# Pushing the Boundaries in Regression Testing

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Large Test Suites

Regression Testing

Limited Resource

# Selection

Large Test Suites

Limited Resource

Uses impact analysis to precisely identify the changed parts of the program and only test those parts

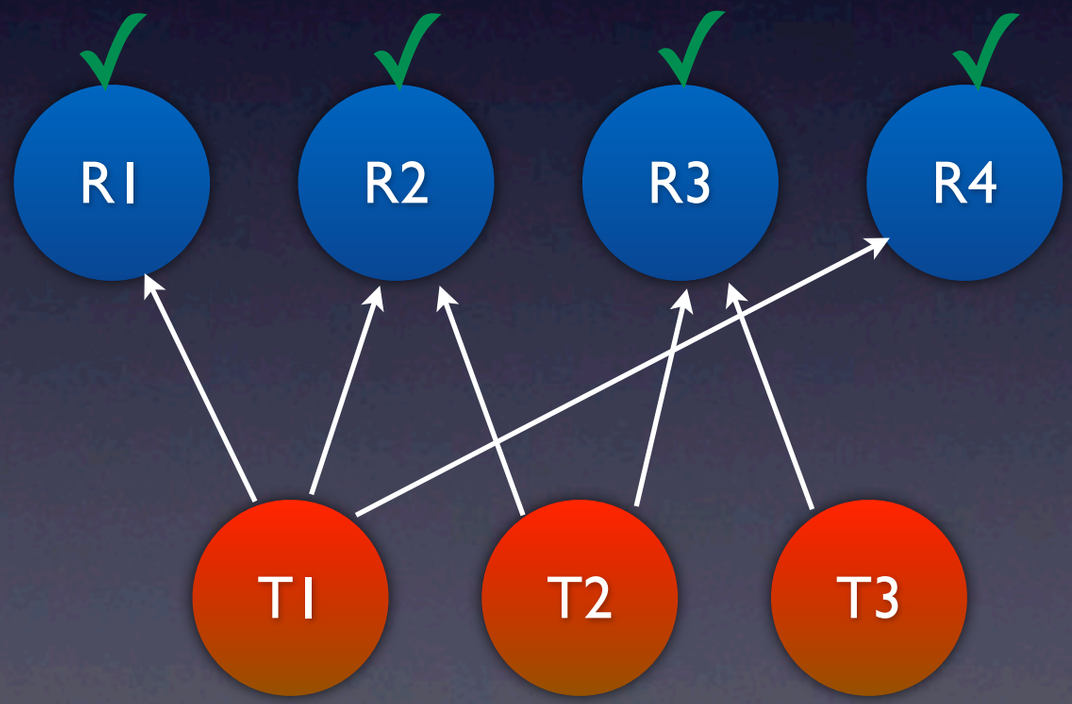
Often not the answer:

- requires static analysis
- not enough reduction

# Minimisation

Large Test Suites

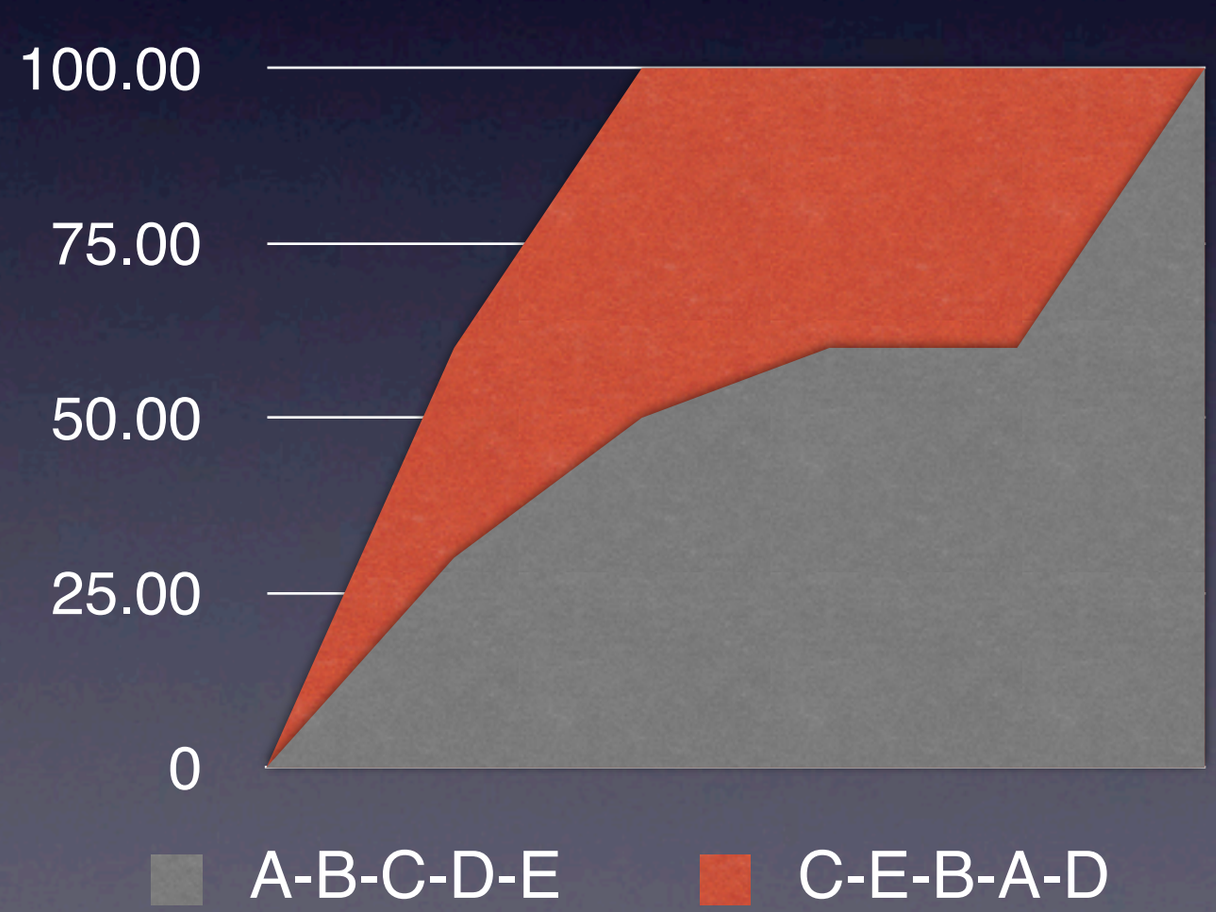
Seeks to reduce the size of test suites while satisfying test adequacy goals



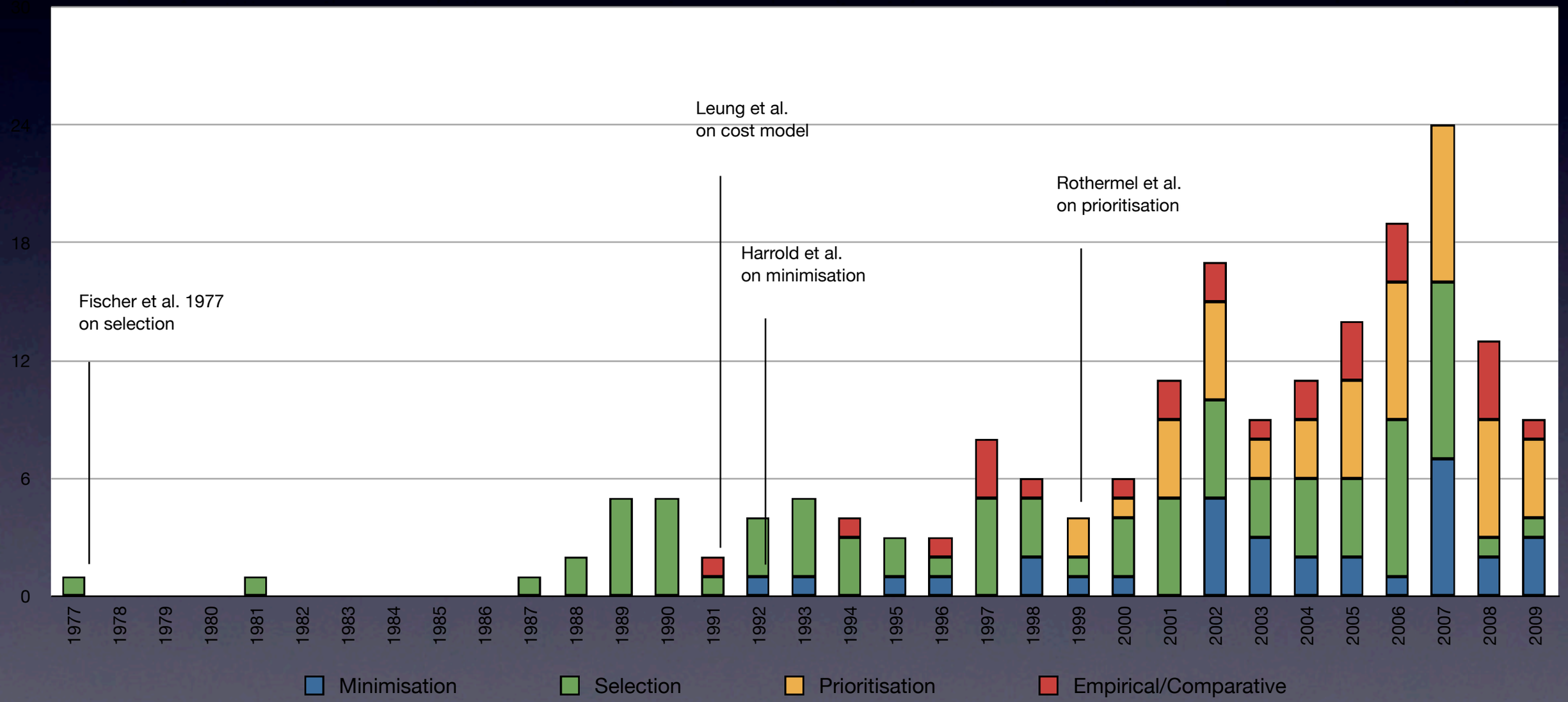
# Prioritisation

Limited Resource

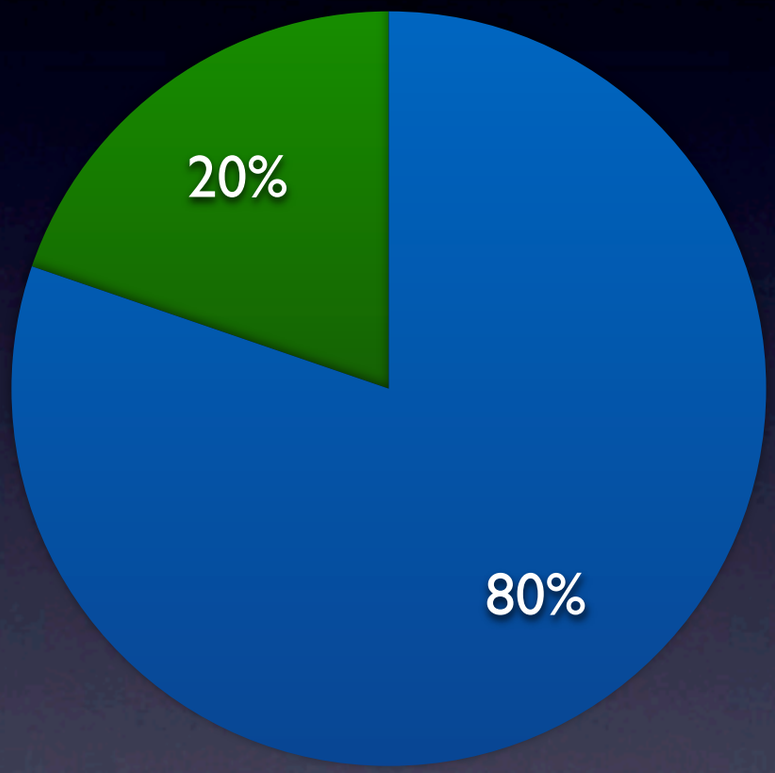
Seeks to achieve test adequacy as much and as early as possible



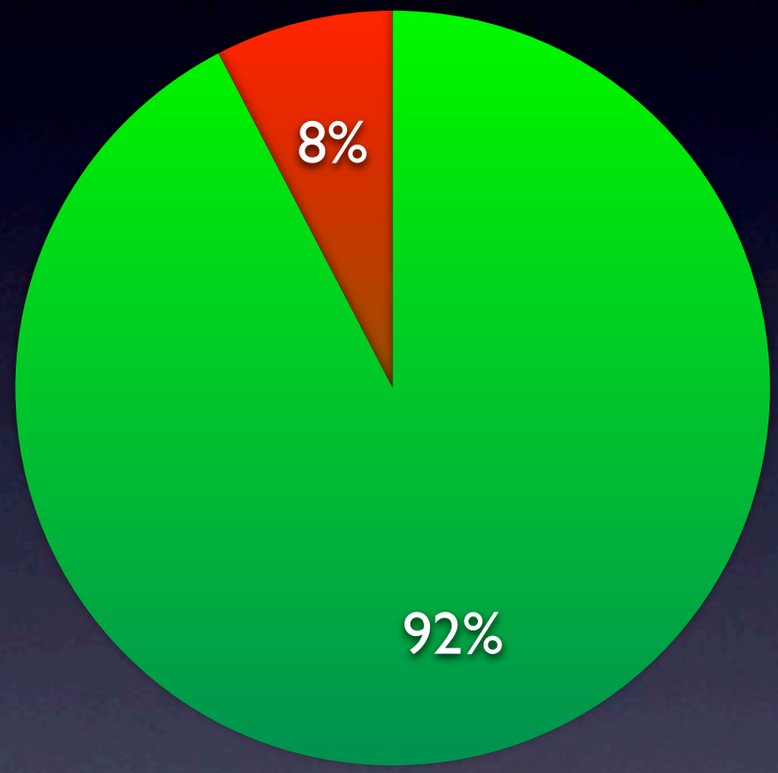
# Publication Trend



# Potential Impact




- Purely Academic
- Author from Industry




- Toy Programs
- Industrial Scale Subjects

Summary of 157 papers on regression testing techniques from a recent survey

# Research Output

- Pareto Efficient Multi-Objective Test Case Selection: S. Yoo & M. Harman, ISSTA 2007
- Mesuring and Improving Latency to Avoid Test Suite Wear-Out: S. Yoo, M. Harman & S. Ur, SBST 2009
- Clustering Test Cases to Achieve Effective and Scalable Prioritisation Incorporating Expert Knowledge: S. Yoo, M. Harman, P. Tonella & A. Susi, ISSTA 2009

# Multi-Objectiveness : Problems

- “After performing minimisation, the test suite is still too big. What can I actually do in the next 6 hours?”
- “I care not just code coverage, but something else too. Can I also achieve X with the minimised suite?”

| Test Case | Program Blocks | | | | | | | | | | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| T1 | x | x | x | x | x | x | x | x | | | 4 |
| T2 | x | x | | x | x | x | x | x | x | x | 5 |
| T3 | x | x | x | | | | | | x | | 3 |
| T4 | x | x | x | x | x | | | | | | 3 |

## Single Objective

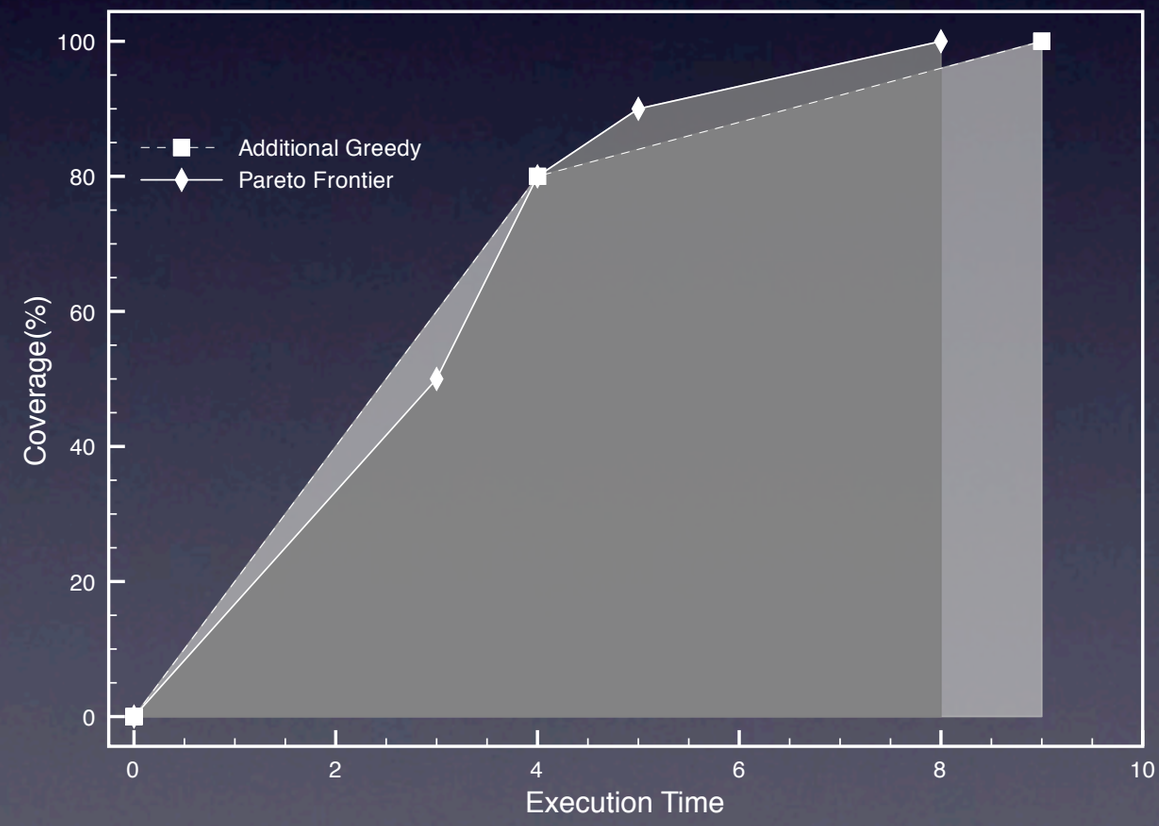
Choose test case with highest block per time ratio as the next one

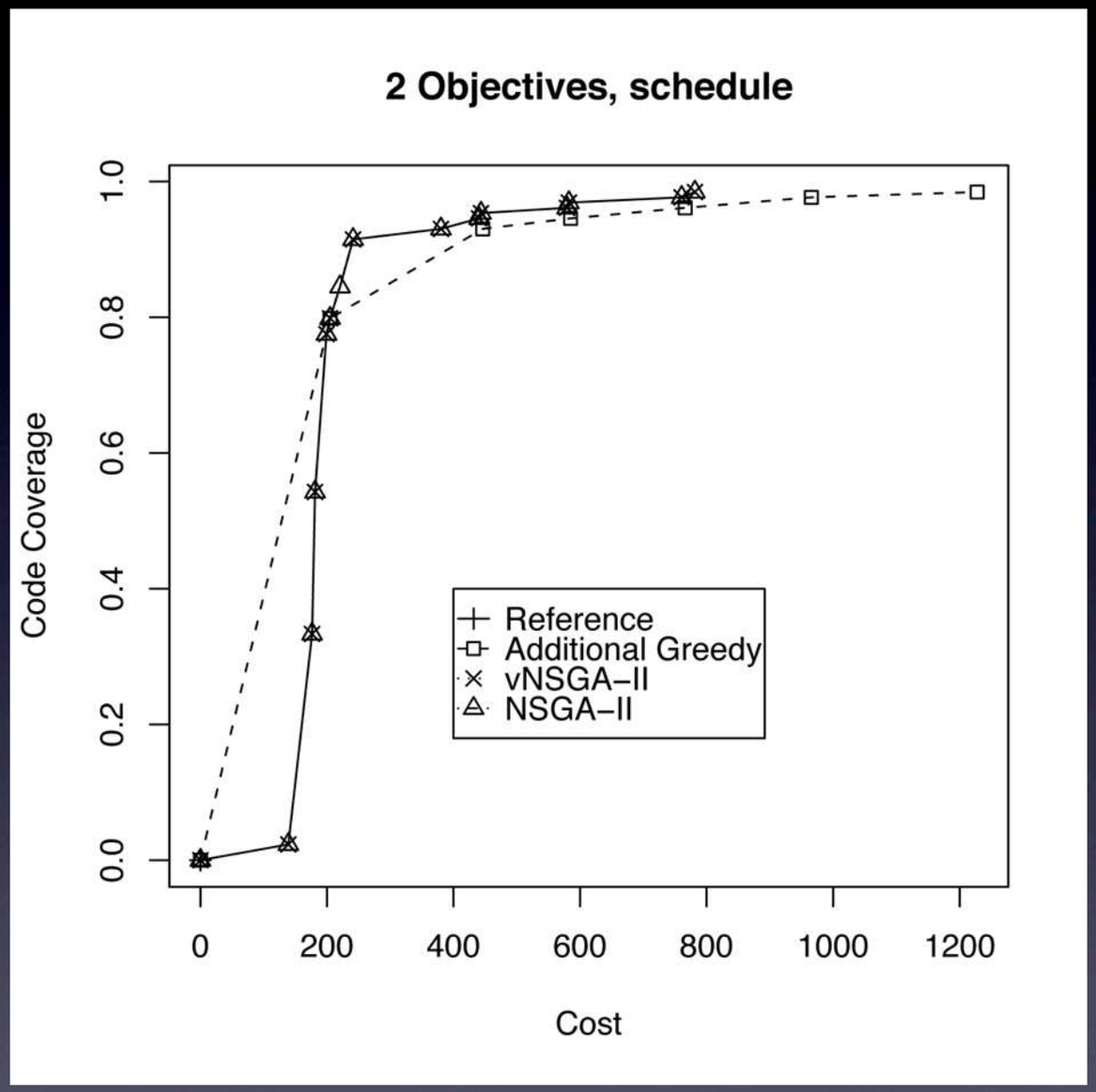
1) T1 (ratio = 2.0)
2) T2 (ratio = 2 / 5 = 0.4)

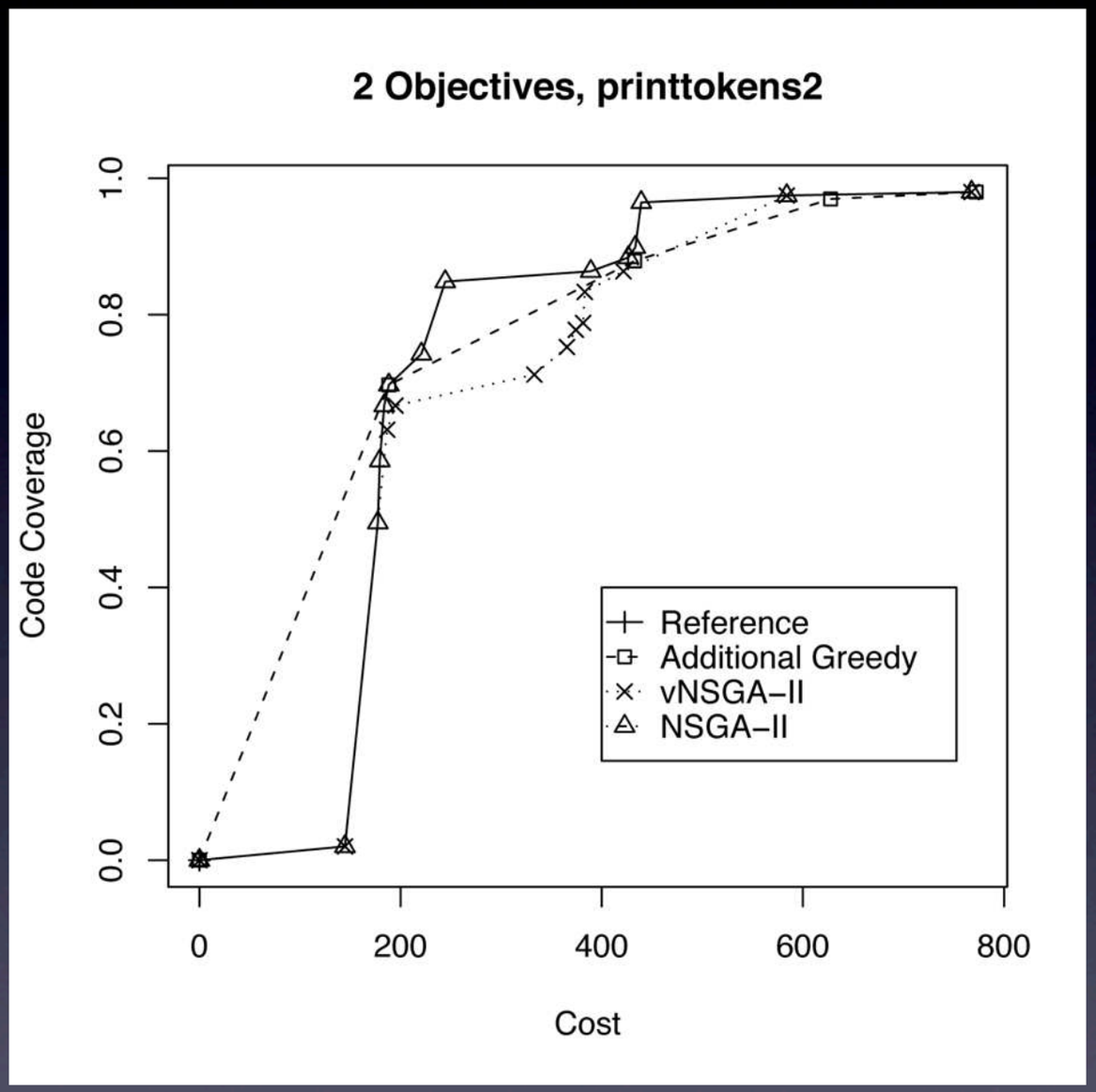
∴ {T1, T2} (takes 9 hours)

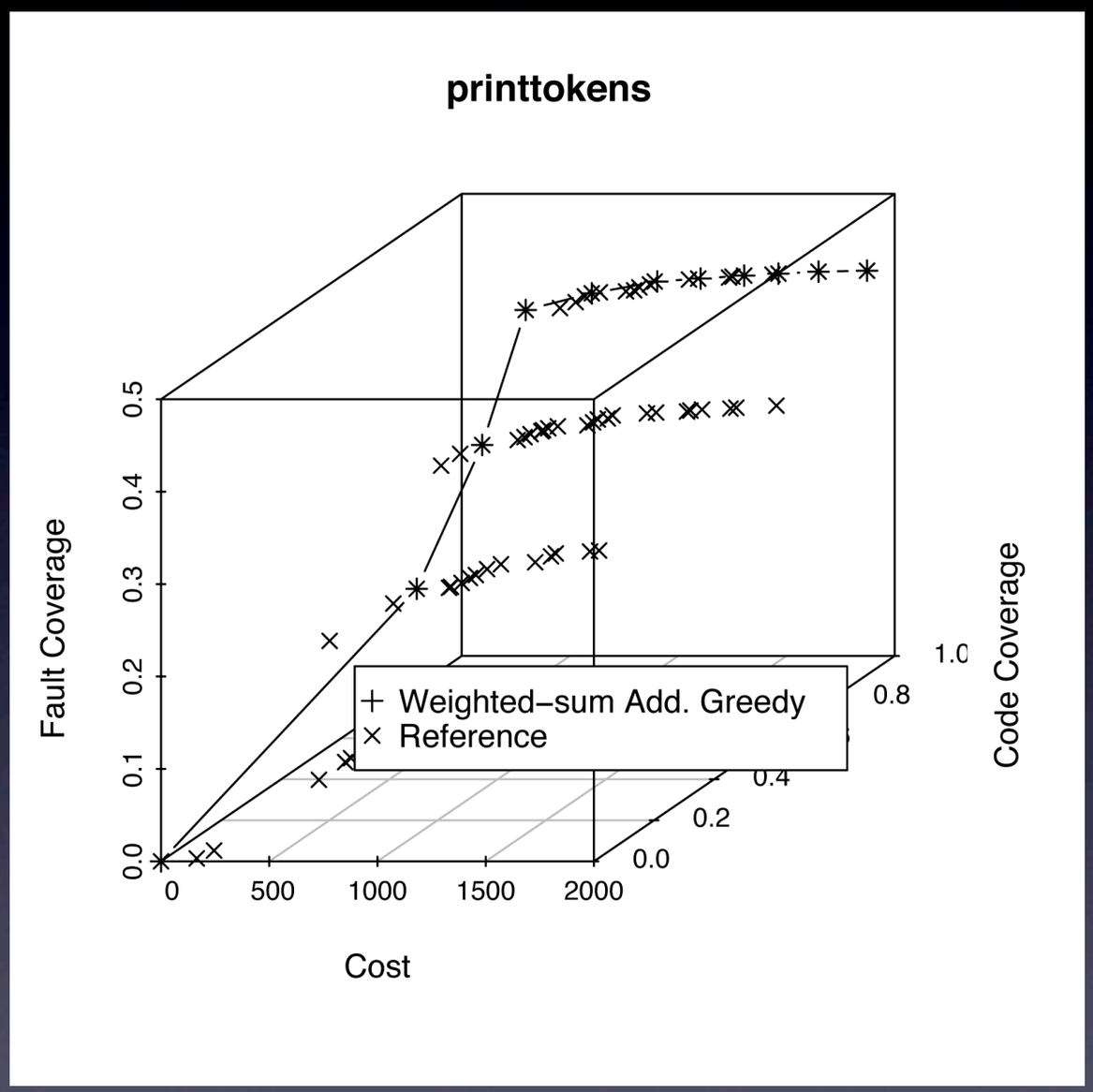
“But what if you have only 7 hours...?”

## Multi Objective




2 Objectives, schedule
Code Coverage
0.0
0.2
0.4
0.6
0.8
1.0
0
200
400
600
800
1000
1200
Cost
Reference
Additional Greedy
vNSGA−II
NSGA−II


2 Objectives, printtokens2
Code Coverage
0.0
0.2
0.4
0.6
0.8
1.0
0
200
400
600
800
Cost
Reference
Additional Greedy
vNSGA−II
NSGA−II


printtokens
Fault Coverage
Code Coverage
Cost
Weighted−sum Add. Greedy
Reference
0.0
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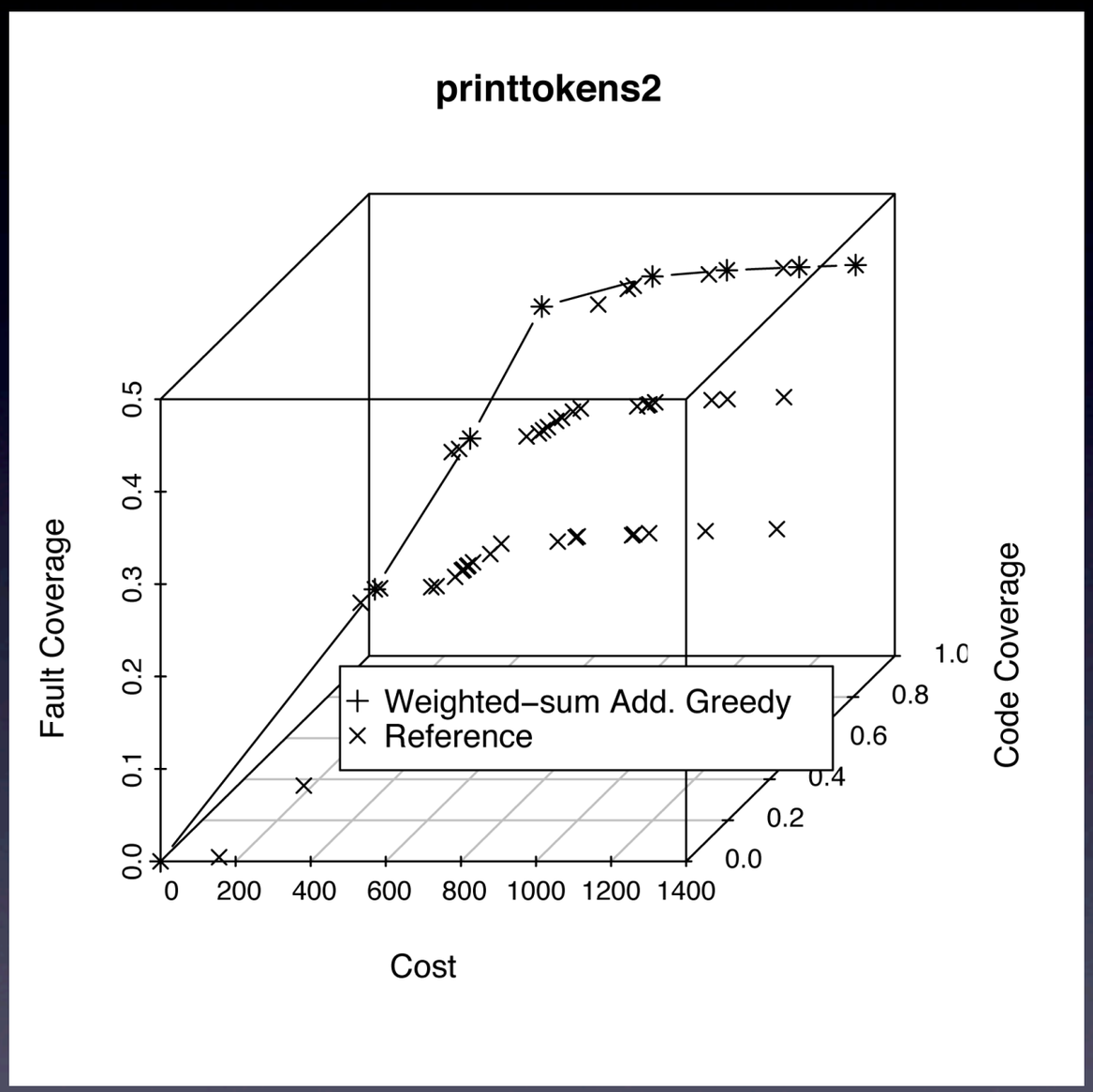
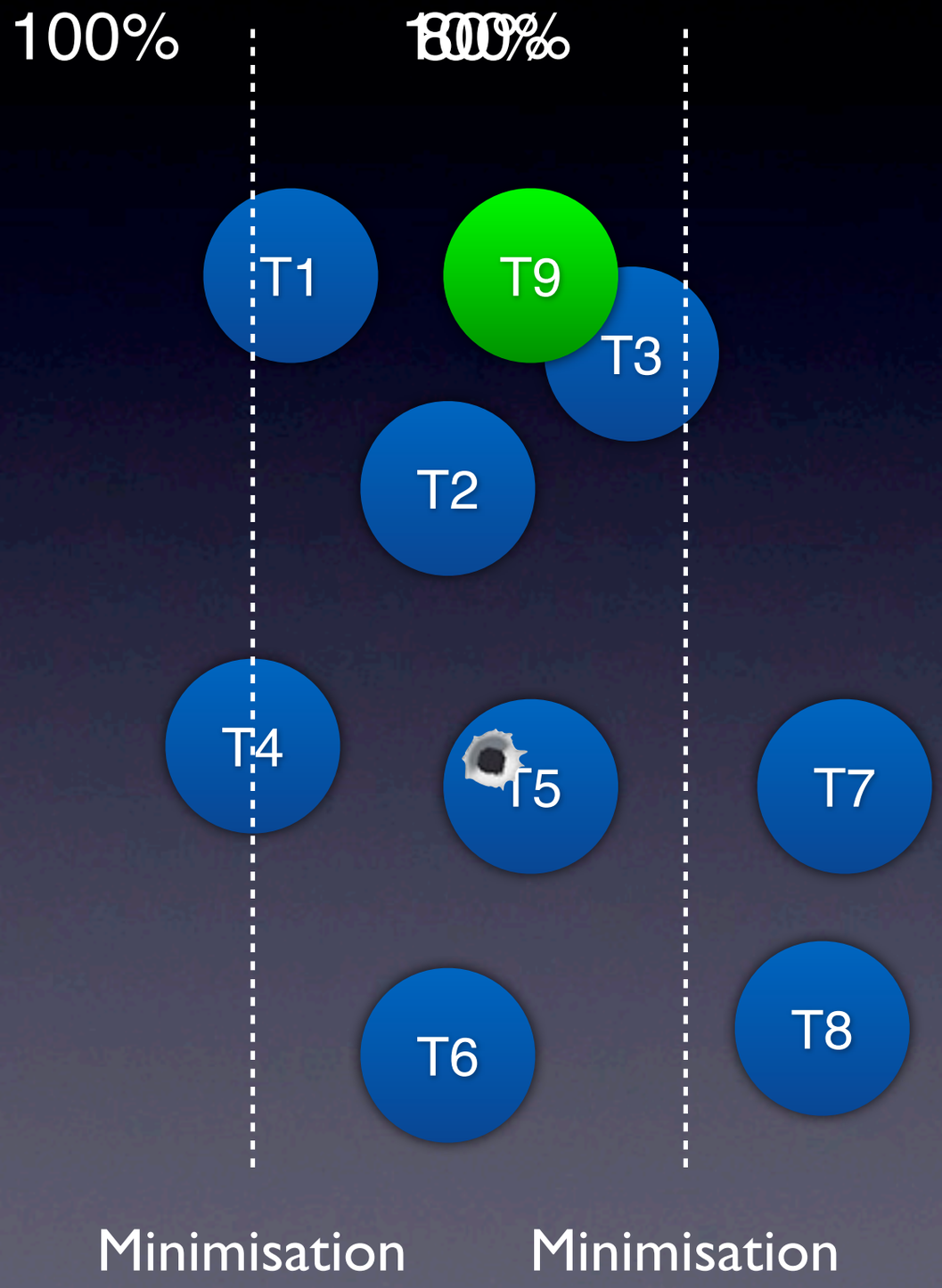
1500
2000
0.0
0.2
0.4
0.8
1.0


printtokens2
Fault Coverage
Code Coverage
Cost
Weighted−sum Add. Greedy
Reference
0.0
0.1
0.2
0.3
0.4
0.5
0
200
400
600
800
1000
1200
1400
0.0
0.2
0.4
0.6
0.8
1.0

# Latency : Problems

- “My regression testing seems to depend on the same test cases all the time; is this okay?”
- “Code coverage is necessary but not sufficient test adequacy; how do we make it safer?”

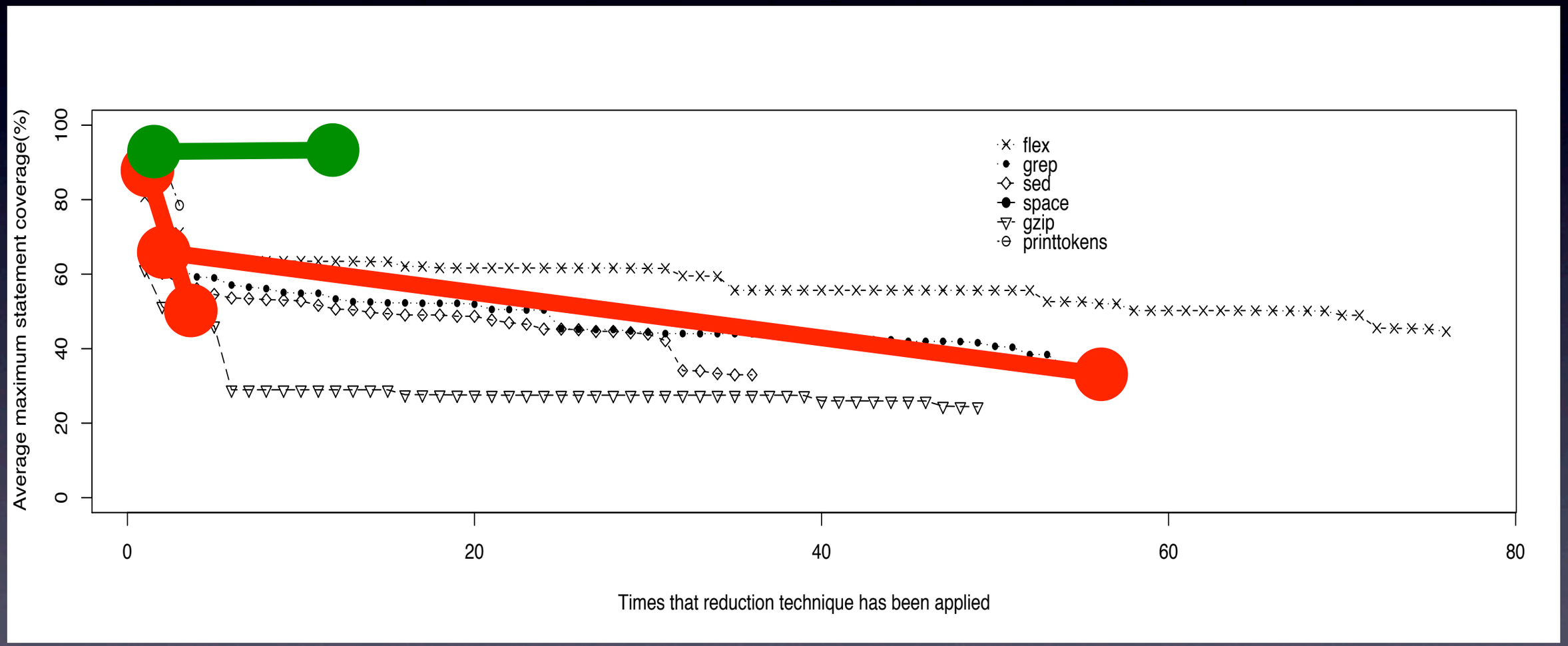
# The Coverage Trap

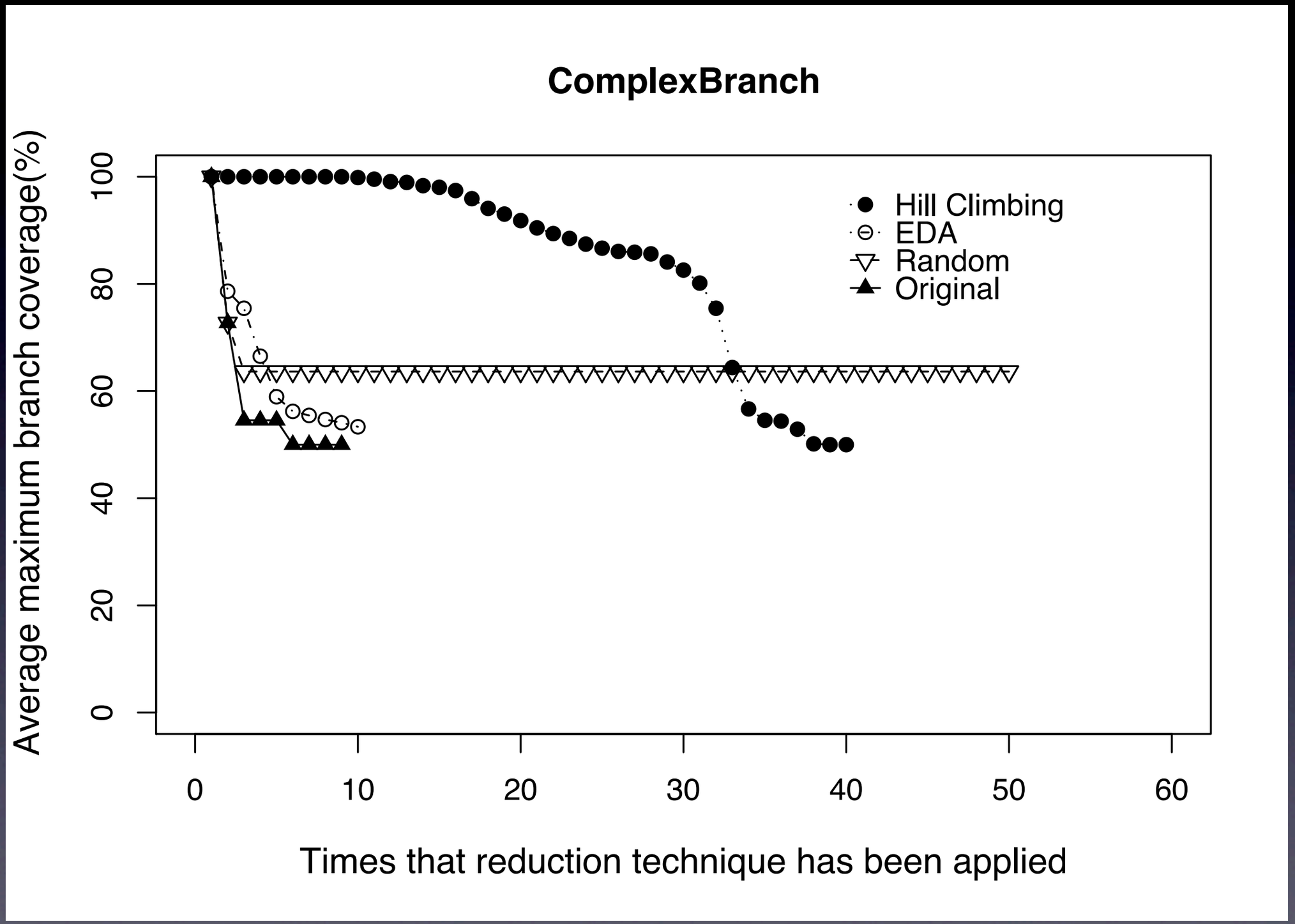



T5 may detect an unknown fault. If the minimisation technique never picks T5, fault detection capability is compromised.

We should consider multiple subsets. If necessary, we should improve the remaining part of the test suite.

# Designing Test Suites

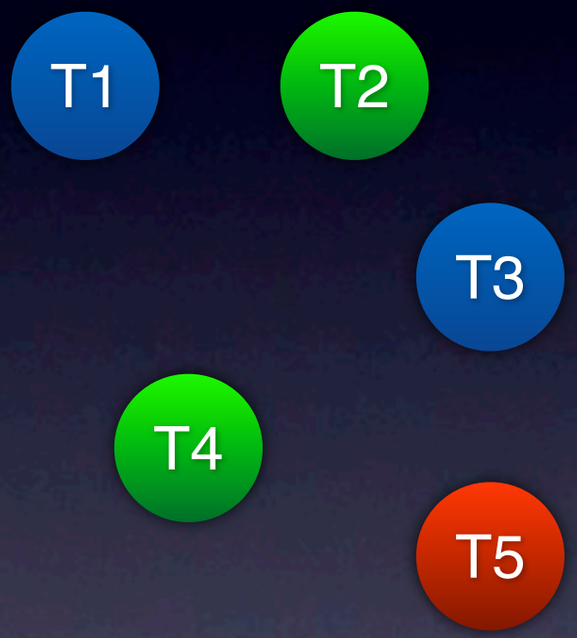



ComplexBranch
Average maximum branch coverage(%)
0
20
40
60
80
100
0
10
20
30
40
50
60
Times that reduction technique has been applied
Hill Climbing
EDA
Random
Original

# Expertise : Problems

- “I have seen the results of automated test case prioritisation and I don’t agree. This is the way it should be!”
- “We need to prioritise a specific set of tests due to business priority.”

# Interleaved Clusters Prioritisation



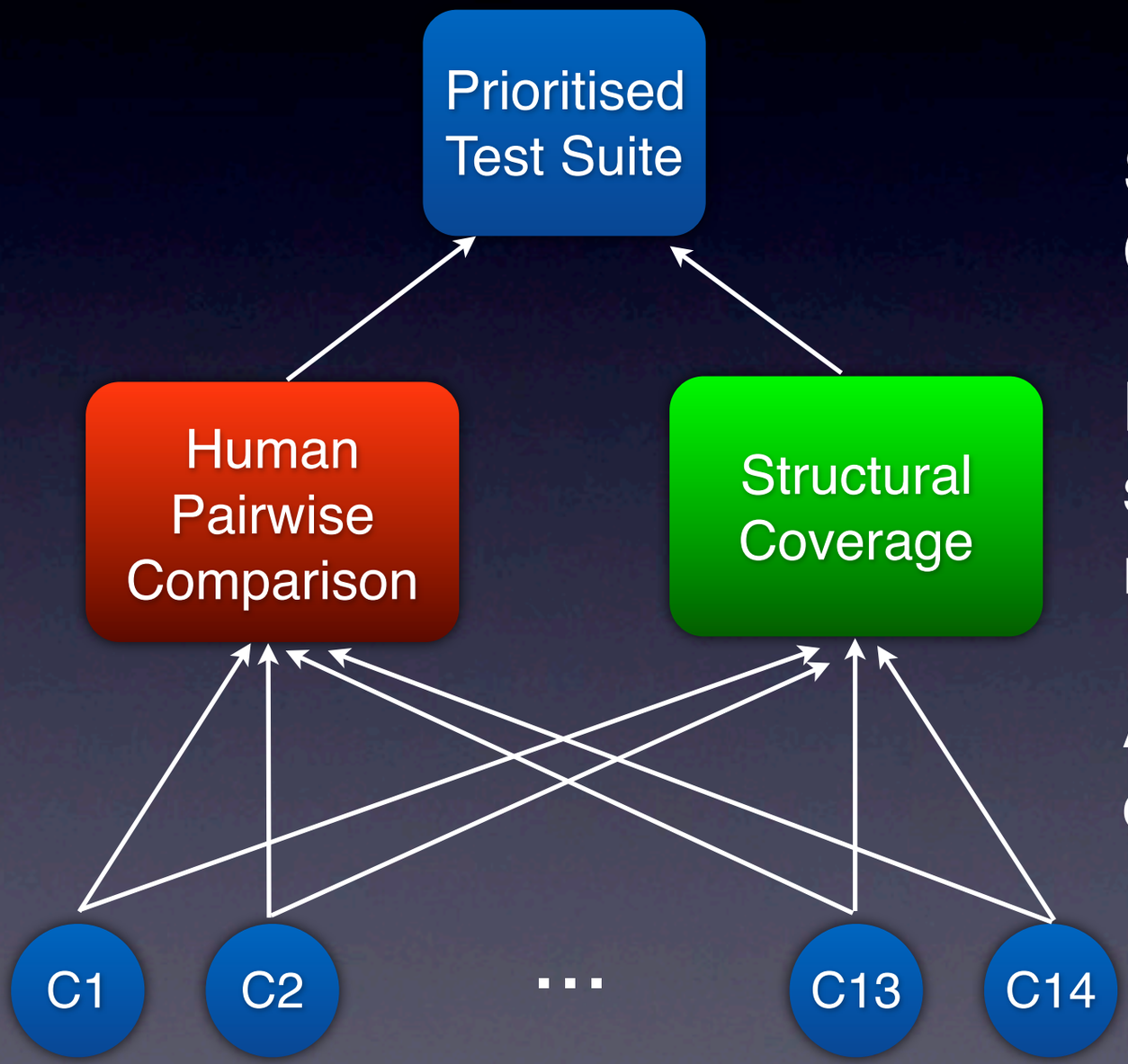

Cluster

Intra-cluster Prioritisation

Inter-cluster Prioritisation

Interleaving Clusters

# Experimental Setup

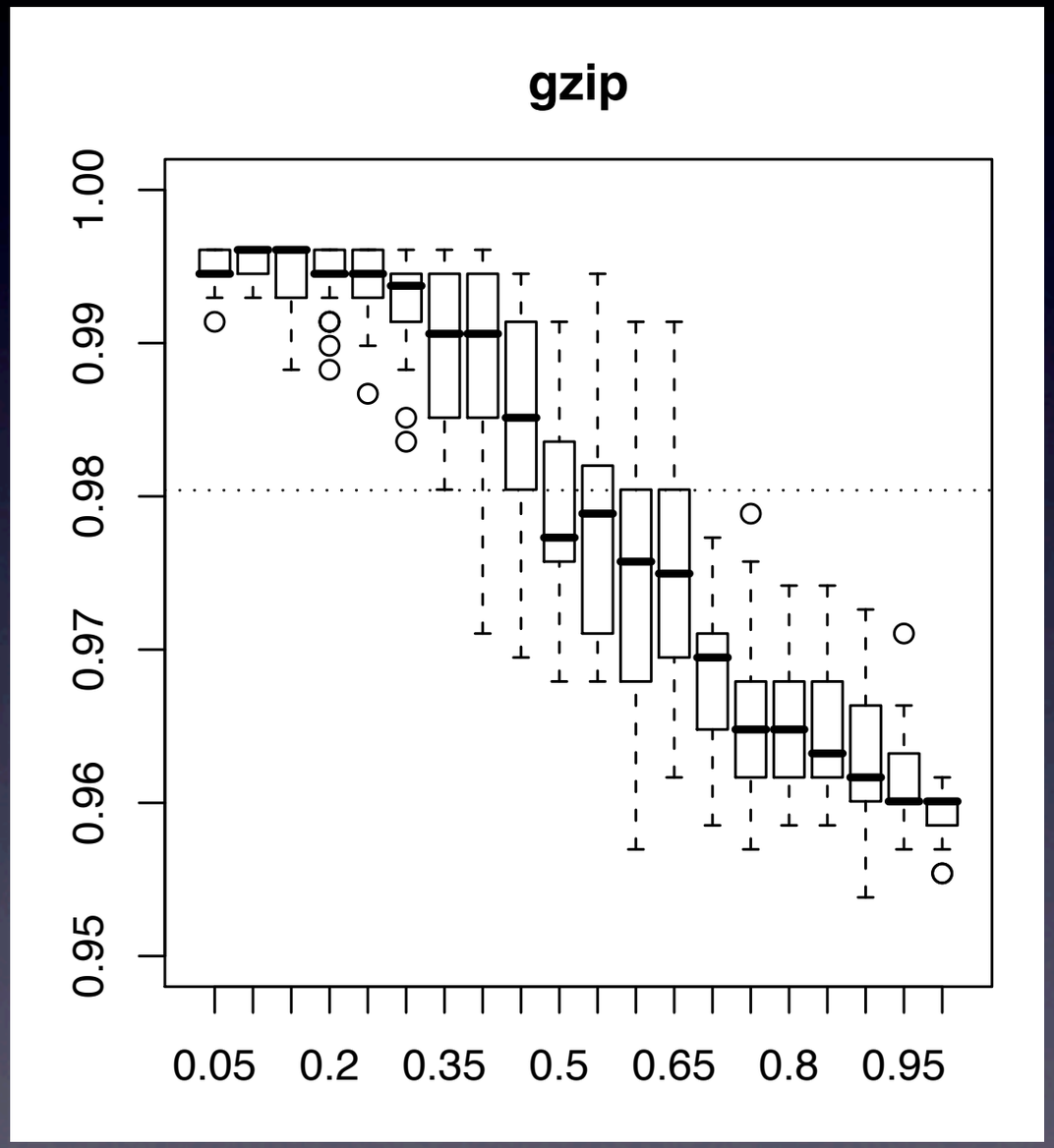



Simple Agglomerative Hierarchical Clustering (k=14)

Hamming distance between stmt. coverage as dissimilarity metric

A human user model with controlled error rate

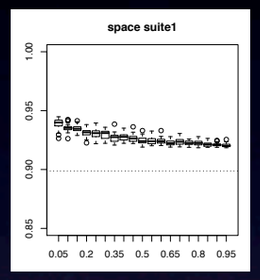
# Tolerance

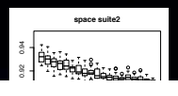


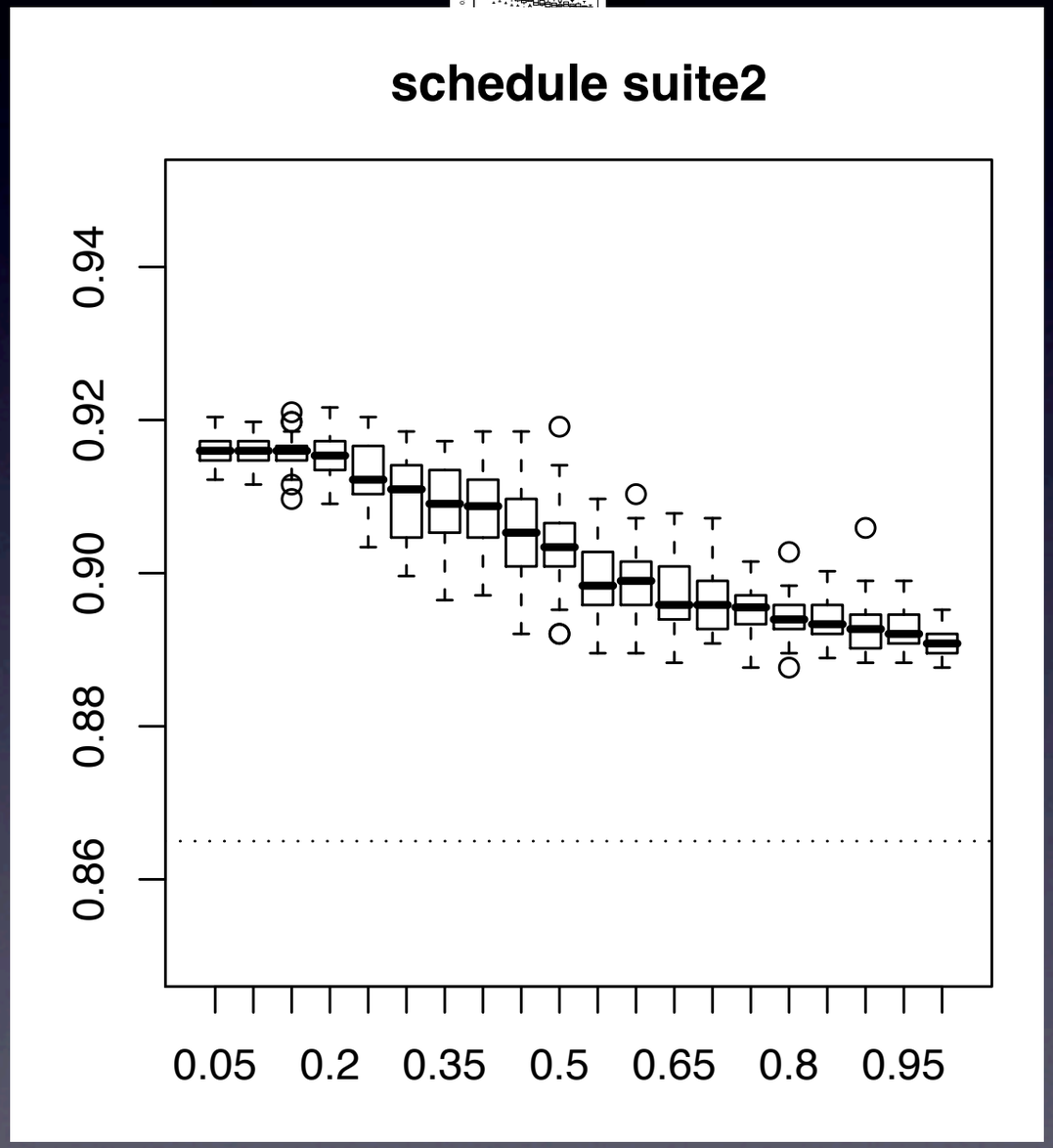

This is what we initially expected to see.

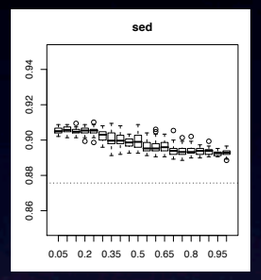
But...

# Tolerance




Some test suites are very resilient to errors

# Boundaries  & Open Questions

- Scalability: not only quantitative but also qualitative scalability
- Complexity: set-up cost, oracle cost, dependency
- Effectiveness: are the traditional metrics good enough?

# Summaries

- Regression testing is hard - not a single solution
- Multi-objective paradigm allows us to formulate a complex problem
- Code coverage needs to be re-thought
- Humans are a vast pool of knowledge