Software Quality Engineering

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Testing, Quality Assurance, and Quantiable Improvement
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Chapter 19. Quality Models and Measurements

- Types of Quality Assessment Models
- Comparing Quality Assessment Models
- Data Requirements and Measurement
- Measurement and Model Selection

QA Data and Analysis

- Generic testing process
    - Test planning and preparation
    - Execution and measurement
    - Test data analysis and followup
    - Related data => quality => decisions
- Other QA activities
    - Similar general process
    - Data from QA/other sources (Chapter 18)
    - Models used in analysis and followup
        - provide timely feedback/assessment
        - prediction, anticipating/planning
        - corrective actions => improvement

QA Models and Measures

- General approach
    - Adapt GQM-paradigm
    - Quality: basic concept and ideas
    - Compare models => taxonomy
    - Data requirements => measurements
    - Practical selection steps
    - Illustrative examples
- Quality attributes and definitions

    - Q models: data => quality
    - Correctness vs. other attributes
    - Our definition/restriction: being defect-free or of low-defect
    - Examples: reliability, safety, defect count/density/distribution/etc

Quality Analysis

- Analysis and modeling
    - Quality models: data => quality
        - a.k.a. quality assessment models or quality evaluation models
    - Various models needed
    - Assessment, prediction, control
    - Management decisions
    - Problematic areas for actions
    - Process improvement
- Measurement data needed
    - Direct quality measurements: success/failure (& defect info)
    - Indirect quality measurements
        - activities/internal/environmental
    - Indirect but early quality indicators
    - All described in Chapter 18

Quality Models

- Practical issues
    - Applicability vs. appl. environment
    - Goal/Usefulness: information/results?
    - Data: measurement data required
    - Cost of models and related data
- Type of quality models
    - Generalized: averages or trends
    - Product-specific: more customized
    - Relating to issues above

Generalized Models

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Overall Generalized Quality Evaluation Models
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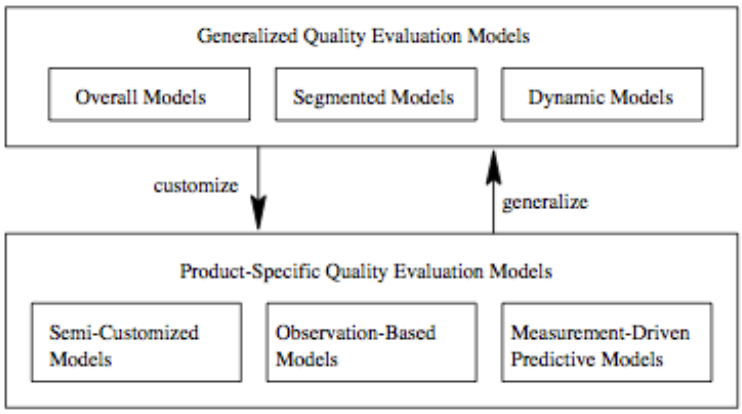
- Model taxonomy: Fig 19.1 (p.324)



    - Generalized
        - overall, segmented, and dynamic
    - Product-specific
        - semi-customized: product history
        - observation-based: observations
        - measurement-driven: predictive

Generalized Models: Overall

- Key characteristics
    - Industrial averages/patterns

      => (single) rough estimate
    - Most widely applicable
    - Low cost of use
- Examples: Defect density
    - Estimate total defect with sizing model
    - Variation: QI in IBM

      (counting in-field unique defect only)
- Non-quantitative overall models
    - As extension to quantitative models
    - Examples: 80:20 rule, and other general observations

Generalized Models: Segmented

- Key characteristics
    - Estimates via product segmentation

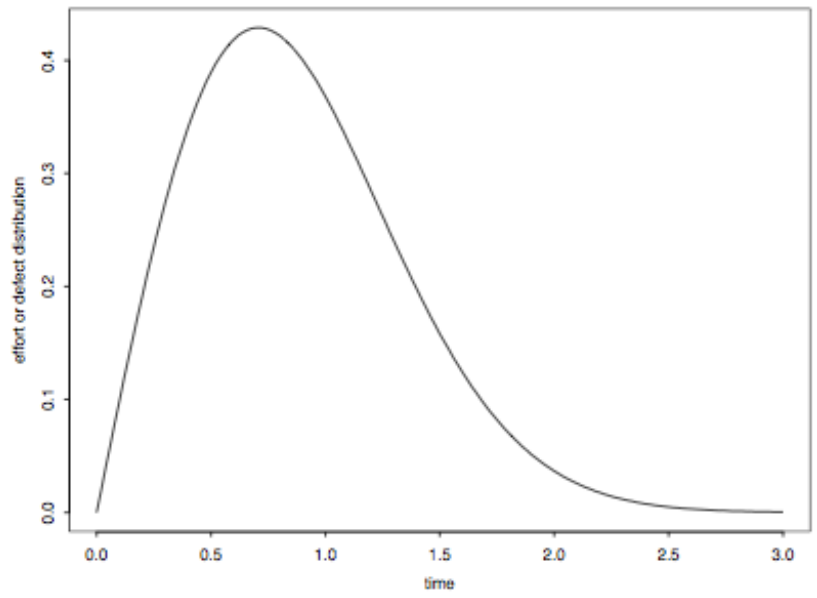
    - Model: segment -> quality
    - Multiple estimates provided
- Example: Table 19.1 (p.326)

Product Type	Failure rate (per hour)	Reliability Level
safety-critical	$< 10^{-7}$	ultra-high
commercial	10^{-3} to 10^{-7}	moderate
auxiliary	$> 10^{-3}$	low

- Other applications
    - Commonly used in software estimation
    - Example: COCOMO models

Generalized Models: Dynamic

- Example: Putnam model Fig 19.2 (p.326)



Rayleigh curve for failure rate: r = 2Bate**(at**(2))

- Overall/average trend over time
    - Often expressed as a mathematical

      function or an empirical curve
    - Combined models possible, e.g., segmented dynamic models

Product-Specific Models (PSM)

- Product-specific models (PSMs)
    - Product-specific information used

      (vs. none used in generalized models)
    - Better accuracy/usefulness at cost increase
    - Three types
        - semi-customized
        - observation-based
        - measurement-driven predictive
- Connection to generalized models (GMs)
    - Customize GMs to PSMs with new/refined models and additional data
    - Generalize PSMs to GMs with empirical evidence and general patterns
    - Illustrated in Fig 19.1 (p.324)

PSM: Semi-Customized

- Semi-customized models
    - Project level model based on history
    - Data captured by phase
    - Both projections and actual
    - Linear extrapolation
- Example: DRM in Table 19.2 (p.327)

Requirement	Design	Coding	Testing	Support
5%	10%	35%	40%	10%

- Related extensions to DRMs
    - Defect dynamics model in Chapter 20,
    - ODC defect analyses in Chapter 20
        - 1-way distribution/trend analysis
        - 2-way analysis of interaction

PSM: Observation-Based

- Observation-based models
    - Detailed observations and modeling
    - Software reliability growth models
    - Other reliability/safety models

- Model characteristics
    - Focus on the effect/observations
    - Assumptions about the causes
    - Assessment-centric
    - Example: Goel-Okumoto NHPP SRGM
        - functional relation: m(t) = N (1 - e ** (-bt))
        - observed failures over time
        - curve fitting
        - reliability assessment/prediction
        - management decisions: exit criteria

PSM: Predictive

- Measurement-driven predictive models
    - Establish predictive relations
    - Modeling techniques: regression, TBM, NN, OSR etc
    - Risk assessment and management
- Model characteristics
    - Response: chief concern
    - Predictors: observable/controllable
    - Linkage quantification

PSM: Predictive Model Example

- Example: Table 19.3 (p.329)

Product	Subset	#Modules	Mean-DF
LS	lrrr	16	9.81
	rlr	53	10.74
	rr	17	22.18
	whole product	1296	1.8
NS	rlll	8	55.0
	rr	5	77.0
	whole product	995	7.9

    - tree-based defect modeling
    - substantially different high-risk areas
    - identification and remedial actions

Model Summary

- Summary: Table 19.4 (p.329)

Model Type	Sub-Type	Primary Result	Applicability
generalized quality models		rough quality estimates	all or by industry
	overall	overall product quality	across industries
	segmented	industry-specific quality	within an industry
	dynamic	quality trend over time	trend in all
product-specific quality models		better quality estimates	specific product
	semi-customized	quality extrapolation	prev→cur release
	observation-based	quality assessments	current product
	measurement-driven	quality predictions	both above

Model Applications

- Applications
  - not data => GMs as early choices
  - Data arrival => phase in PSMs
    - special case: historical data

      => semi-customized models
  - Model customization within application
- Model customization (from generalized to product-specific) in connection with model applications

- Model generalization
    - data/results accumulation
    - generalized model possible?
    - mathematical function/empirical trend

Relating Models to Measurements

- Data (Chapter 18) required by quality models
    - Direct quality measurements
        - to be assessed/predicted/controlled
    - Indirect quality measurements
        - means to achieve the goal
        - environmental, activity, product-internal
    - Data requirement by models: summarized in Table 19.5 (p.331)

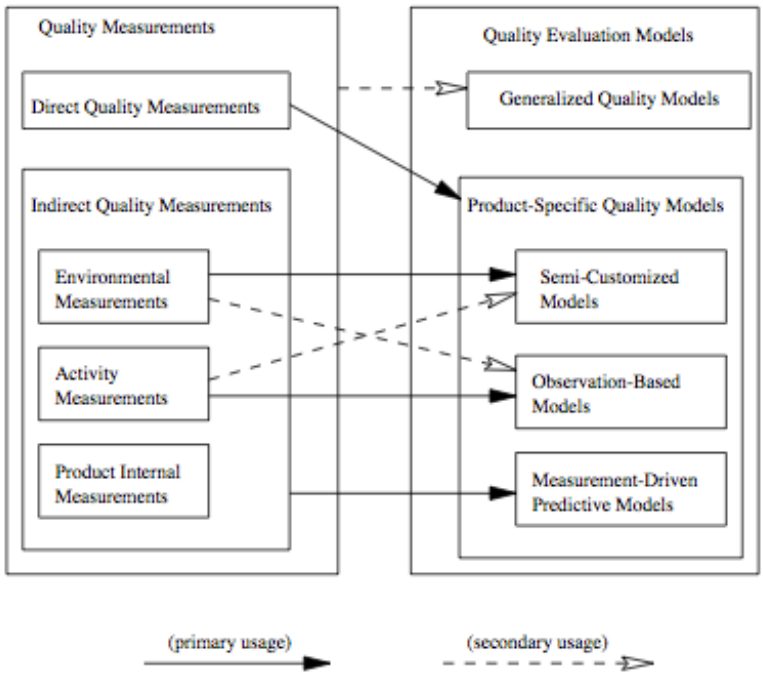
Model Type	Sub-Type	Measurement Data
generalized		industrial averages
	overall	average: all industries
	segmented	average: own industry
	dynamic	trend: all industries
product-specific		product-specific data
	semi-customized	rough historical data
	obser.-based	current observations
	meas.-driven	current & historical data

- Data requirement of GMs
    - Quality averages/patterns: Q
    - No measurements from current project
- Data requirement of PSMs
    - All use direct quality measurements: Q
        - related to other measurements: M
        - as relations: Q ~ M
        - or as functions: Q = f (M)
    - Measurement-driven models
        - M = all measurements
    - Semi-customized models
        - M = environmental measurements
    - Observation-based models

        - M = activity measurements
    - Various other secondary uses

Relating Models to Measurements Quality Measurements

- Relating models to measurements: Fig 19.3 (p.332) - chapter summarized



- Can also be examined from the direction of measurements-models forward links

Model/Measurement Selection

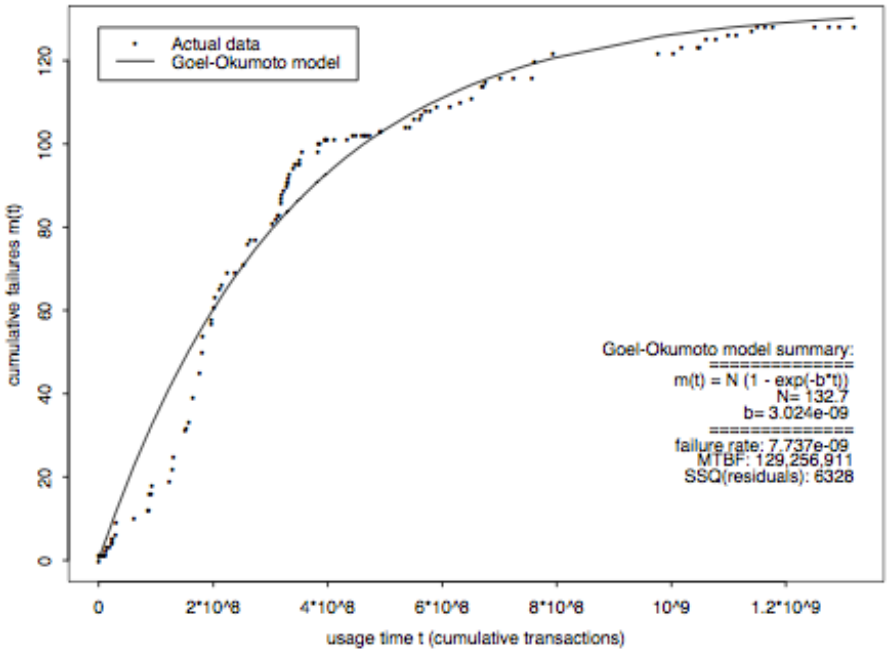
- Customize GQM into 3-steps
- Step 1: Quality goals
    - Restricted, not general goals
- Step 2: Quality models
    - Model characteristics/taxonomy
    - Model applicability/usefulness
    - Data requirement/affordability
- Step 3: Quality measurements
    - Model-measurements relations
    - Detailed model information

Selection Example A

- Goal: rough quality estimates
- Situation 1
    - No product specific data
    - Industrial averages/patterns
    - Commercial tools: SLIM etc
    - Product planning stage
    - Defect profile in lifecycle
    - Use generalized models
- Situation 2
    - Data from related products
    - DRM for legacy products
    - ODC profile for IBM products
    - Semi-customized models

Selection Example B

- Goal: customer-view of quality in system testing
- Quality model
    - SRGMs: info. about reliability
    - Assessment: customer-view
    - Prediction: project management
    - Decisions: exit criteria
    - Affordability: data and modeling
- Quality measurements
    - Reliability: failure-free operation for a given time under a specific environment
    - Result: success/failure measurement
    - Time measurement: re(cid:13)ect activity
    - Environment: implicitly assumed
- Fig 19.4 (p.335): SRGM, an observation-based model, selected for Example B



- reliability assessed/predicted
- time = transactions

Selection Example C

- Goal: testing process/quality improvement, but SRGMs inadequate
- Selecting TBRM in Fig 19.5 (p.336) to focus on reliability improvement

Selection Example C

- TBRM: improvement focus
  - what's wrong: risk identification
  - what to do: remedial actions
- Data attributes: Table 19.6 (p.336)
  - Result: success/failure measurement
  - Timing info.: time-domain analysis
  - Input state: input-domain analysis

  Timing:

  ```
  calendar date (year, month, day), tday (cumulative testing days
  since the start of testing), and rsn (run sequence number, uniquely
  identifies a run in the execution sequence).
  ```

Input state:

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SC (scenario class), SN (scenario number), log (corresponding to a
sub-product with a separate test log) and tester.
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Result:

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result indicator of the test run, with 1 indicating success and 0
indicating failure.
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Summary and Perspectives

- Practical need for quality measurement and model selection
- Viable approach
    - Model characteristics => taxonomy
    - Model data requirement: different types of quality measurements
    - Selection steps: customized GQM
    - Viability: examples
- Perspective and future work
    - Refined taxonomy
    - Relating models to measurements
        - more details and specific info
    - Lifecycle activities and support
    - Automation?