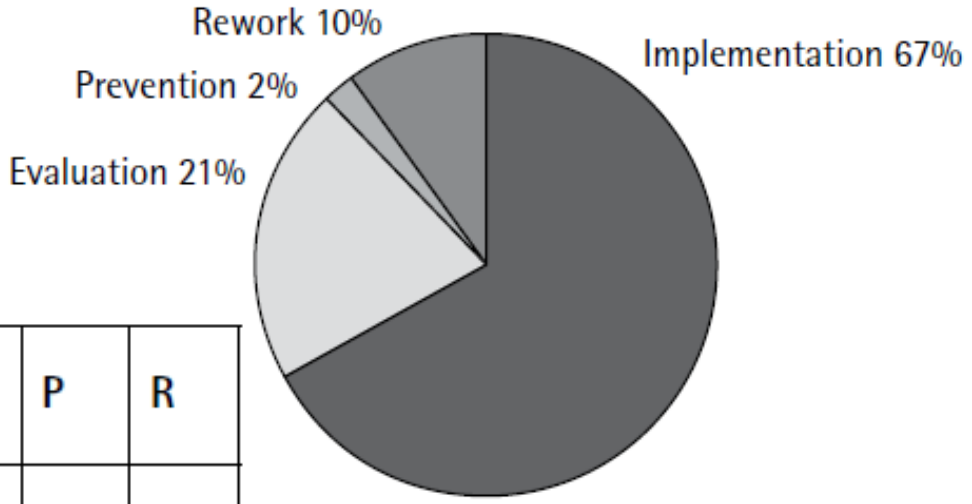
1. Define the model for your project
   - Customization
2. Determine the cost items
   - Detailed cost items for each class of costs
3. Collect data to estimate
   - Quantify each cost item



Estimate CoSQ

Major categories	Subcategories	Definition	Typical costs
Prevention cost	Quality basis definition	Effort to define quality, and to set quality goals, standards, and thresholds. Quality trade-off analysis.	Definition of release criteria for acceptance testing and related quality standards
	Project and process-oriented interventions	Effort to prevent poor product quality or improve process quality	Process improvement, updating of procedures and work instructions; metric collection and analysis; internal and external quality audits; training and certification of employees
Evaluation or appraisal cost	Discovery of the condition of the product nonconformance.	Discovery of the level of nonconformance	Test, walk-through, inspection, desk-check, quality assurance
	Ensuring the achievement of quality.	Quality control gating	Contract/proposal review, product quality audits, "go" or "no go" decisions to release or proceed, quality assurance of subcontractor
Cost of anomalies or nonconformance	Internal anomalies or nonconformance	Problem detected before delivery to the customer	Rework (e.g., recode, retest, rereview, redocument, etc.)
	External anomalies or nonconformance	Problem detected after delivery to the customer	Warranty support, resolution of complaints, reimbursement damage paid to customer, domino effect (e.g. other projects are delayed), reduction of sales, damage to reputation of enterprise, increased marketing

Estimate CoSQ



Distribution of effort in the 88,000-hour project

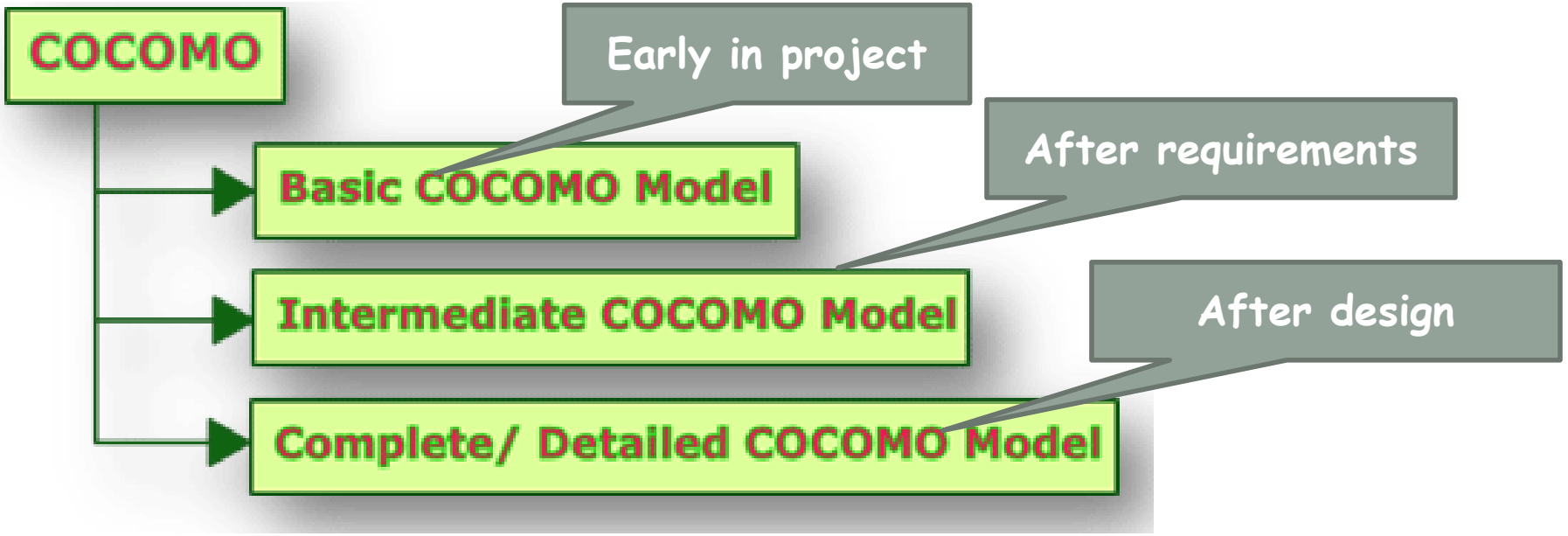
Task name	Effort measured (hours)	I	E	P	R
Software problem correction	883	132	0	0	751
Train simulator-software code and test	195	117	78	0	0
Baseline acceptance	24	0	12	12	0

Examples of cost of software quality data for three tasks

Software Cost Estimation

- COCOMO (**CO**nstructive **CO**st **MO**del)
  - To tune software process (lifecycle practices)
  - To support continuous model improvement

- Different levels of detail and accuracy



Software Cost with COCOMO

- Different modes for various development settings

1. Organic mode
   - Low complexity, high flexibility
2. Semi-detached mode
   - Intermediate complexity, mostly less rigid requirements
3. Embedded mode
   - High complexity, tight constraints

Software Cost with COCOMO

- Effort (in Man Months)

$$E = a(KDSI)^b * EAF\ (MM)$$

Thousand (K) lines of Delivered Source Instructions

Effort Adjustment Factor

- Development time (in months)

$$D = c(E)^d \quad (\text{months})$$

Software Cost with COCOMO

- Values to pick for the parameters (a, b, c, d)

Mode	a	b	c	d
Organic	2.4	1.05	2.5	0.38
Semi-detached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32

Software Cost with COCOMO

- *Organic Mode:*
  E = 2.4 * (KDSI)^1.05 D = 2.5 * (E)^0.38
- *Semi-Detached Mode:*
  E = 3.0 * (KDSI)^1.12 D = 2.5 * (E)^0.35
- *Embedded Mode:*
  E = 3.6 * (KDSI)^1.20 D = 2.5 * (E)^0.32

$E = a(KDSI)^b * EAF$	$D = c(E)^d$

Mode	a	b	c	d
Organic	2.4	1.05	2.5	0.38
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Embedded	3.6	1.20	2.5	0.32

Software Cost with COCOMO

- The Project
  - A flight control system
  - 391,000 lines of code
  - High reliability: EAF = 1.4

- The Cost estimation

- E (effort) = $3.6 * (391)^{1.2} * 1.4 = 5{,}093$ Man-months
- D (development time) = $2.5 * (5{,}093)^{0.32} = 38.4$ months
- P (people required) = E / D = 133

Readings on quality cost estimation

- References

- [1] Measuring Cost of Quality (CoQ) on SDLC Projects is Indispensible for Effective Software Quality Assurance, https://arxiv.org/ftp/arxiv/papers/1405/1405.4824.pdf

- [2] Measuring the Cost of Software Quality of a Large Software Project at Bombardier Transportation: A Case Study, https://www.etsmtl.ca/Professeurs/claporte/documents/publications/Project-at-bombardier-transportation_SQP_June-2012.pdf

Summary

- Process and business value of software quality
  - Process: Less rework, time saving
  - Business: Customer attraction/retention, reputation
- CoSQ model
  - Control costs: prevention, detection, managerial
  - Failure of control costs: internal, external
- Software cost estimation
  - COCOMO: Effort, Development time, Man power