Risk-Based Quality Improvement
for Embedded Systems

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Quality, Reliability, and Risk

Observation: Highly uneven distribution of cost, usage, quality, defect, performance, etc.

- “80:20” rule or Pareto’s principle.
- Units: component, owner, feature, etc.
- Focus: high-risk/high-leverage units.
- Measurement distribution example above.
Risk Identification and Management

- Risk identification:
  - Qualitative: Causal analysis, etc.
  - Quantitative:
    - Old: correlation, regression, etc.
    - New: PCA, DA, TBM, etc.
    - AI/learning: NN, OSR, etc.

- Risk management:
  - Current project: Remedial actions
  - Similar projects: Corrective actions
  - Future projects: Preventive actions
Risk Focus: Important Usage

- Focusing on functions/modules with:
  - High usage frequency and importance
  - Non-uniform attention/effort in
    - testing $\Rightarrow$ UBST
    - other focused quality assurance

- Usage-based statistical testing (UBST)
  - Capture user/usage information
  - Usage model $=$ Operational profile (OP)
  - OP-guided testing $=$ UBST
  - SRMs: Testing results $\Rightarrow$ reliability
  - New applications in web, ES, etc.

Risk Focus: Defect-Prediction

- Analyzing defect-metrics relations
  - Correlation/regression (example above)
  - Impact: Behavior modification
Risk Focus: Defect-Reduction

- Early successes ⇒ Behavior modification
  - Validation ⇒ hypothesis testing (HT)
  - Need more sophisticated methods

- HT in Koru and Tian, IEEE-TSE 8/2005:
  - High-defect (HD) modules vs. high-complexity (HC) modules
  - HD and HC statistically different
  - Complexity ranking of HD: 60 ~ 80%
Risk Focus: Defect-Reduction

- TBDM for defect↓ and quality↑:
  - Tian and Troster, JSS 12/1998
  - Tian/Nguyen/Allen/Appan, JSS 9/2001
Risk Focus: Reliability Growth

- Focused/accelerated reliability improvement via tree-based reliability models (TBRMs)
  - Measure: Purification level $\rho = \frac{\lambda_0 - \lambda_T}{\lambda_0}$
  - A/B/C: $0.35 \sim 0.72$ vs. D: $0.94 \sim 0.99$
Summary and Perspectives

• Existing work and successes:
  ▶ Size/complexity $\uparrow \Rightarrow$ selective effort
  ▶ 80:20 $\Rightarrow$ risk focus
  ▶ Risk identification/management:
    – usage-based statistical testing
    – defect-prone module characterization
    – risk-based reliability improvement

• Impact on embedded systems:
  ▶ Similar set of problems
  ▶ Interaction: OP/UBST applicable
  ▶ Other risk identification/management
References – To Probe Further


