
A Literature Survey of the Quality Economics of Defect-Detection Techniques

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- Defect-detection techniques (DDT) such as reviews and tests are an indispensable part of quality improvements
- Also the costs are significant:
 - ◆ Myers (1979) assigns 50% of the development costs to fault removal
 - ◆ Jones (1987) states that 30–40% of the development costs are spent for quality assurance and fault removal
 - ◆ The US *National Institute of Standards and Technology* (2002) even assigns 80% of the costs to fault detection and removal
- There is an opportunity for cost savings!

- The general question is how to use defect-detection techniques in a cost-optimal way.
- However, we need to know which costs and factors contribute to the economics of defect-detection
- Ntafos (2001): “Cost is clearly a central factor in any realistic comparison but it is hard to measure, data are not easy to obtain, and little has been done to deal with it.”
- Rai et al. (1998): “A better understanding of the costs and benefits of SQA and improvements to existing quantitative models should be useful to decision-makers.”
- So what do we do about the data?
- We cannot collect all the data when using such a quantitative model

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**Software Quality
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Quality Economics

An Analytical Model

Difficulty Functions

Example: Direct
Costs

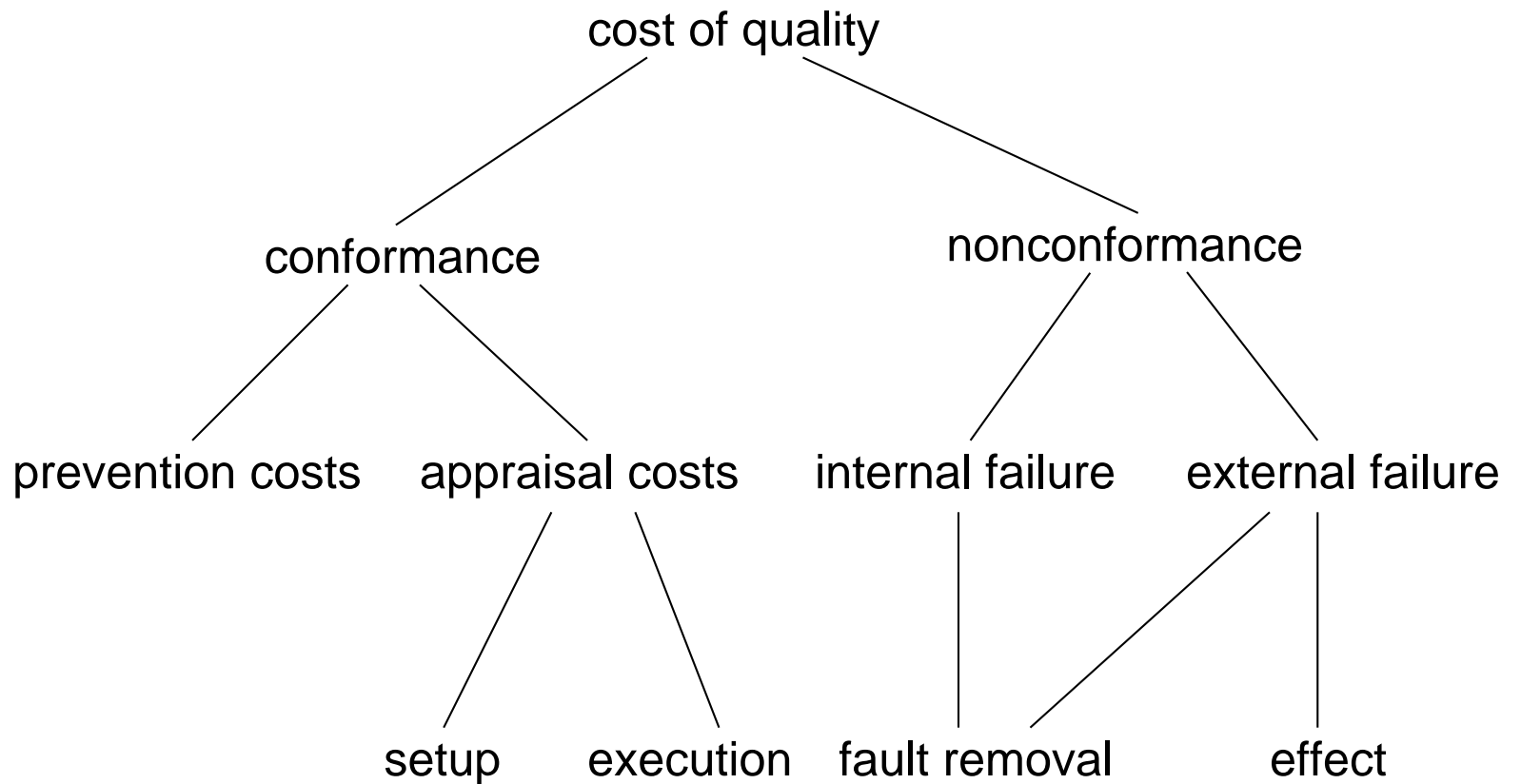
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Software Quality Economics

- Quality economics is the cost/benefit analysis w.r.t. quality
- The benefits are saved costs



- Captures the relationships of the main factors stochastically
- Three components:
 - ◆ Direct costs $E[d_A(t_A)]$
 - ◆ Future costs $E[o_A(t_A)]$
 - ◆ Revenues / saved costs $E[r_A(t_A)]$
- Not covered:
 - ◆ Time to market
 - ◆ Net present value

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- The *difficulty function* proposed by Littlewood et al. (2000) describes the difficulty of a specific technique to find a specific defect
- Similar to the effectiveness but specific to the defect or defect type
- Extended by the *effort* dimension

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Software Quality Economics

Quality Economics

An Analytical Model

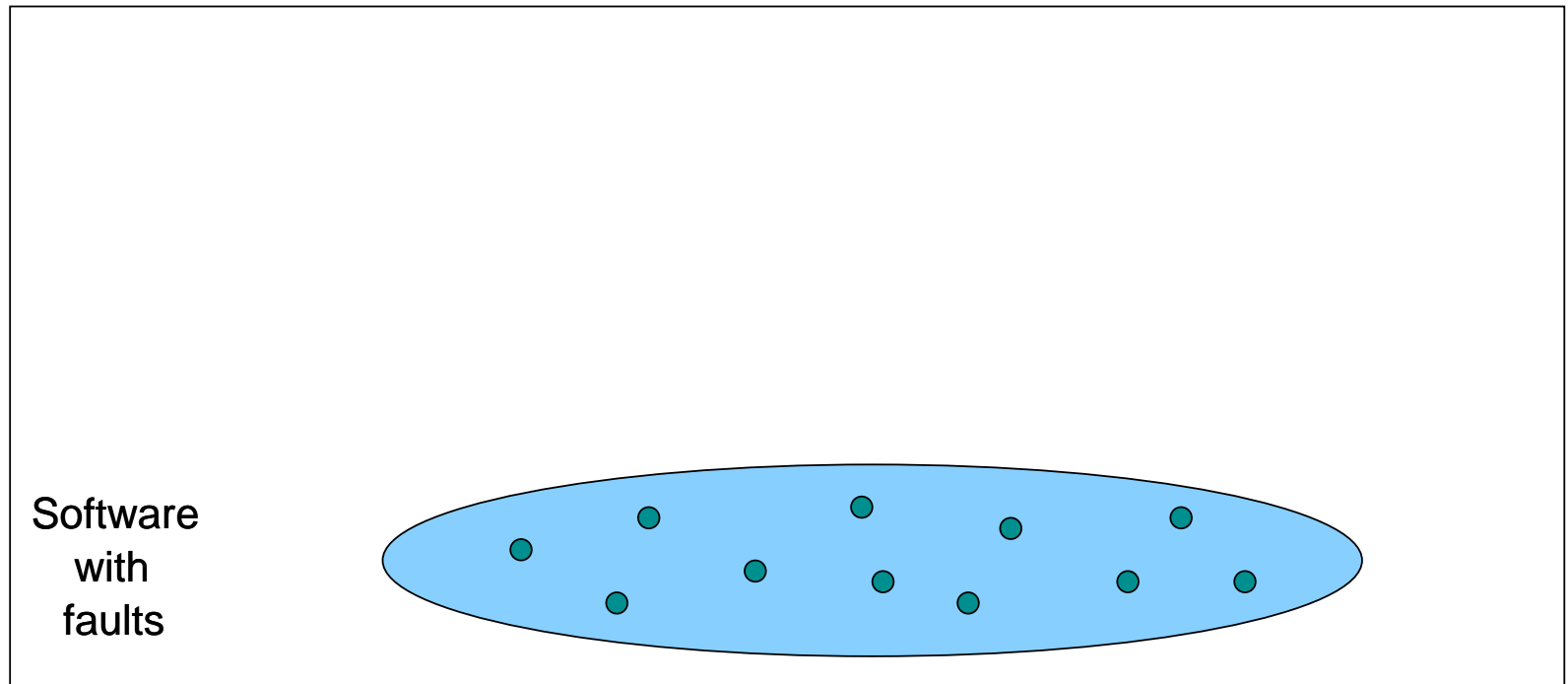
Difficulty Functions

Example: Direct Costs

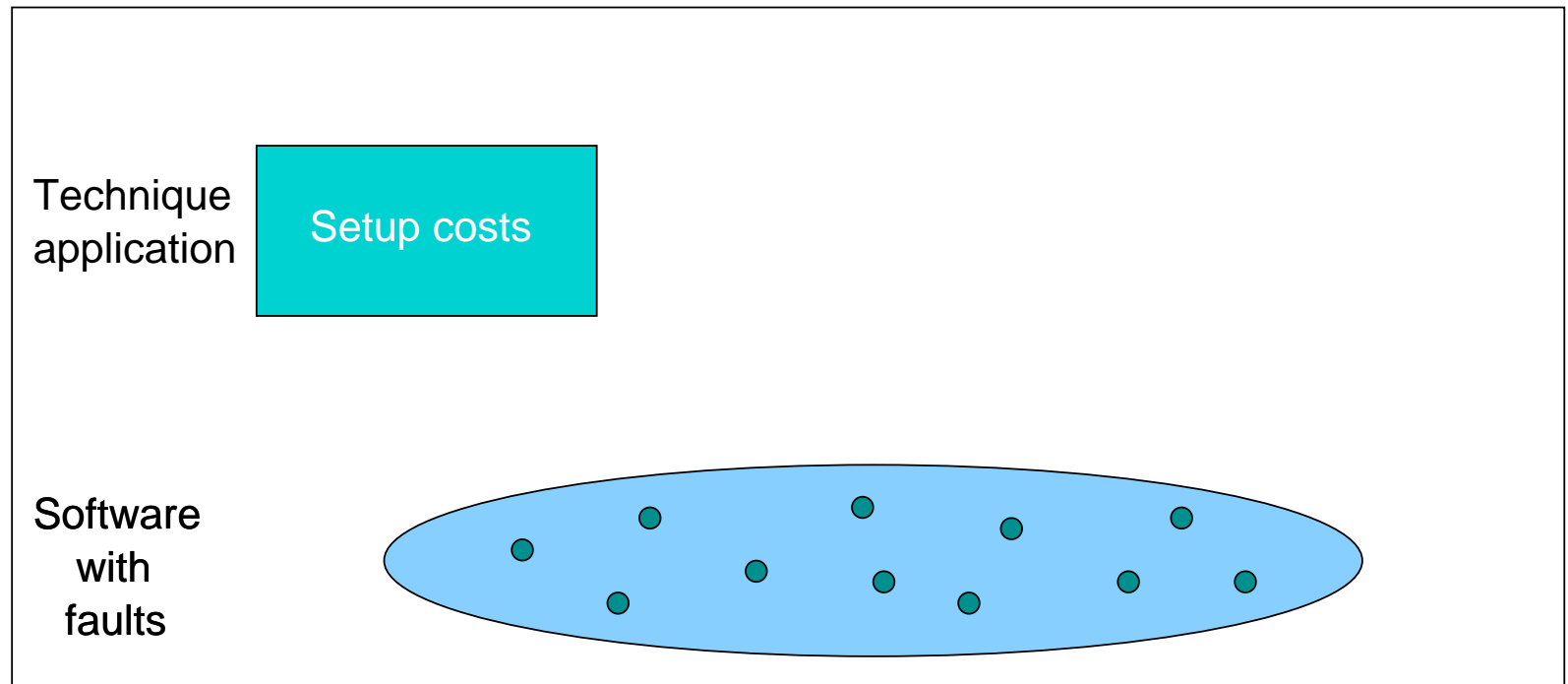
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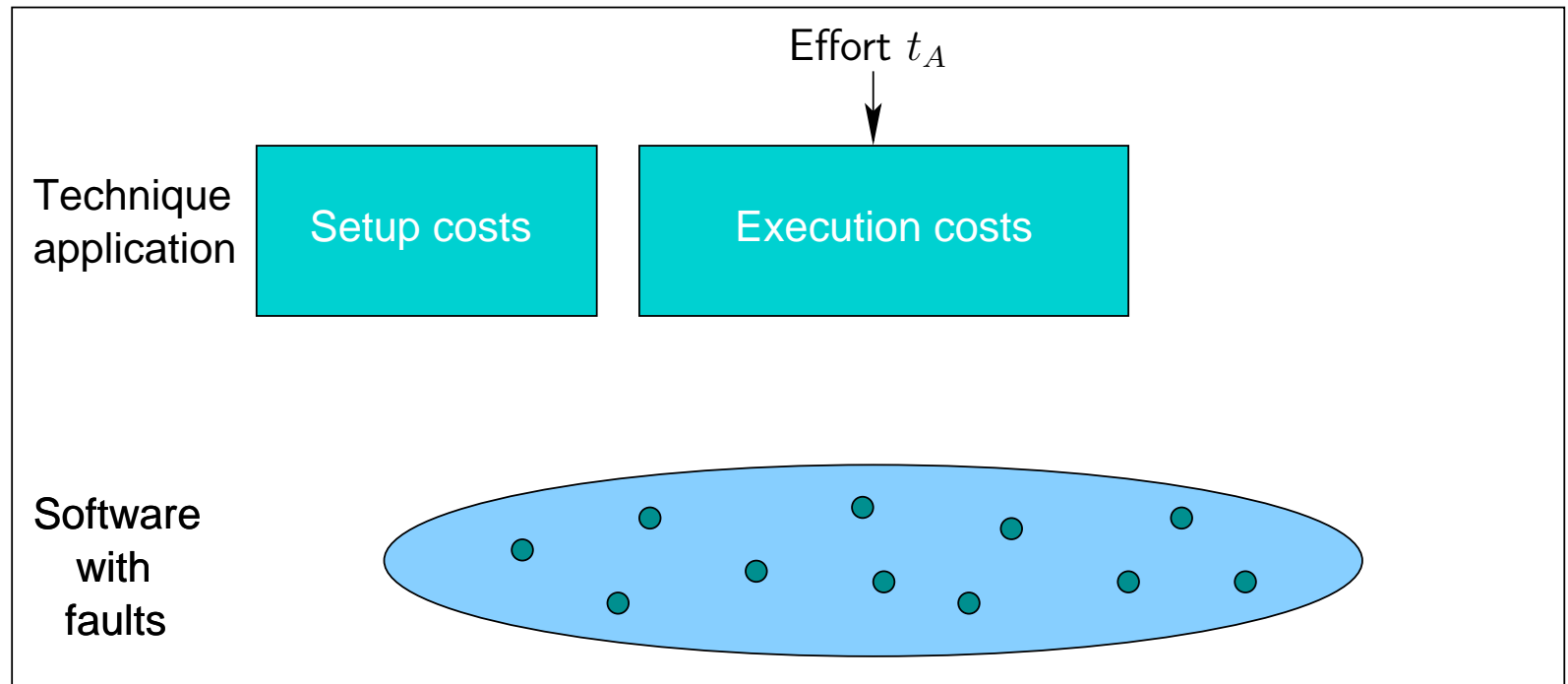
(1)



- Costs that can be measured during the usage of a technique application

$$E[d_A(t_A)] = u_A \quad (1)$$

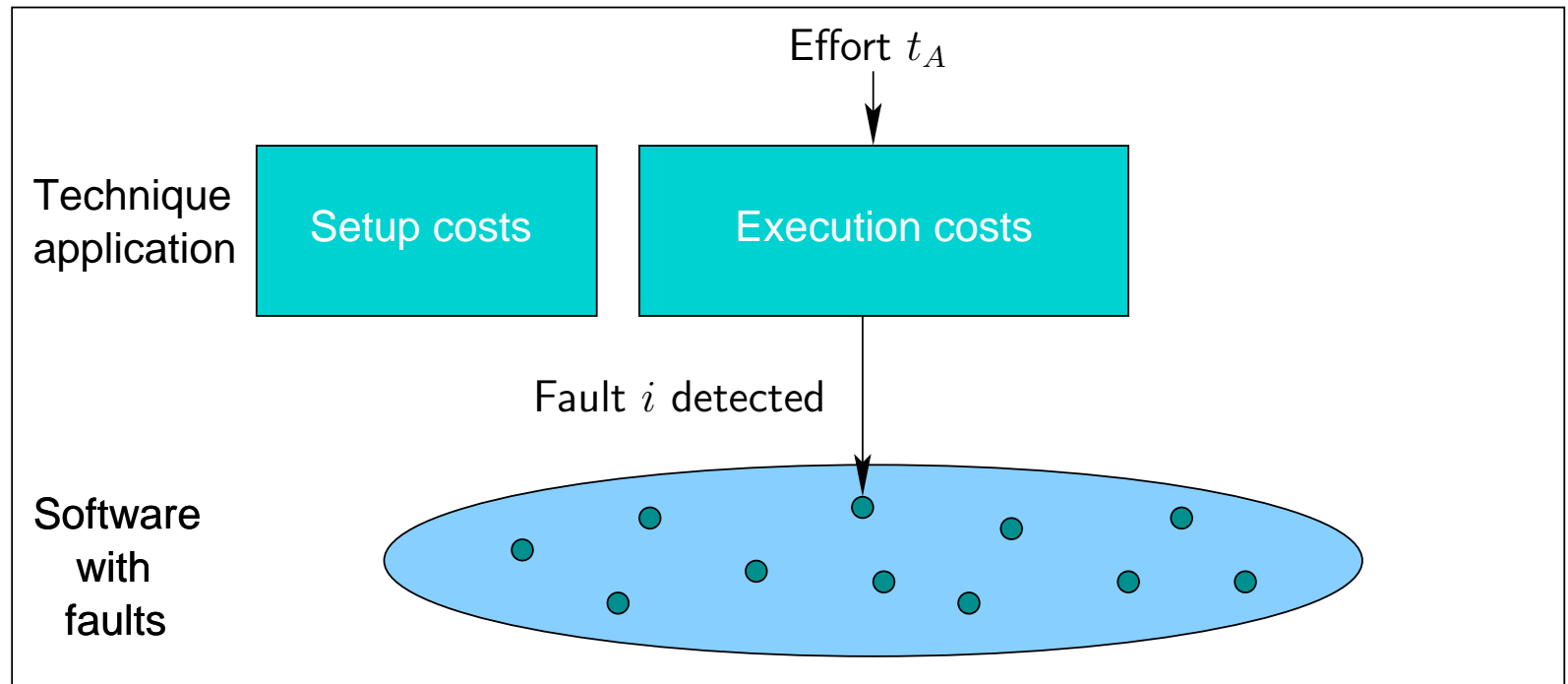
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- Costs that can be measured during the usage of a technique application

$$E[d_A(t_A)] = u_A + e_A(t_A) \quad (1)$$

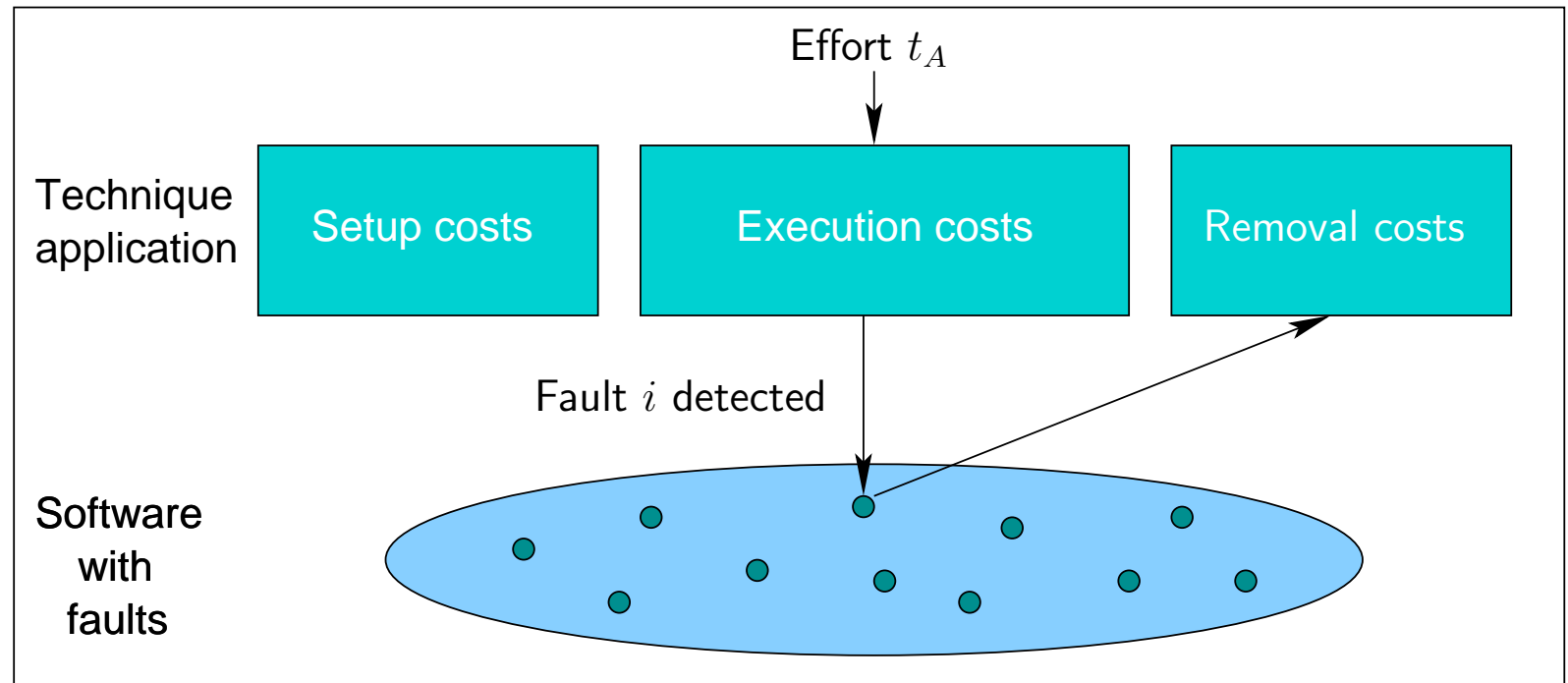
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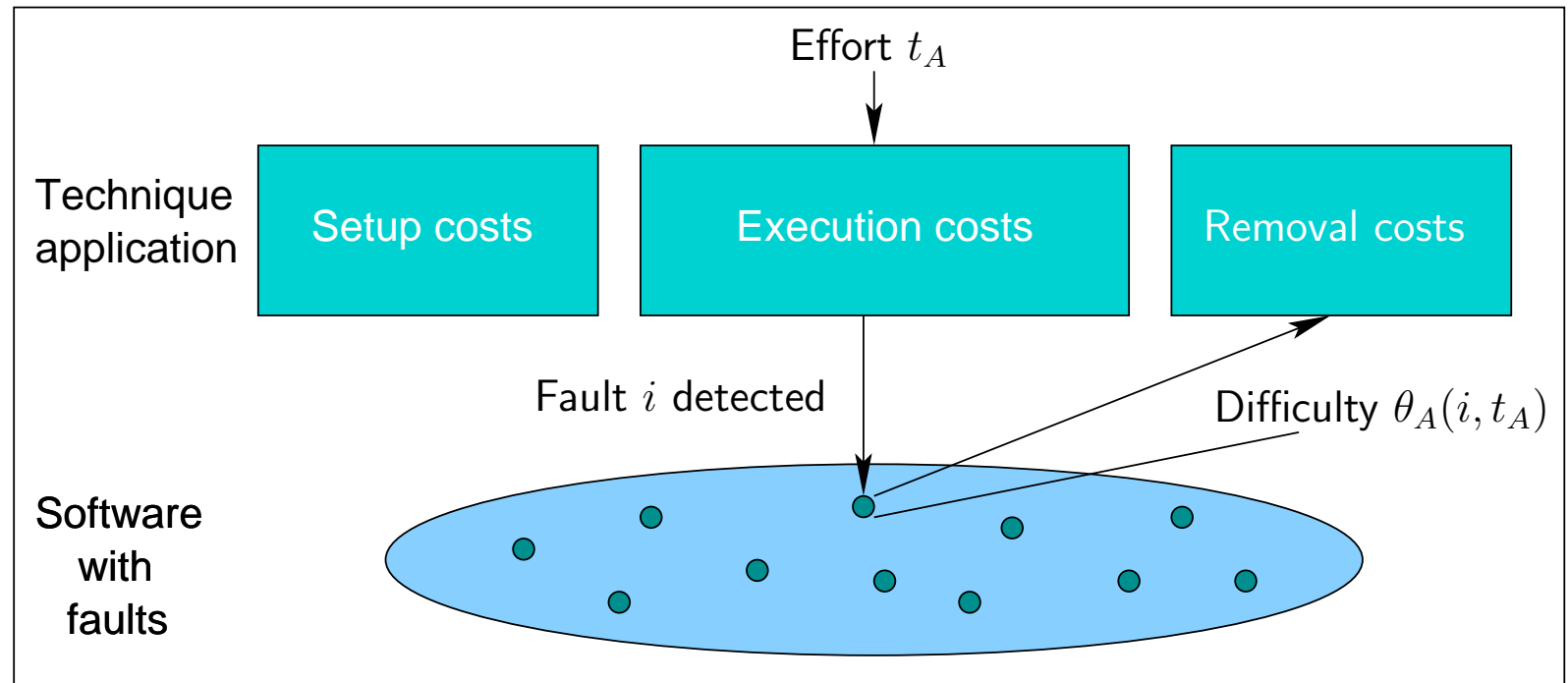
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- Costs that can be measured during the usage of a technique application

$$E[d_A(t_A)] = u_A + e_A(t_A) + \sum_i v_A(i) \tag{1}$$

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- Costs that can be measured during the usage of a technique application

$$E[d_A(t_A)] = u_A + e_A(t_A) + \sum_i (1 - \theta_A(i, t_A))v_A(i) \quad (1)$$

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Results: Review and
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Results: Field Defect
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- Review of 68 books, journal and conference papers
- Case and field studies, experiments
- All weighted equal
- Using simple statistics:
 - ◆ Highest and lowest values
 - ◆ Mean and median
- The average difficulty is approximated by $1 - \text{effectiveness}$

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- Only little data for the setup and execution costs
- Some data can be found in Jones (1991)

Difficulties in percentages

Type	Lowest	Mean	Median	Highest
Functional	12	46.74	51.15	67
Structural	11	45.22	43.15	83
All	11	50.15	53	92.8

Only a small number of studies w.r.t. defect types

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Removal costs in staff-hours per defect

Type	Lowest	Mean	Median	Highest
Unit	1.5	3.46	2.5	6
Integration	3.06	5.42	4.55	9.5
System	2.82	8.37	6.2	20
All	0.2	8	4.95	52

Execution costs in staff-hours per KLOC

Design	Lowest	Mean	Median	Highest
Preparation	3.6	4.68	4.68	5.76
Meeting	3.6	4.07	4.07	4.54
All	7.2	8.75	8.75	10.3
Code	Lowest	Mean	Median	Highest
Preparation	4.91	6.49	6.67	7.9
Meeting	3.32	7.02	4.4	13.33
All	6.67	13.2	11.15	22

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Average difficulty

Lowest	Mean	Median	Highest
7.3	65.86	70	91.5

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Removal costs in staff-hours/defect

Phase	Lowest	Mean	Median	Highest
Requirements	0.05	1.06	1.1	2
Design	0.07	2.31	0.83	6.3
Coding	0.17	2.71	1.95	6.3
All	0.05	1.91	1.2	7.5

Results: Field Defect Removal Costs

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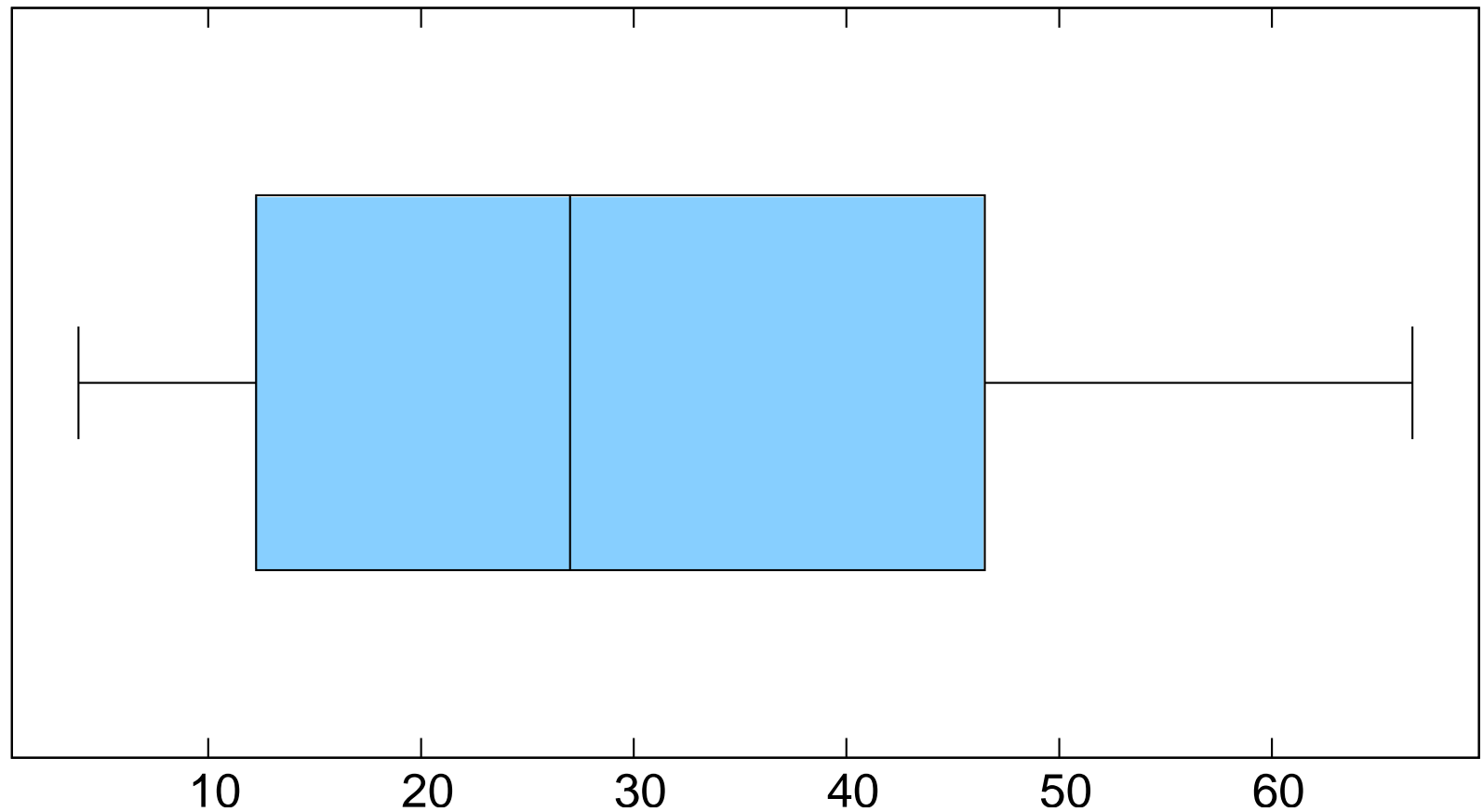
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Lowest	Mean	Median	Highest
3.9	27.24	27	66.6



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Test vs. Inspection

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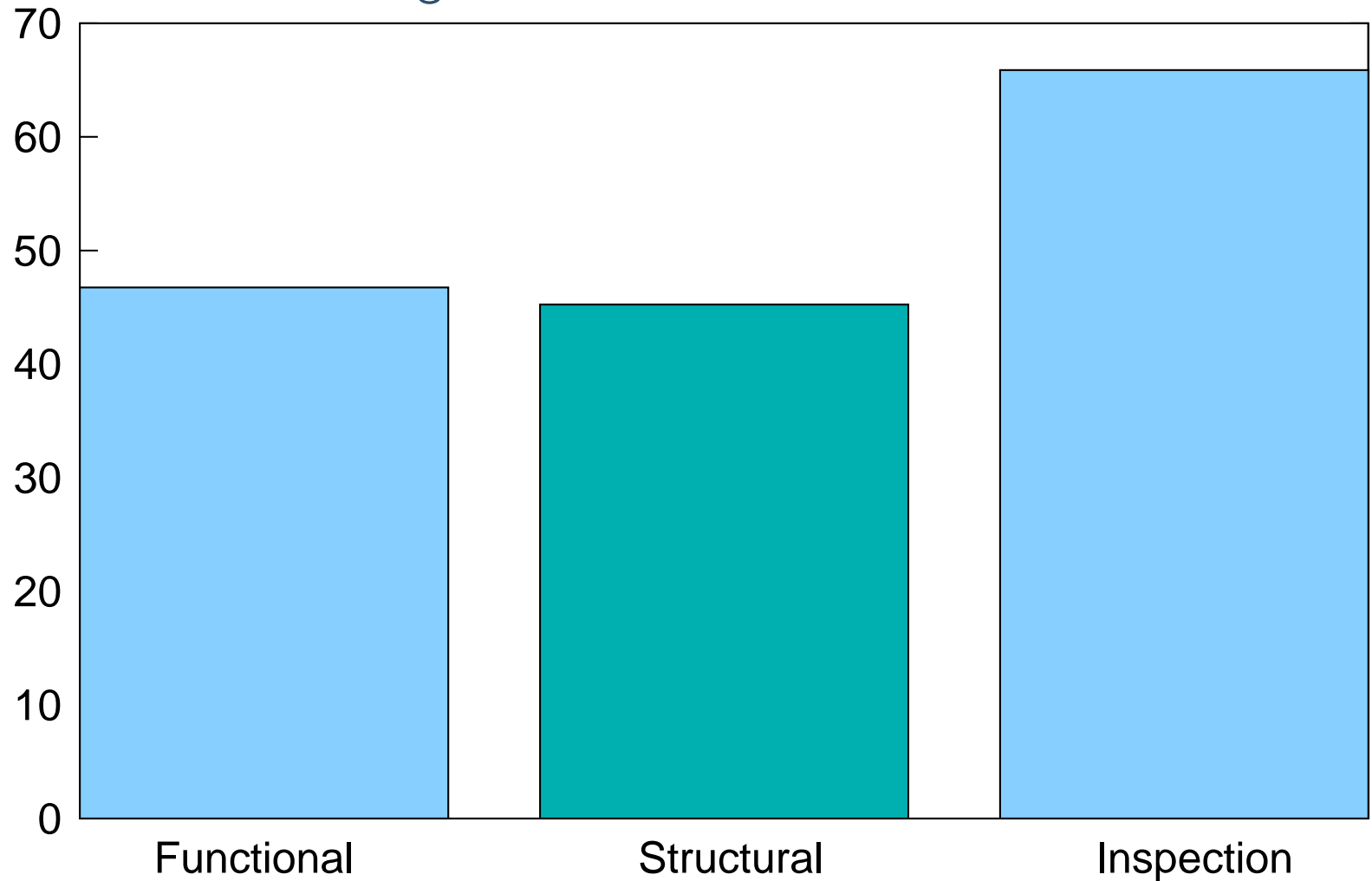
Conclusions

Tests have on average less difficulties

Technique	Mean Difficulty
Functional testing	46.74
Structural testing	45.22
Inspection	65.86

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Tests have on average less difficulties

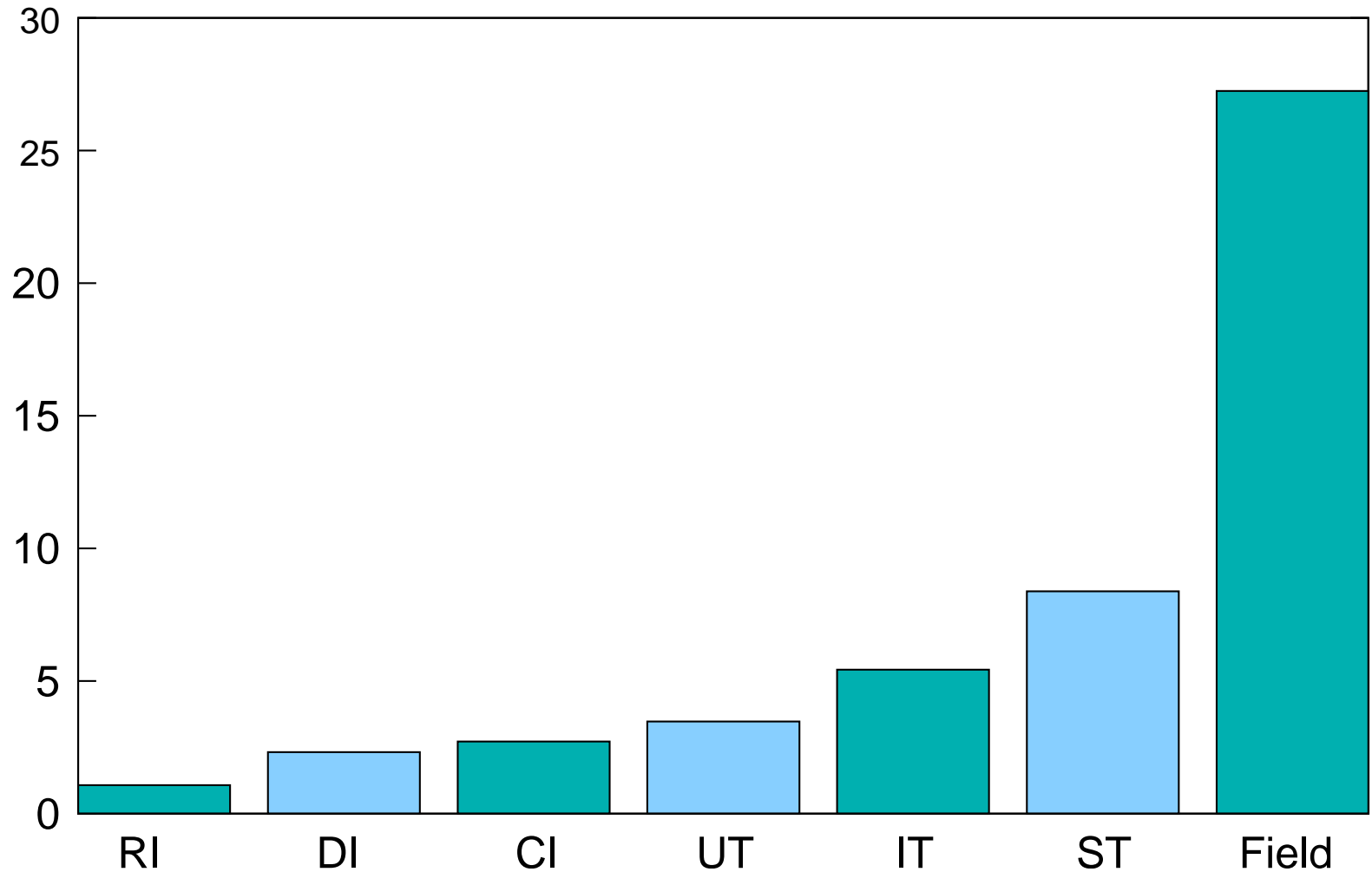


The removal costs increase over the phases

Technique	Mean Removal Costs
Req. inspection	1.06
Design inspection	2.31
Code inspection	2.71
Unit test	3.46
Integration test	5.42
System test	8.37
Field	27.24

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The removal costs increase over the phases



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- We need more empirical research on
 - ◆ Distribution of defects of document types
 - ◆ Effect costs
 - ◆ Relationship between difficulty (effectiveness) and effort
- In empirical studies, the sample size should be available

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Future Work

- Costs and benefits are a central factor in planning software quality assurance
- We need analytical models that explain the relationships of factors
- We need empirical data for these factors to
 1. analyse their importance and
 2. reduce the effort of using the models
- Over the phases the removal costs increase

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- Empirical evaluation of different techniques and factors
- Further sensitivity analyses
- Evaluation of the predictive validity of the model
- Evaluation of the influence of other factors