Software Quality Engineering

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Testing, Quality Assurance, and Quantiable Improvement
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Chapter 17. Comparing QA Alternatives

- General Areas/Questions for Comparison
- Applicability, Effectiveness, and Cost
- Summary and Recommendations

QA Alternatives

- Defect and QA
    - Defect: error/fault/failure
    - Defect prevention/removal/containment
    - Map to major QA activities
- Defect prevention
    - Error source removal & error blocking
- Defect removal: Inspection/testing/etc
- Defect containment: Fault tolerance and failure containment (safety assurance)
- Comparison: This chapter

Comparison

- Cost-benefit under given environments
    - Environments: applicable or not?
    - Cost to perform
    - Benefit: quality, directly or indirectly
- Testing as the comparison baseline
    - Most commonly performed QA activity
    - Empirical and internal data for testing
    - QA alternatives compared to testing
        - defect prevention (DP),
        - inspection,
        - formal verification (FV),
        - fault tolerance (FT),

        - failure containment (FC)
    - FT & FC: separate items in comparison

Comparison: Applicability

- Applicability questions
    - High-level questions:

      development vs. field usage (and support/maintenance)
    - Low level questions:

      development phases/activities
- Applicability to maintenance
    - Not applicable: Defect prevention

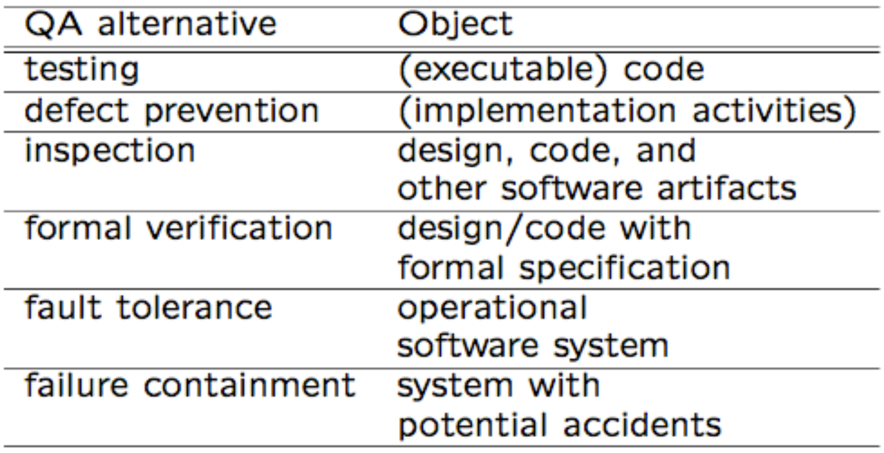
      (although lessons applied to future)
    - Applicable to a limited degree:

      Inspection, testing, formal verification, as related to reported field failures
    - Applicable:

      fault tolerance and failure containment, but designed/implemented during development
- Our focus:

  applicability to development
- Objects QA activities applied on
    - Mostly on specific objects
        - e.g., testing executable code
    - Exception: defect prevention on

      (implementation related) dev. activities
- Summary: Table 17.1 (p.289)

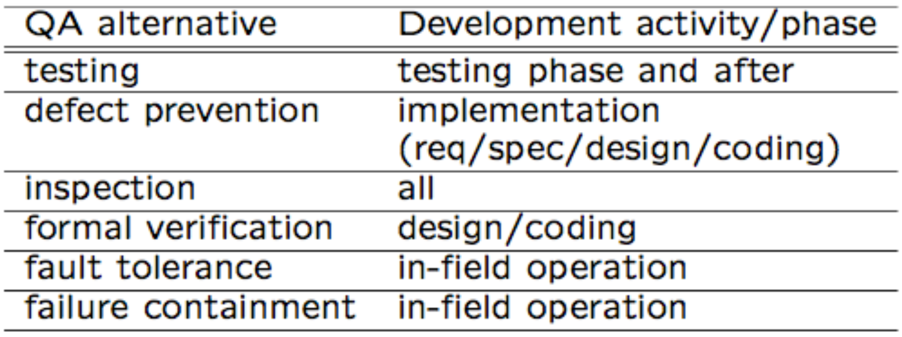


QA alternative	Object
testing	(executable) code
defect prevention	(implementation activities)
inspection	design, code, and other software artifacts
formal verification	design/code with formal specification
fault tolerance	operational software system
failure containment	system with potential accidents

- Applicability to development phases
    - In waterfall or V-model: implementation

(requirement/design/coding) & testing/later

  - Inspection in all phases
  - Other QA in specific sets of phases
- Summary: Table 17.2 (p.290)



QA alternative	Development activity/phase
testing	testing phase and after
defect prevention	implementation (req/spec/design/coding)
inspection	all
formal verification	design/coding
fault tolerance	in-field operation
failure containment	in-field operation

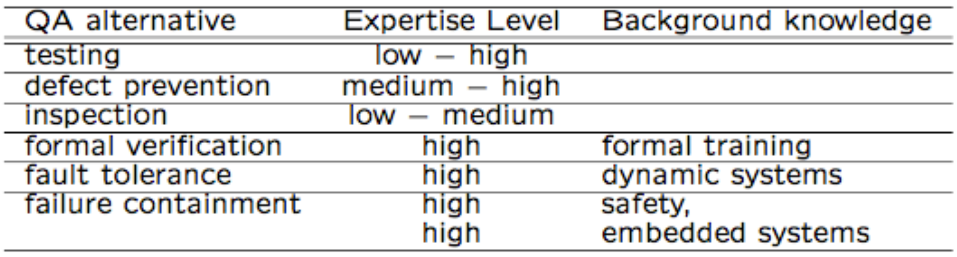
- Applicability to product domain/segment
  - All QA alternatives can be applied to all domains/segments
  - Other factors: cost-benefit ratio
  - Higher cost needs to be justified by higher payoff/returns
  - Further comparison in connect to cost and effectiveness comparisons
- Also relate to general context of QA
  - QA distribution: Fig 4.1 (p.45)
  - Related activities in other phases, e.g., design/implementation for FT/SSE
- Other process variations: similar to smaller cycles of waterfall

Comparison: Applicability/Expertise

- Pre-condition to performing specific QA activities
  - specific expertise required
  - also related to cost
- Expertise areas
  - Specifics about the QA alternative
  - Background/domain-specific knowledge
  - FV: formal training
  - FT: dynamic system behavior
  - FC: embedded system safety
  - Other QA: general CS/SE knowledge
- General expertise levels:

  mostly in ranges, depending on specific techniques used
- Specific background knowledge

- Summary: Table 17.3 (p.291)



QA alternative	Expertise Level	Background knowledge
testing	low – high	
defect prevention	medium – high	
inspection	low – medium	
formal verification	high	formal training
fault tolerance	high	dynamic systems
failure containment	high	safety,
	high	embedded systems

Comparison: Benefit or Effectiveness

- General benefit questions
  - Better quality: views and perspectives?
  - Defect-centered view in this book

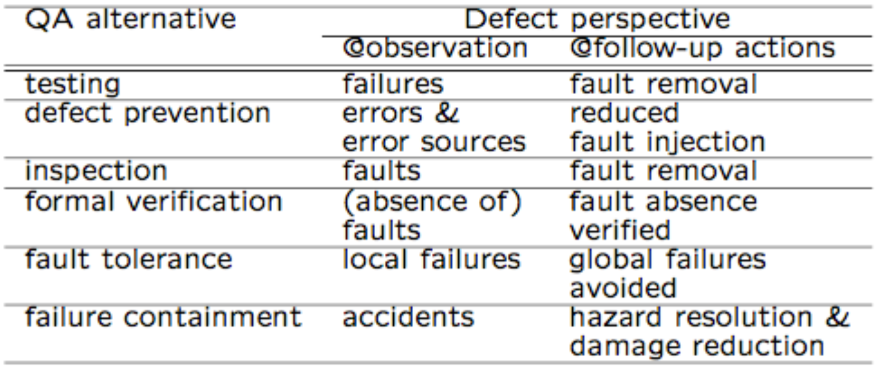
    => fewer defects
  - Defect-related questions below
  - Other benefit: experience, culture change, process improvement, etc
- Defect related question
  - Defect specifics: errors/faults/failures
  - Problem or defect types
  - Defect levels or pervasiveness
  - Information for defect drops and quality improves

Comparison: Effectiveness

- Defect specifics or perspectives
  - Dealing with errors/faults/failures?
  - Direct action vs followup action:

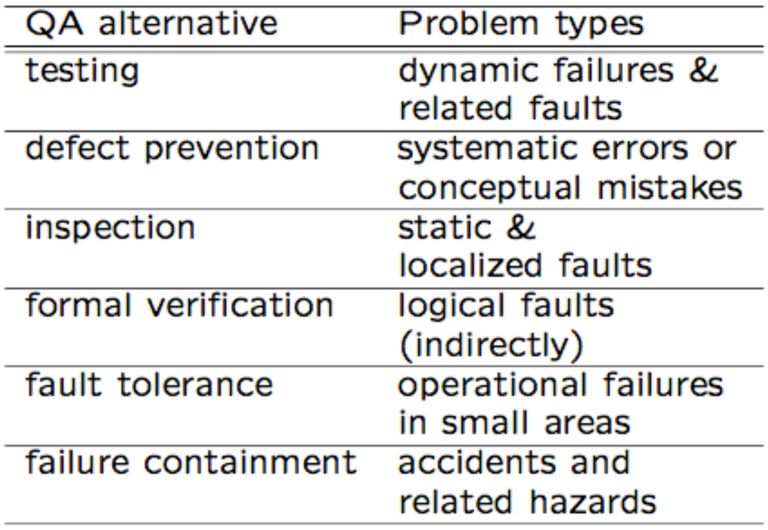
    may deal with different defect perspectives
  - Example:

    failures detected in testing but (failure-causing) faults fixed in followup
- Summary: Table 17.4 (p.292)



QA alternative	Defect perspective	
	@observation	@follow-up actions
testing	failures	fault removal
defect prevention	errors & error sources	reduced fault injection
inspection	faults	fault removal
formal verification	(absence of) faults	fault absence verified
fault tolerance	local failures	global failures avoided
failure containment	accidents	hazard resolution & damage reduction

- Table 17.5 (p.292) above



QA alternative	Problem types
testing	dynamic failures & related faults
defect prevention	systematic errors or conceptual mistakes
inspection	static & localized faults
formal verification	logical faults (indirectly)
fault tolerance	operational failures in small areas
failure containment	accidents and related hazards

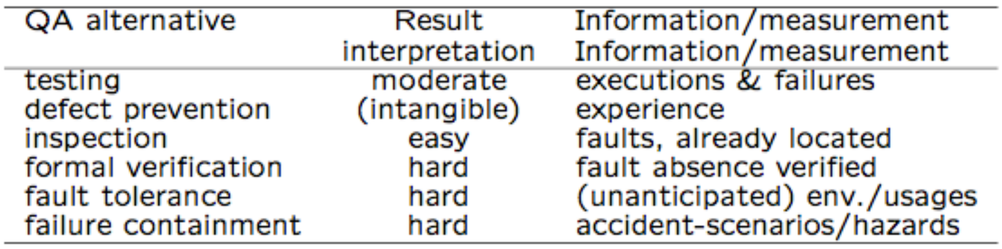
- Problem or defect types
  - errors/faults/failures of different types or characteristics
- Defect types: Inspection vs. testing
  - Static analysis vs. dynamic execution

    => static vs dynamic problems and conceptual/logical problems vs. timing problems
  - Localized defects easily detected by inspection

    vs. interface/interaction problems detected by testing
- Defect types: Other QA
  - defect prevention: negating causes or pre-conditions to pervasive problems
  - fault tolerance: rare conditions
  - safety assurance: accidents
  - FV: logical problems, but indirectly
- Information for defect decrease and quality improve
- Result interpretation
  - specific pieces of info

    - interpret the info./result
    - link to quality, impact, meaning, etc.?
- Using information/measurement
    - to provide feedback
    - to guide followup activities
    - to help decision making/improvement
    - goal: defect drops and quality improves

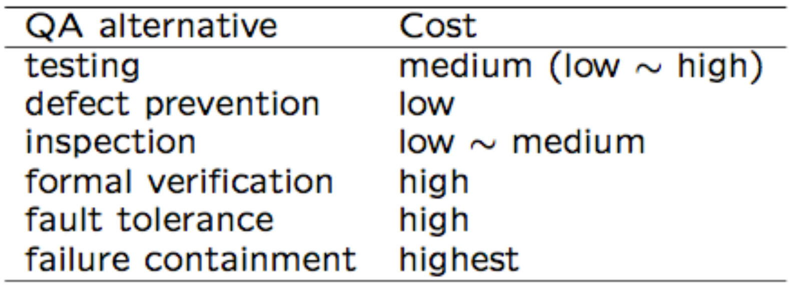
      (usually via analysis/modeling)
    - Part IV. Quantifiable Improvement: measure-analyze-feedback-improve steps
- Ease of result interpretation
- Specific info/measurement
- All Summarized in Table 17.7 (p.295)



QA alternative	Result interpretation	Information/measurement Information/measurement
testing	moderate	executions & failures
defect prevention	(intangible)	experience
inspection	easy	faults, already located
formal verification	hard	fault absence verified
fault tolerance	hard	(unanticipated) env./usages
failure containment	hard	accident-scenarios/hazards

Comparison: Cost

- Cost measurement/characterization
    - Direct cost: $
    - Indirect cost: time, effort, etc
    - Things affecting cost: simplicity, expertise (already addressed), tools, etc
    - Cost to perform specific QA activities
- Factors beyond cost to perform QA
    - Cost of failures and related damage
    - Other cost, particularly for defect containment (FT and FC)
    - Operational cost, e.g., FT mechanisms slow down normal operations
    - Implementation cost of FT mechanisms
- Overall cost comparison
    - rough values and ranges
    - multiple factors but focus on performing the specific QA activities
- Table 17.8 (p.297)



QA alternative	Cost
testing	medium (low ∼ high)
defect prevention	low
inspection	low ∼ medium
formal verification	high
fault tolerance	high
failure containment	highest

Comparison: Summary

- Testing
  - Important link in dev. process
  - Activities spilt over to other phases
    - OP development, test preparation, etc
    - (partial) code exist before testing
  - Dynamic/run-time/interaction problems
  - Medium/low defect situations
  - Techniques and tools
  - Coverage vs. reliability focus
  - Cost: moderate
- Defect prevention
  - Most effective if causes known
  - Good at pervasive problems
  - Low cost, due to downstream damage#
  - Issue: “if causes", and up-front cost
- Inspection
  - Good throughout dev. process
  - Works on many software artifacts
  - Conceptual/static faults
  - High fault density situations
    - non-blocking
    - experience => efficiency improve
  - Human intensive, varied cost
- Formal verification
  - Positive confirmation/correctness
  - On design/code with formal spec
  - Low/no defect situations

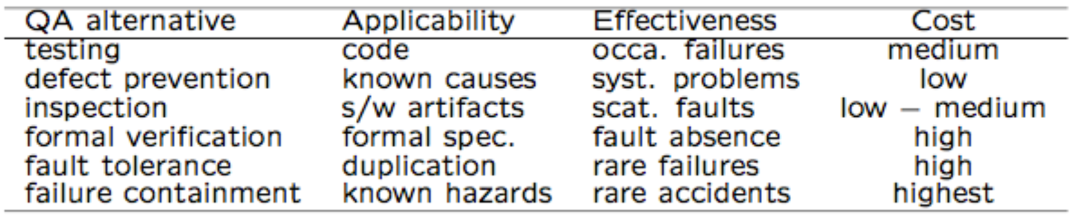
    - Practicality: high cost ! benefit?
    - Human intensive, rigorous training

      (therefore, high up-front cost)
- Fault tolerance
    - Dynamic problems (must be rare)
    - High cost & reliability (low defect)
    - Technique problems (independent NVP?)
    - Process/technology intensive
- Failure containment
    - Similar to FT above, but even more so
    - Rare conditions related to accidents
    - Extremely high cost

      => apply only when safety matters
    - Many specialized techniques
    - Process/technology intensive

Comparison: Grand Summary

- Grand summary: Table 17.9 (p.298)



QA alternative	Applicability	Effectiveness	Cost
testing	code	occa. failures	medium
defect prevention	known causes	syst. problems	low
inspection	s/w artifacts	scat. faults	low – medium
formal verification	formal spec.	fault absence	high
fault tolerance	duplication	rare failures	high
failure containment	known hazards	rare accidents	highest

- Pairwise comparison, if needed
- Different strength/weakness

  => hybrid/integrated strategies

Pairwise Comparison

- Inspection vs. preventive actions
    - Inspection coupled with causal analysis
    - Together drive preventive actions
    - Key difference: error vs fault focus
- Inspection vs. formal verification
    - FV ~= formalized inspection
    - Focus: people vs. mathematical/logical

    - Applicability to design/code only?
    - Existence of formal specifications?
    - Tradeoff: formality vs. cost
    - Training and acceptability issues
- Inspection vs. testing
    - Existence of the implemented product
    - Levels of quality/defects
    - Static vs. dynamic defects
    - Localized vs. interconnected defects
    - Combined approaches
        - phases and transitions
        - inspection of testing entities/processes
- Inspection vs. fault tolerance
    - Complementary instead of competing

      (e.g., inspect individual versions)
    - Static vs. dynamic
    - Inspection of FT techniques/mechanisms
- Other comparisons: Similar to above

Recommendation: Integration

- Different QA alternatives often complementary instead of competing to one another
    - Dealing with different problems
    - Work in different phases/environments
    - Combined effect

      => use multiple QA alternatives together
    - Shared resource and expertise
- Integration: Concerted QA effort
    - As a series of defense (Fig 3.1, p.30)
    - Satisfy specific product/segment needs
    - Fit into process and overall environment
    - Adaptation/customization often needed
    - Match to organizational culture