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 $\Rightarrow$ quality $\Rightarrow$ decisions

● Other QA activities:
  ▶ Similar general process.
  ▶ Data from QA/other sources (Ch.18).
  ▶ Models used in analysis and followup:
    – provide timely feedback/assessment
    – prediction, anticipating/planning
    – corrective actions $\Rightarrow$ 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
    - overall, segmented, and dynamic
  - Product-specific:
    - semi-customized: product history
    - observation-based: observations
    - measurement-driven: predictive
  - Model taxonomy: Fig 19.1 (p.324).
  - Relating to issues above
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.

- Examples:
  - Table 19.1 (p.326): reliability levels.
  - Segmented defect density model (derived from previous overall model)

- Other applications.
  - Commonly used in software estimation.
  - Example: COCOMO models.
Generalized Models: Dynamic

- Key characteristics:
  - Overall/average trend over time.
  - Often expressed as a mathematical function or an empirical curve.

- Example: Putnam
  - Rayleigh curve for failure rate $r$:
    $$ r = 2Bate^{-at^2} $$
  - Other variations in literature.
  - Similar: reliability growth trend.

- Combined models possible, e.g., segmented dynamic models.
**Product-Specific Models (PSM)**

- Product-specific models (PSMs):
  - Product-specific info. used (vs. none used in generalized models)
  - Better accuracy/usefulness at cost
  - 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)

• Related examples:
  ▶ Defect dynamics model in Ch.20, as extension to DRM above.
  ▶ ODC defect analyses in Ch.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
  - Example: Table 19.3 (p.329)
    - tree-based defect modeling
    - substantially different high-risk areas
    - identification and remedial actions
Model Summary and Application

- Summary: Table 19.4 (p.329)
  - Primary results/usefulness.
  - Applicability.

- Model generalization or customization in connection with model applications.

- Applications:
  - \( \neg \) data \( \Rightarrow \) GMs as early choices.
  - Data arrival \( \Rightarrow \) phase in PSMs:
    - special case: historical data
      \( \Rightarrow \) semi-customized models early.
  - Model customization within.
  - Model generalization: data out.
Relating Models to Measurements

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

- Data requirement of GMs:
  - Quality averages/patterns: \( \overline{Q} \)
  - No measurements from current project
Relating Models to Measurements

• 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

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

• Relating models to measurements:
  Fig 19.3 (p.332) – chapter summarized.
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: reflect activity
  - Fig 19.4 (p.335): time = transactions
  - Environment: implicitly assumed
Selection Example C

- Goal: testing process/quality improvement

- Quality model: Fig 19.5 (p.336)
  ▶ Inadequacy of SRGMs
  ▶ TBRM: improvement focus
    - what’s wrong: risk identification
    - what to do: remedial actions
  ▶ Affordability: data and modeling

- Quality measurements:
  ▶ Result: success/failure measurement
  ▶ Timing info.: time-domain analysis
  ▶ Input state: input-domain analysis
  ▶ Data attributes: Table 19.6 (p.336)
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?