

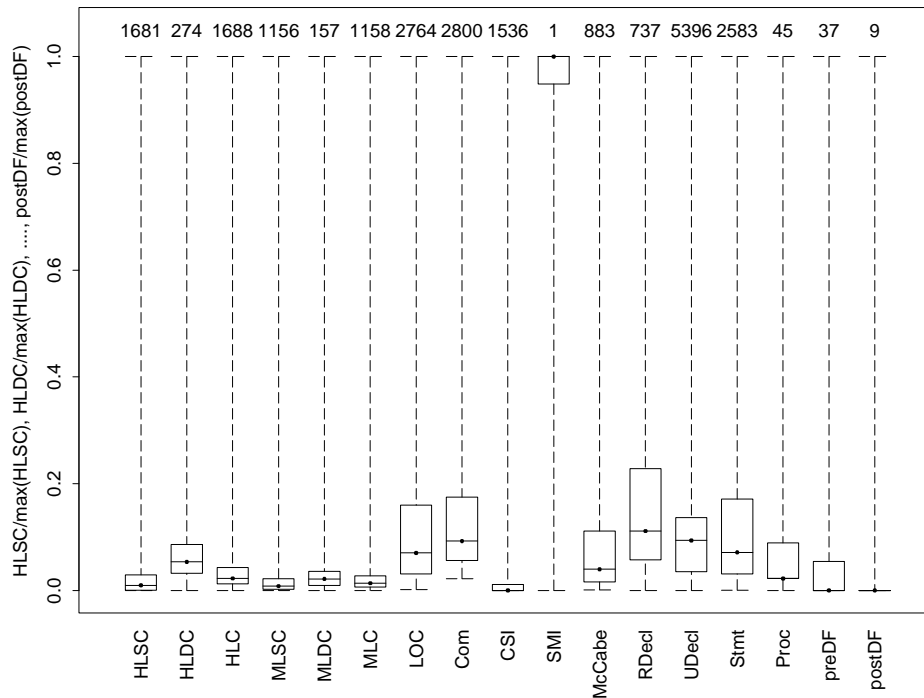
# Risk-Based Quality Improvement for Embedded Systems

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## Contents

- Quality, Reliability, and Risk
- Successes in Risk Id./Management
- Implications for Embedded Systems

## 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

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- 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

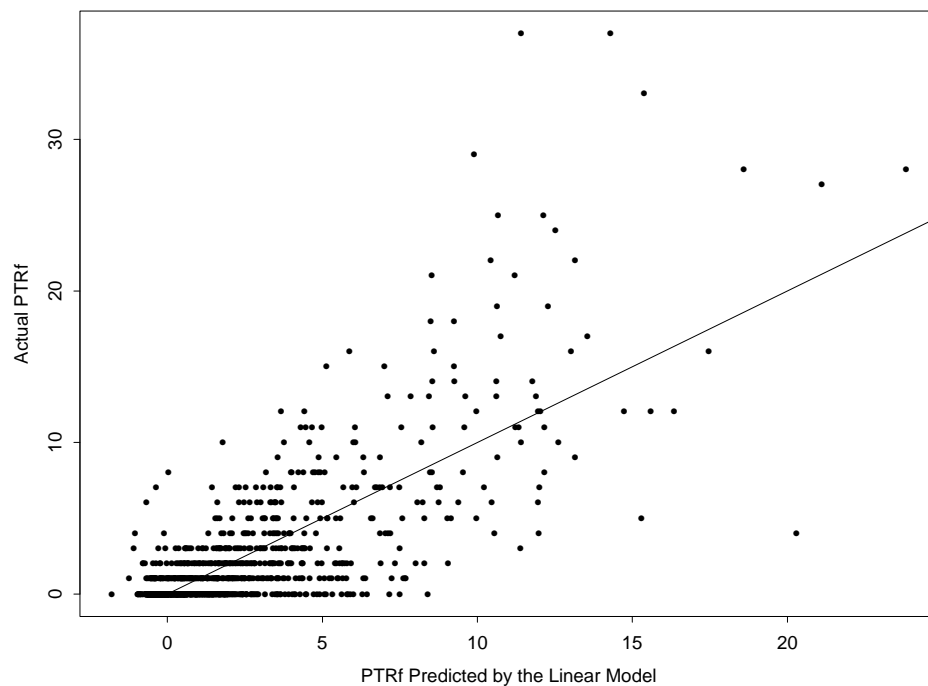
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## Risk Focus: Important Usage

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- Focusing on functions/modules with:
  - ▷ High usage frequency and importance
  - ▷ Non-uniform attention/effort in
    - testing ⇒ 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 ⇒ reliability
  - ▷ New applications in web, ES, etc.
  
- In Tian, *Software Quality Engineering*, IEEE/CS-Wiley, 2005.

## Risk Focus: Defect-Prediction



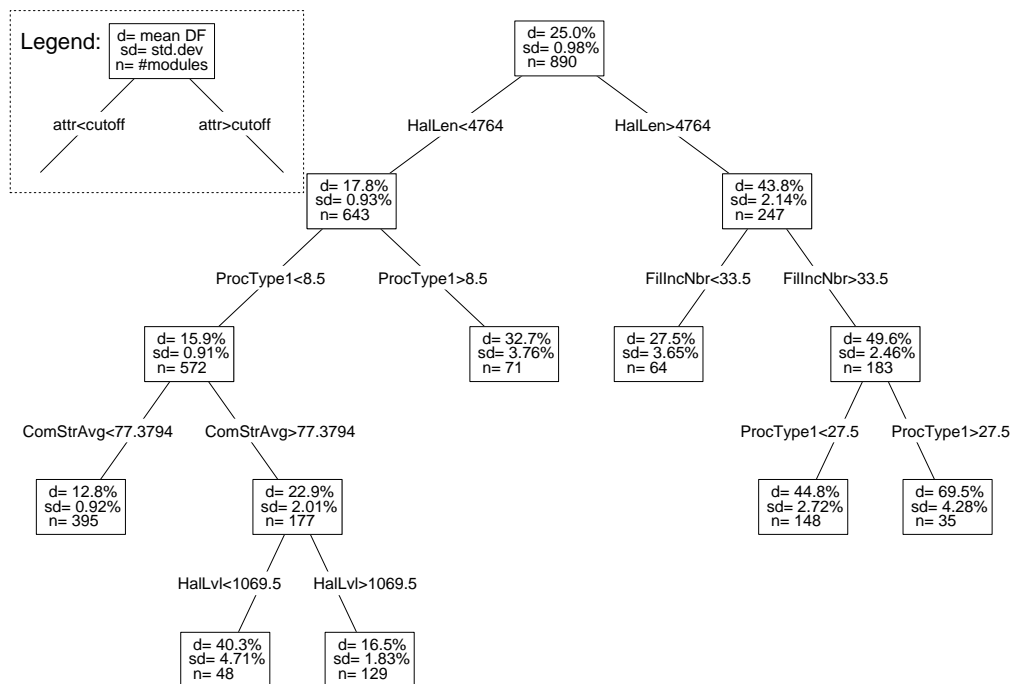
- Analyzing defect-metrics relations
  - ▷ Correlation/regression (example above)
  - ▷ Impact: Behavior modification

## Risk Focus: Defect-Reduction

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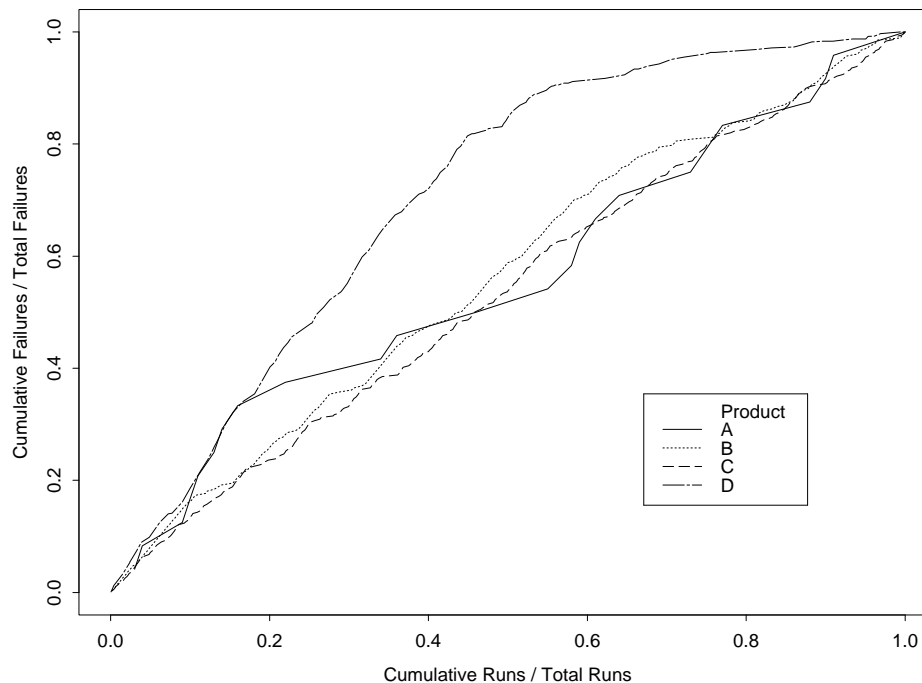
- Early successes  $\Rightarrow$  Behavior modification
  - ▷ Validation  $\Rightarrow$  hypothesis testing (HT)
  - ▷ Need more sophisticated methods
  
- HT in Koru and Tian, IEEE-TSE 8/2005:
  - ▷ High-defect (HD) modules vs. high-complexity (HC) modules
  - ▷ HD and HC statistically different
  - ▷ 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 ~ 0.72 vs. D: 0.94 ~ 0.99

## Summary and Perspectives

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- 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

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1. A.G. Koru and J. Tian, “Comparing High-Change Modules and Modules with the Highest Measurement Values in Two Large Scale Open-Source Products”, *IEEE Trans. on Software Engineering* 31(8): 625-642, Aug., 2005.
2. J. Tian, *Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement*, Wiley-IEEE/CS Press, 2005.
3. J. Tian, A. Nguyen, C. Allen, and R. Appan, “Experience with Identifying and Characterizing Problem Prone Modules in Telecommunication Software Systems”, *J. of Systems and Software* 57(3):207-215, July, 2001.
4. J. Tian and J. Troster, “A Comparison of Measurement and Defect Characteristics of New and Legacy Software Systems”, *J. of Systems and Software* 44(2):135-146, Dec., 1998.