

Software Quality Engineering

Testing, Quality Assurance, and Quantifiable 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

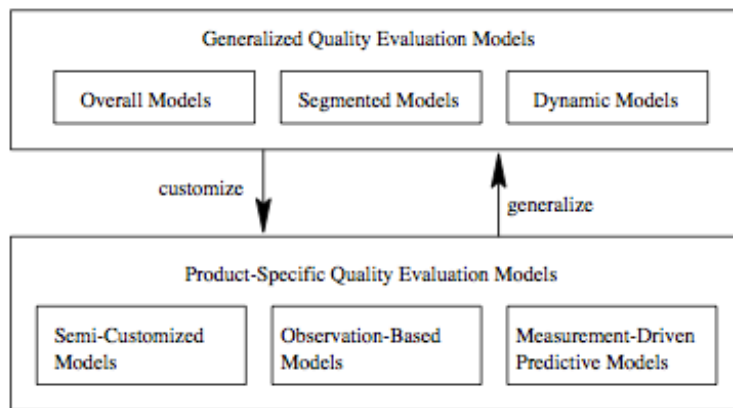
Quality Models

- 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

Overall Generalized Quality Evaluation Models

- 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

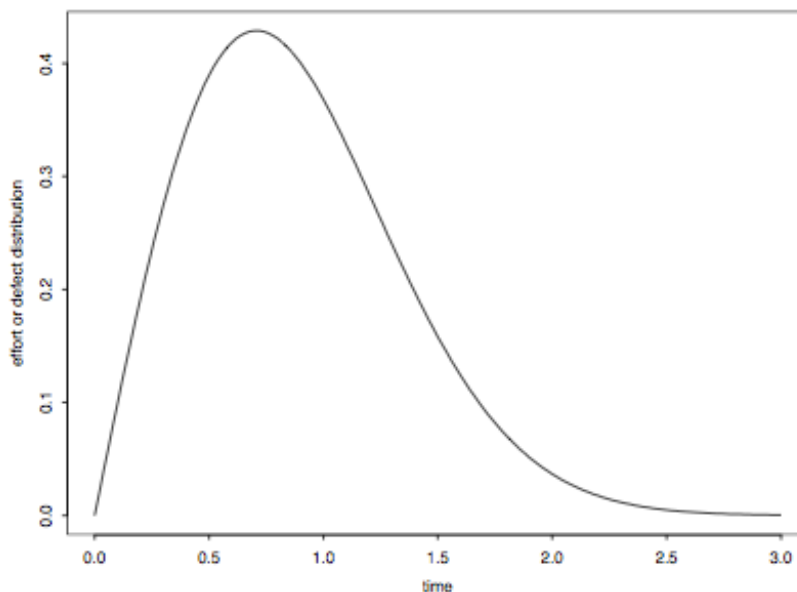
- Model: segment -> quality
- Multiple estimates provided
- Example: Table 19.1 (p.326)

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

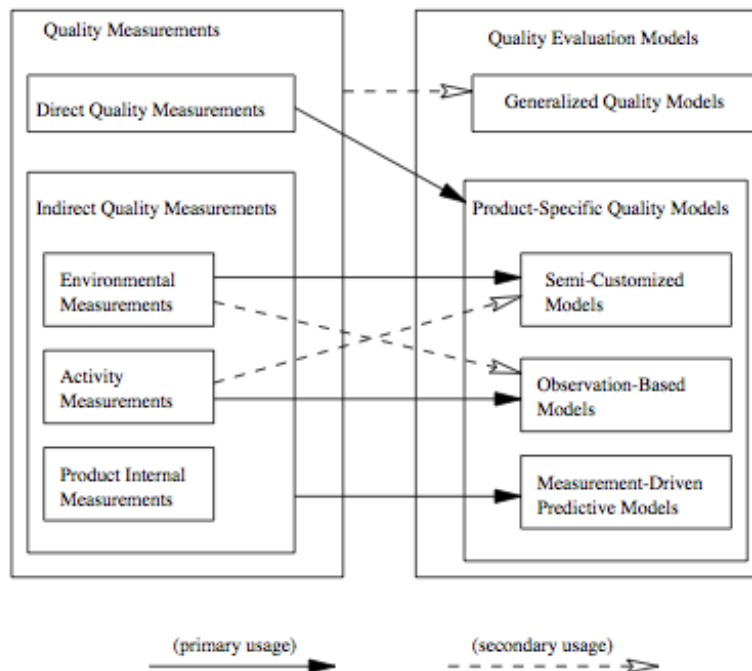
- Data requirement of GMs
 - Quality averages/patterns: Q
 - No measurements from current project
- Data requirement of PSMs
 - All use direct quality measurements: Q
 - related to other measurements: M
 - as relations: $Q \sim M$
 - or as functions: $Q = f(M)$
 - Measurement-driven models
 - M = all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

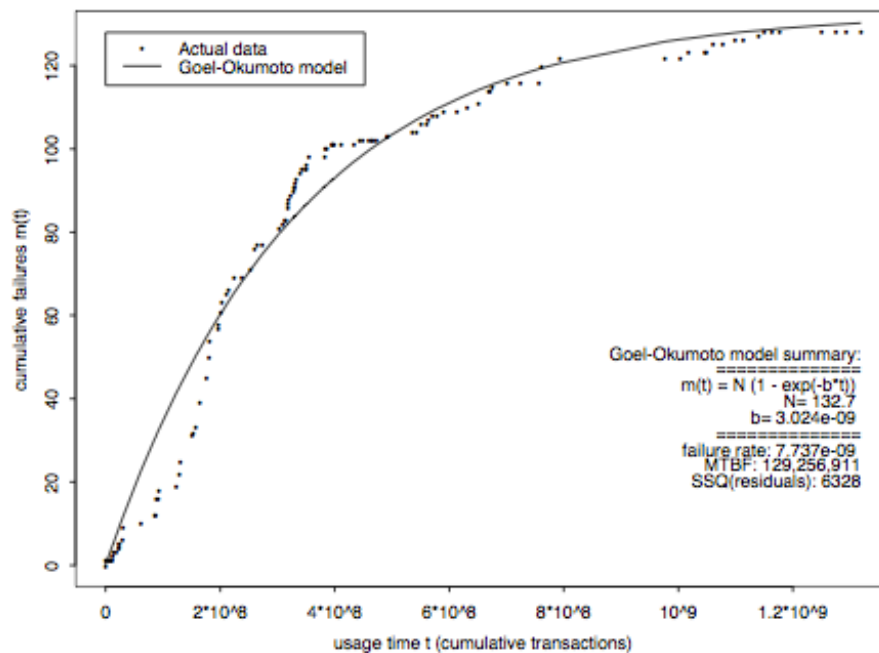
- Goal: rough quality estimates
- Situation 1
 - No product specific data
 - Industrial averages/patterns
 - Commercial tools: SLIM etc
 - Product planning stage
 - Defect profile in lifecycle
 - Use generalized models
- Situation 2
 - Data from related products
 - DRM for legacy products
 - ODC profile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

Selection Example B

- 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:

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

Result:

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

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?