

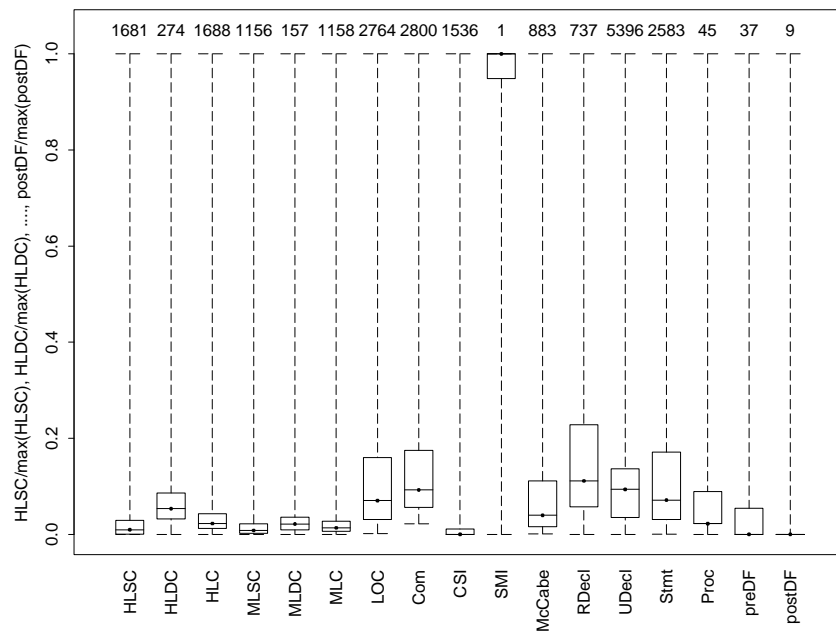
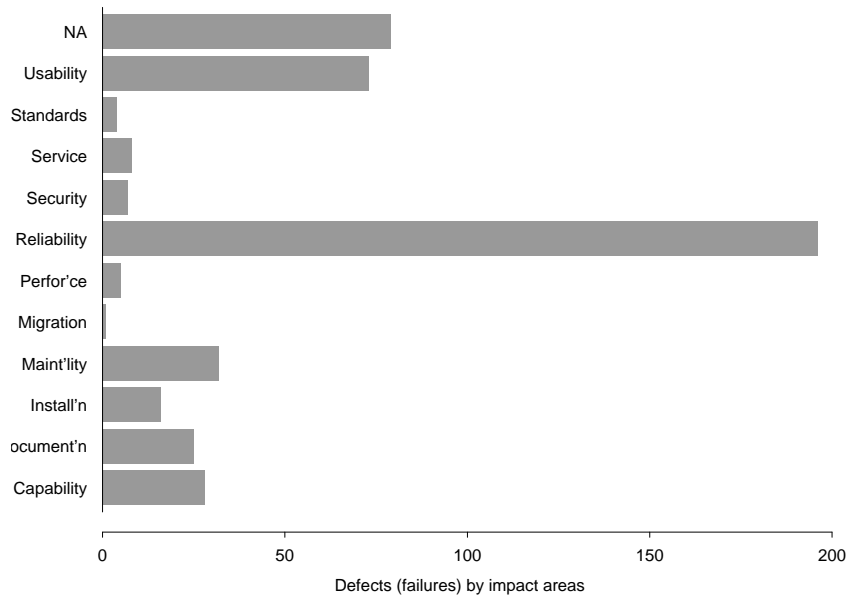
Risk-Based Quantifiable Quality Improvement

Jeff Tian (tian@engr.smu.edu)
Southern Methodist University
Dallas, Texas, USA

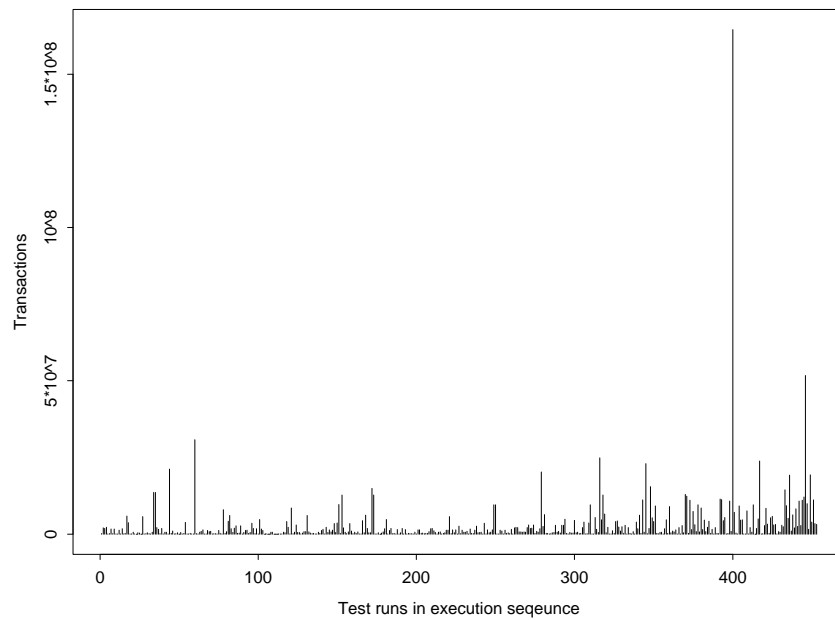
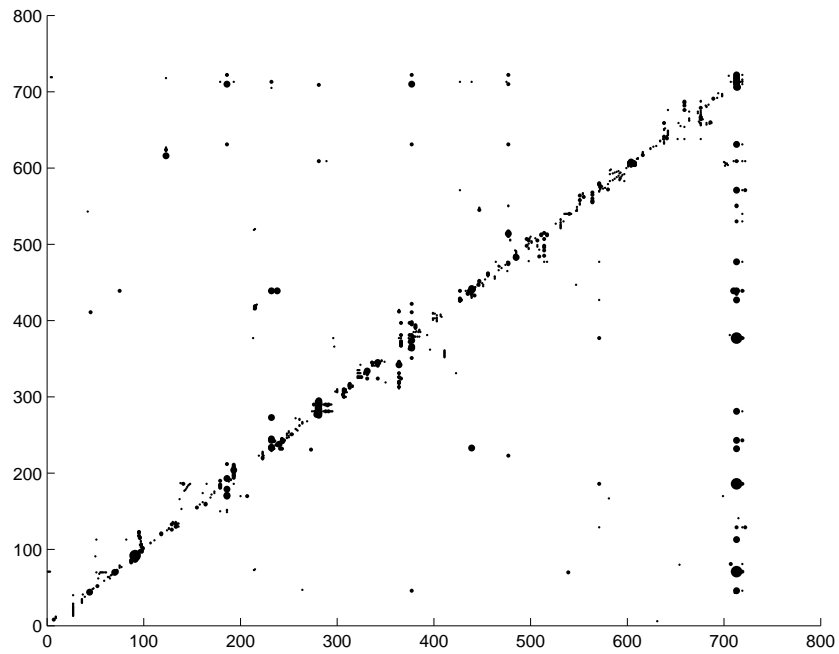
Contents

- Quality, Quantification, and Risk
- Quality↑ \Leftarrow Risk↓
- Quality↑ for Customers/Users
- Quality↑ for Software Organizations

Risk: Defect/Metrics Data



Risk: Usage/Workload Data



Quality, Quantification, and Risk

- **Risk:** 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.

- Quantifiable quality improvement:
 - ▷ Quality: reliability, low-defects, etc.
 - ▷ Quantified: data and measurement
 - ▷ Improvement: risk-id/management

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

In-/Ex-ternal Perspectives

- External risk to customers/users
 - ▷ Reliability: probability of failure-free operations for a time period or input set
 - ▷ Usage affects reliability
 - ⇒ usage: OP (operational profile) for usage-based statistical testing (UBST)
 - ▷ Risk-based reliability improvement

- Internal risk to software organizations:
 - ▷ Defect risk identification & reduction.
 - ▷ Metrics-defect predictive modeling.
 - ▷ ODC and extensions.

Application Domains

- NASA/SEL: metrics in modeling
 - ▷ early work (pre-1992) at U. Maryland
 - ▷ axiomatic framework on measurement
 - ▷ selection procedure as optimization
 - ▷ used for better effort prediction

- Commercial software:
 - ▷ IBM (1992–1995+)
 - ▷ UBST and OP for compilers
 - ▷ Reliability modeling for DBMS etc.
 - ▷ ODC and extensions
 - ▷ Defect/metrics analysis and modeling
 - ▷ Reliability improvement using TBRM

Application Domains

- Telecommunications software:
 - ▷ Nortel (pre-2002):
 - similar to IBM work +
 - formal hypothesis testing HC-HD?
 - characterization of HD modules
 - ▷ Verizon (2004+):
 - e-commerce quality improvement

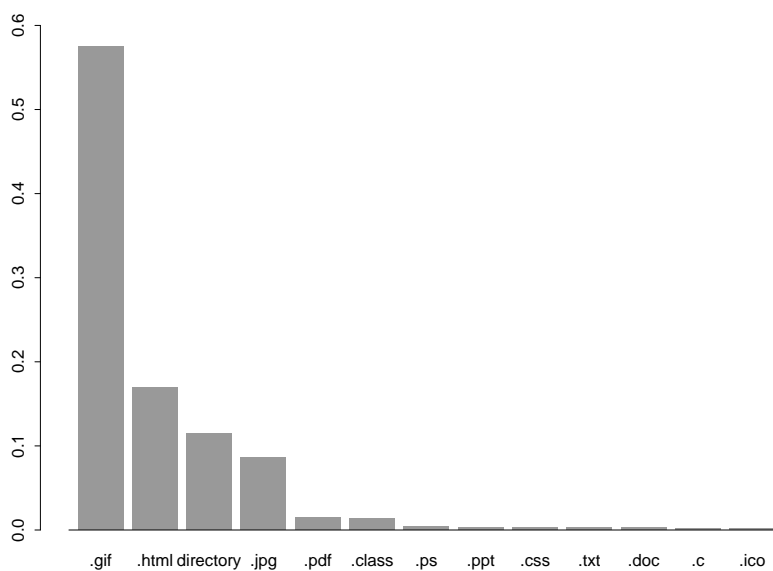
- Other applications: quality improvement
 - ▷ LM: aeronautic/embedded QI
 - reliability, DEA, HP
 - ▷ web testing and QI (later)
 - ▷ open source software QI
 - ▷ safety-critical systems

Risk Focus: Important Usage

- Focusing on functions/modules with:
 - ▷ High usage frequency and importance
 - ▷ Non-uniform testing effort
 - ⇒ usage-based statistical testing (UBST)
 - ▷ Other focused quality assurance

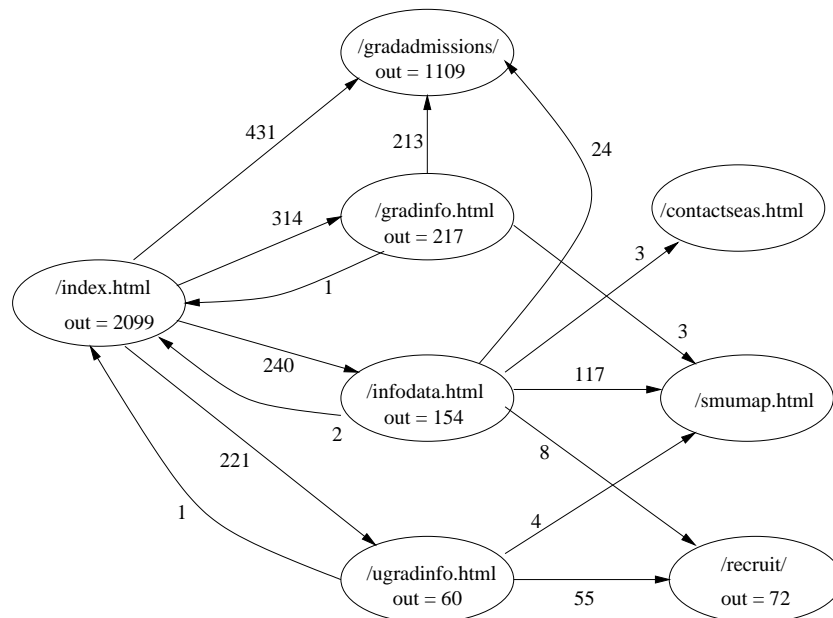
- UBST = OP-guided testing
 - ▷ Capture user/usage information
 - ▷ Usage model = Operational profile (OP)
 - ▷ SRMs: Testing results ⇒ reliability
 - ▷ New applications in web, etc.

Web Testing Example



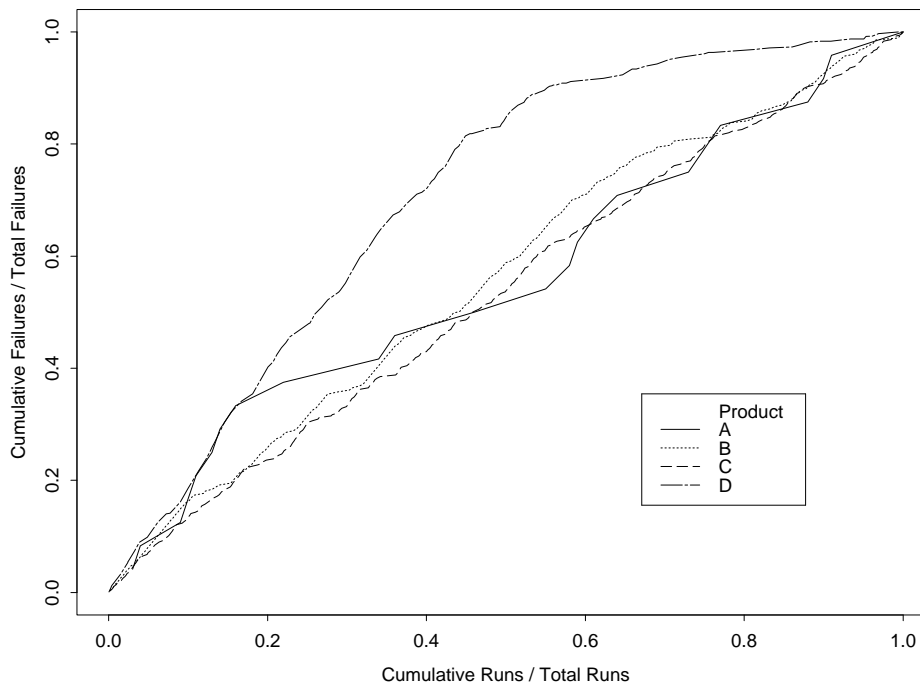
- High-level usage: Musa's flat OP
- Other usage/testing: UMMs, etc

Web Testing Example



- UMMs (Unified Markov Models):
 - ▷ Navigation patterns/probabilities
 - ▷ Expansion to lower-level models
 - ▷ Driving existing white-box testing

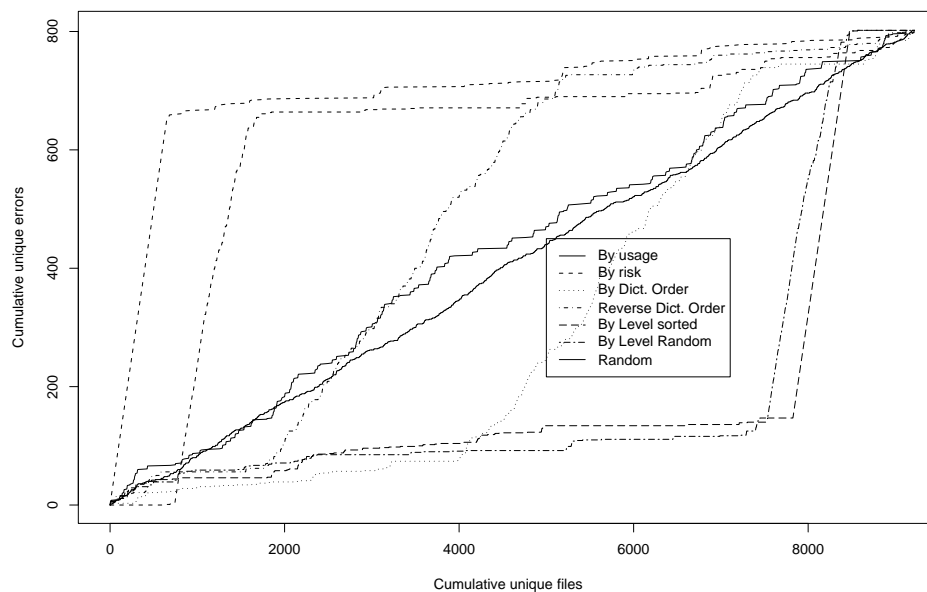
Risk Focus: Reliability Growth



- 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

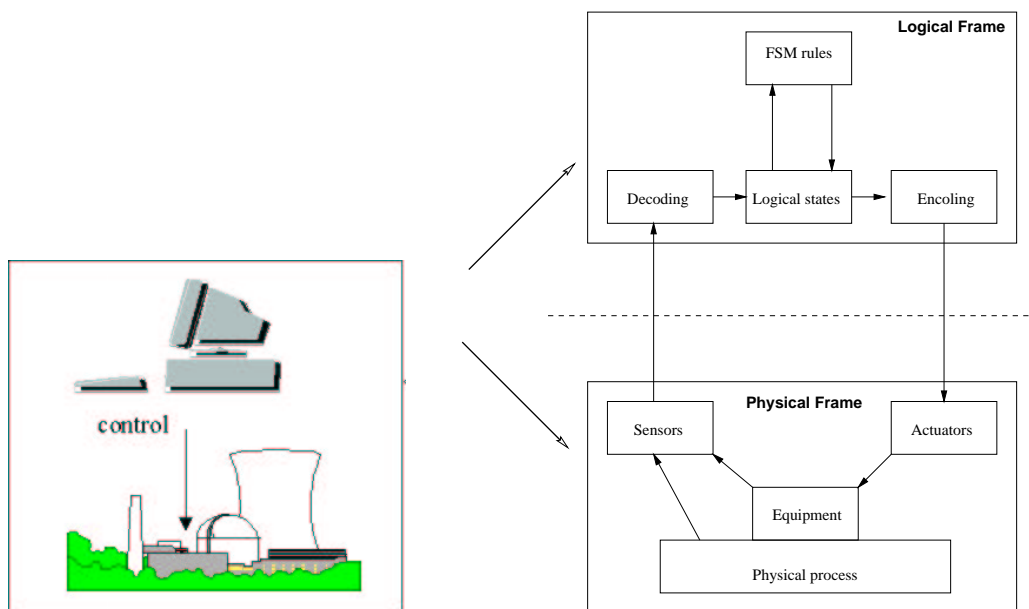
Risk Focus: Web Reliability

- Different web sites: SMU/KDE/AMS
 - ▷ workload measurement:
hits, bytes, users, sessions
 - ▷ operational reliability: Nelson model
 - ▷ reliability growth simulation:
 $\approx 2/3$ defect reduction in 1 month
 - ▷ accelerated reliability growth via (ODC inspired) risk identification (below)

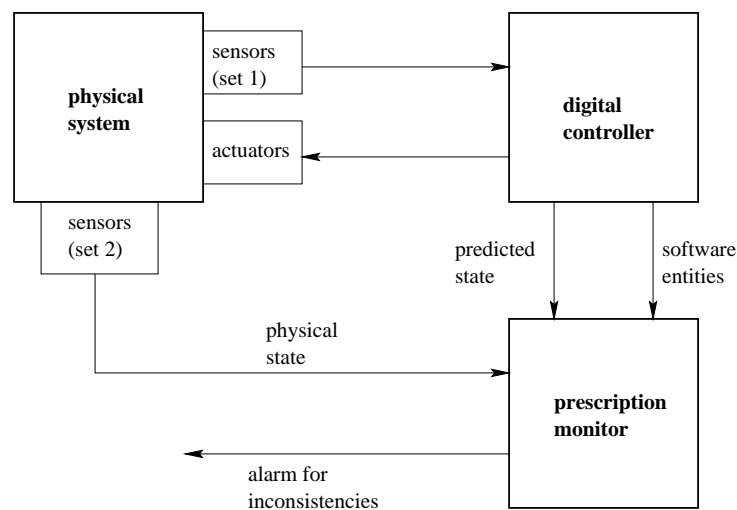


Risk Focus: Safety

- TFM: Two-Frame-Model
 - ▷ Physical and logical frame
 - ▷ Sensors: physical \Rightarrow logical
 - ▷ Actuators: logical \Rightarrow physical
 - ▷ Focus: interface/interaction problems

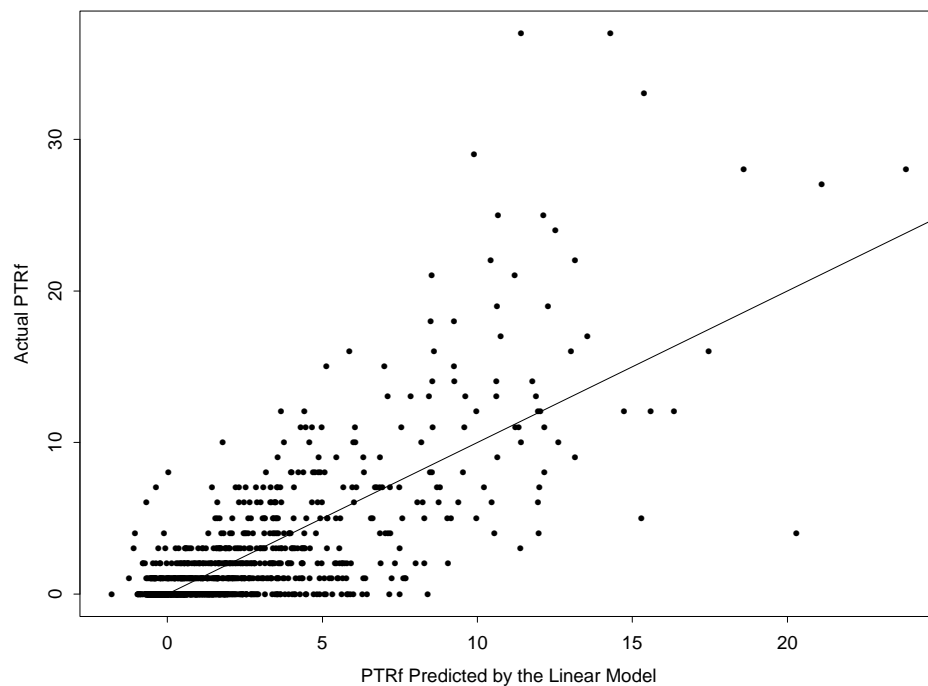


Risk Focus: Safety



- Prescriptive specification checking:
 - ▷ Analyze sources of hazard
 - frame inconsistencies, sub-types
 - ▷ Derive systematic assertions
 - ▷ Dynamically check the assertions

Risk Focus: Defect-Prediction



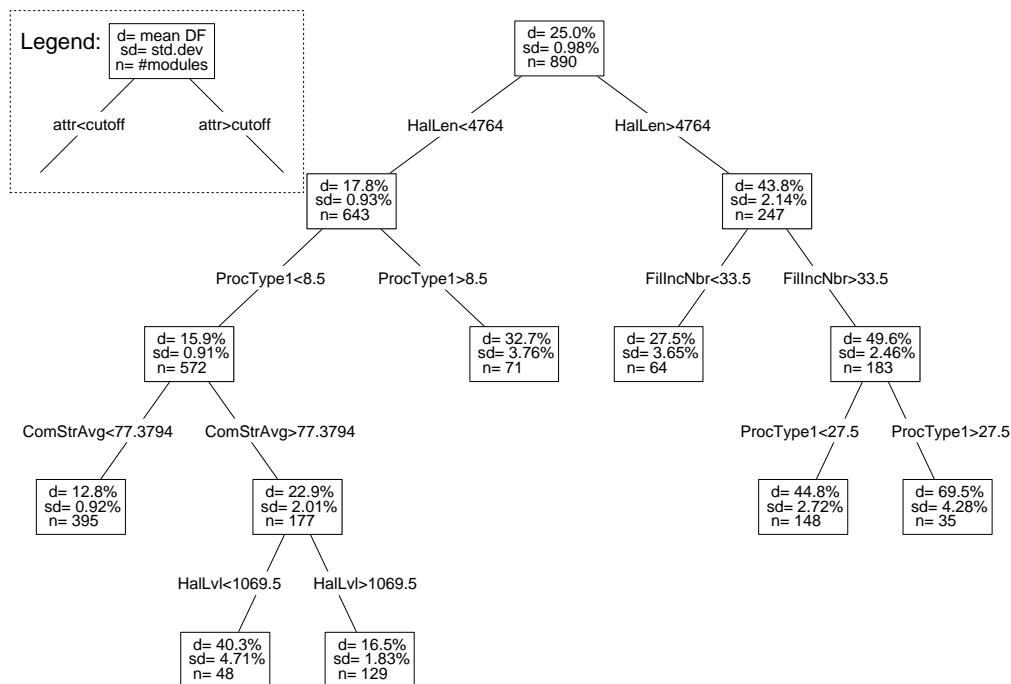
- Analyzing defect-metrics relations
 - ▷ Correlation/regression (example above)
 - ▷ Impact: Behavior modification

Risk Focus: Defect-Reduction

- 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

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

- Positive impact on different systems:
 - ▷ Commercial software: defect/reliability
 - ▷ Web-based: heterogeneity/quality
 - ▷ Embedded: safety/performance
 - ▷ Other types too