Smarter Testing with Artificial Intelligence

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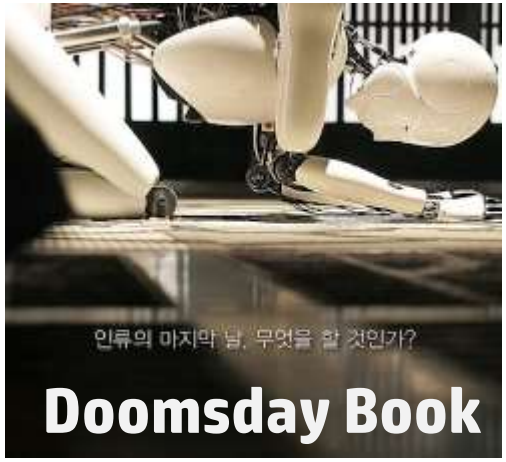
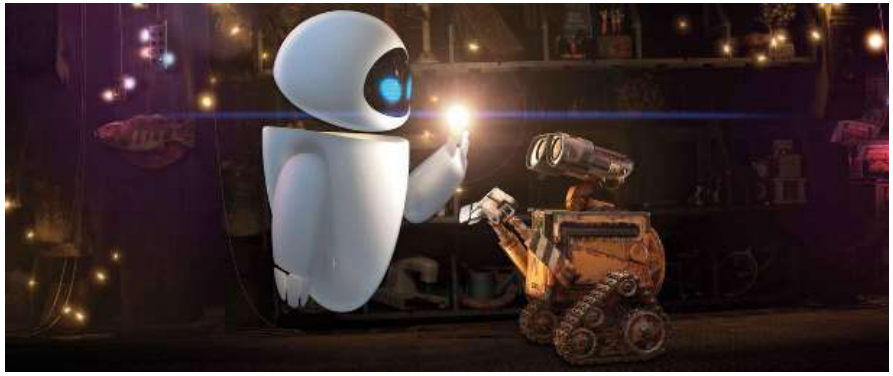
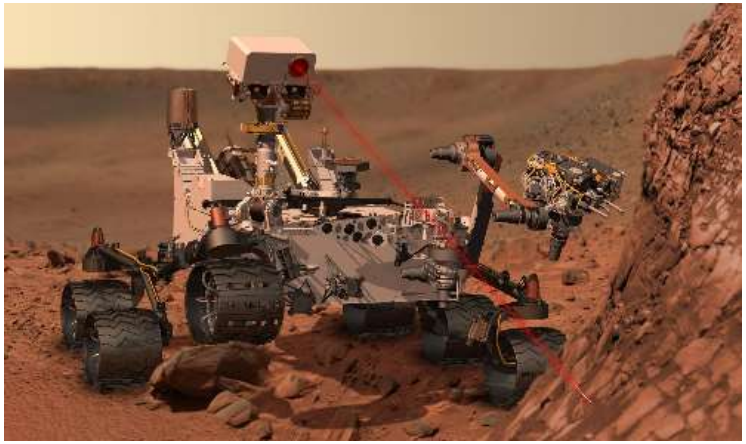
Artificial Intelligence (AI) in the Cinema





Artificial Intelligence (AI) Works!

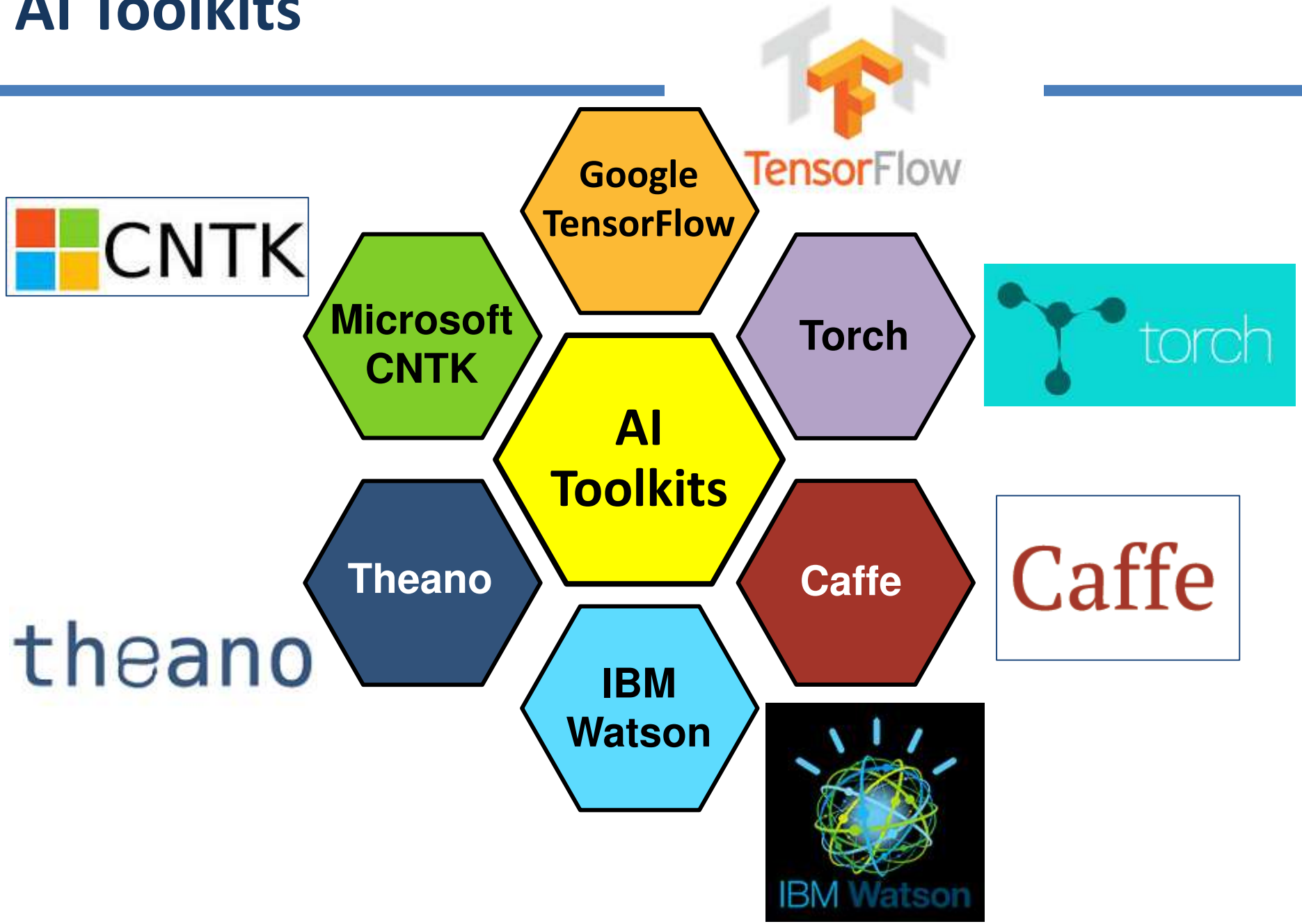


Artificial Intelligence Techniques

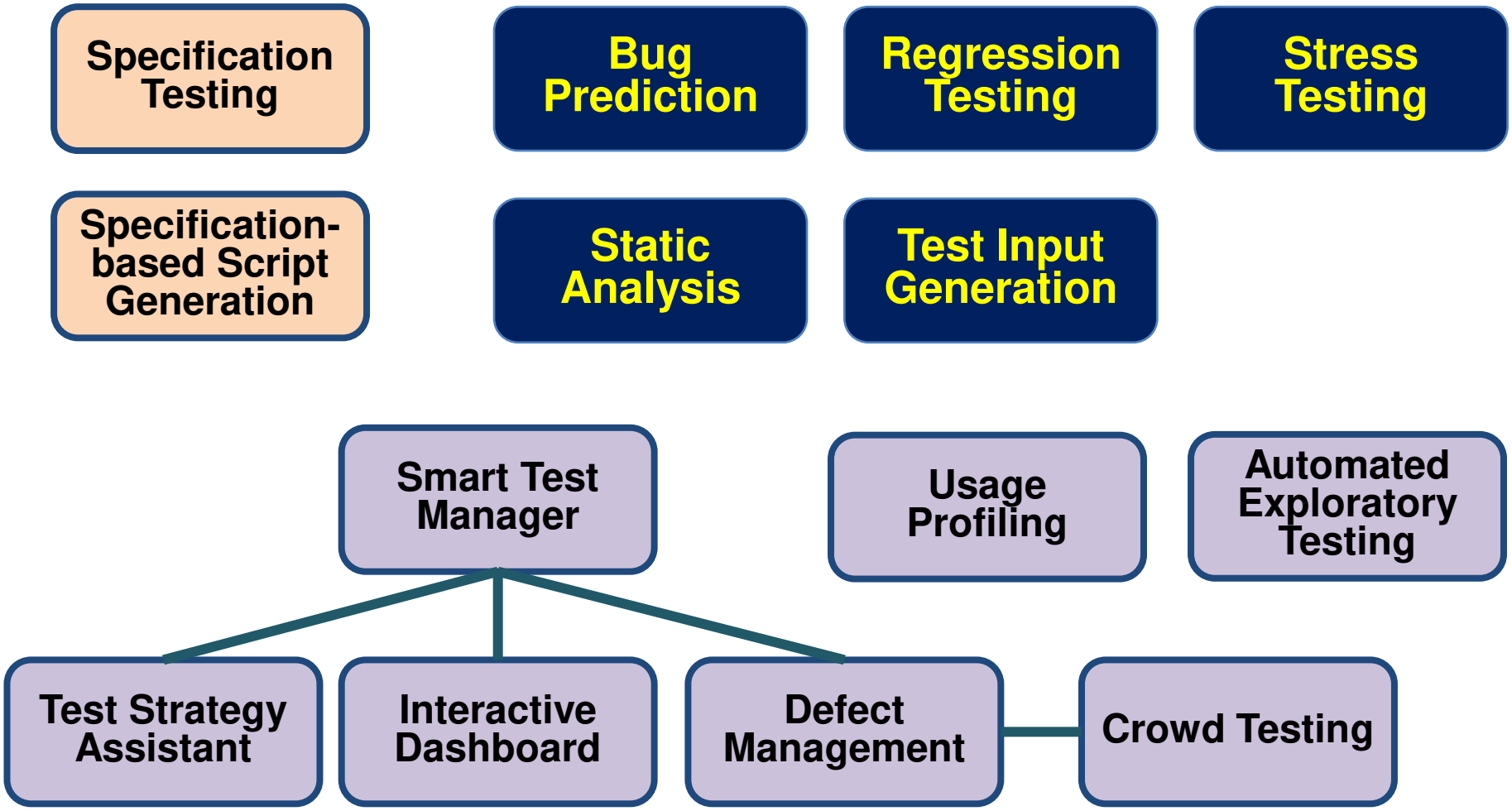
- **Neural Networks**
- **Expert/Knowledge-based Systems**
- **Machine Learning**
- **Fuzzy and Probabilistic Logic**
- **Classification**
- **Search and Optimization**

- **Much of today's effective AI uses a variety of overlapping techniques**
  - and exploits the availability of processing power & storage

AI Toolkits

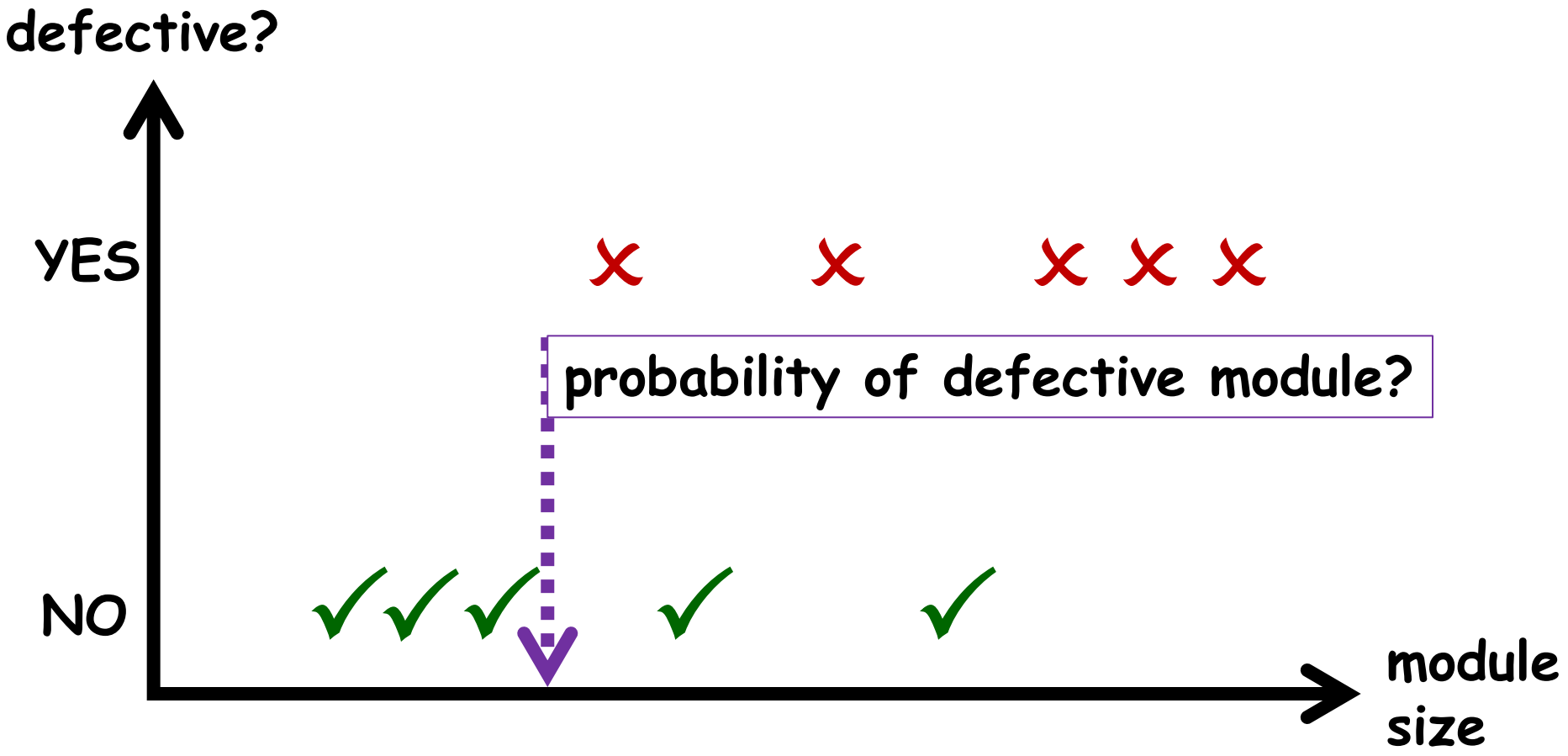

Google TensorFlow
TensorFlow
CNTK
Microsoft CNTK
Torch
torch
AI Toolkits
Theano
theano
Caffe
Caffe
IBM Watson
IBM Watson

AI - Smart Testing Opportunities

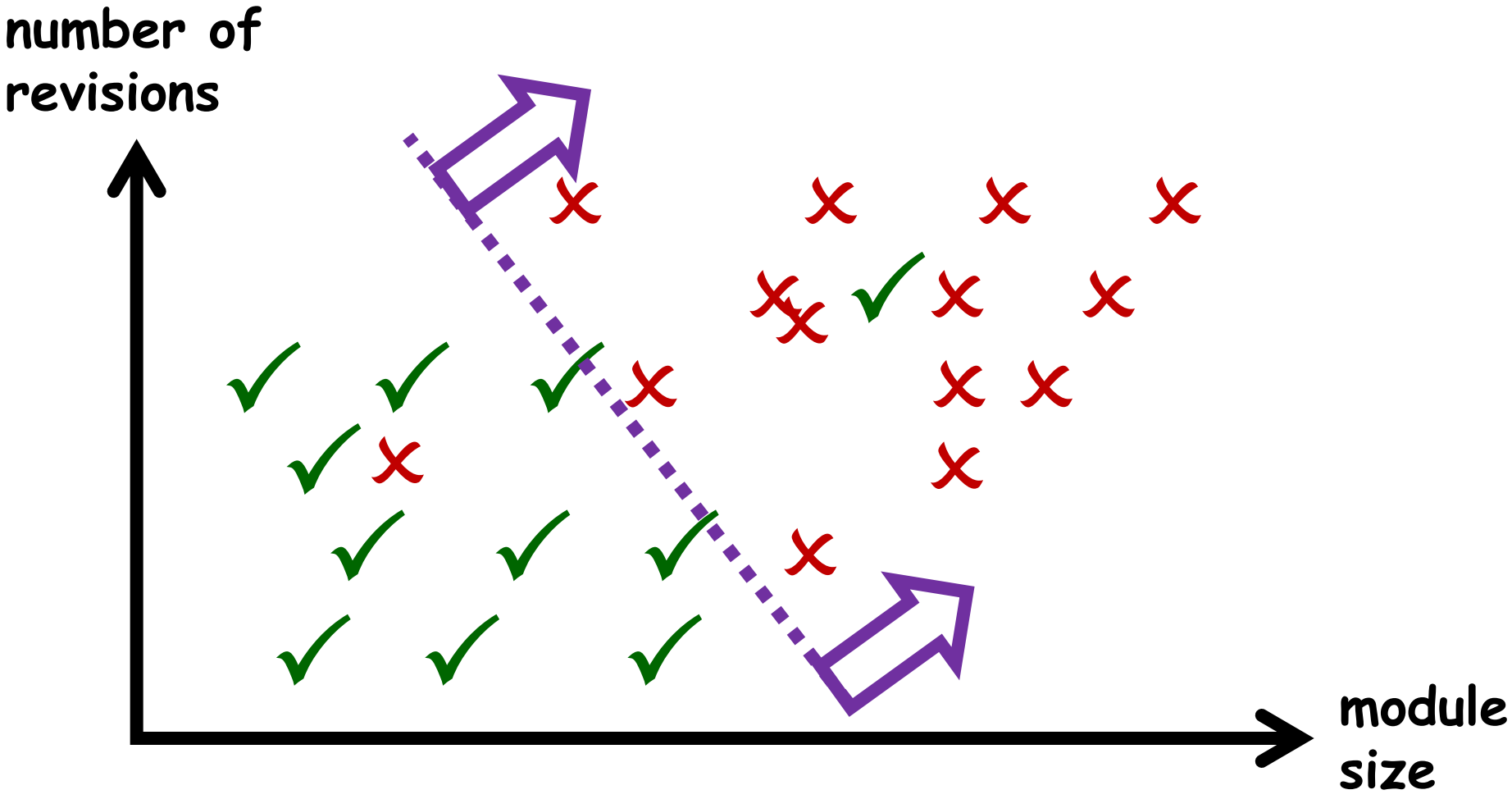


Bug Prediction

Bug Prediction – a Single Attribute



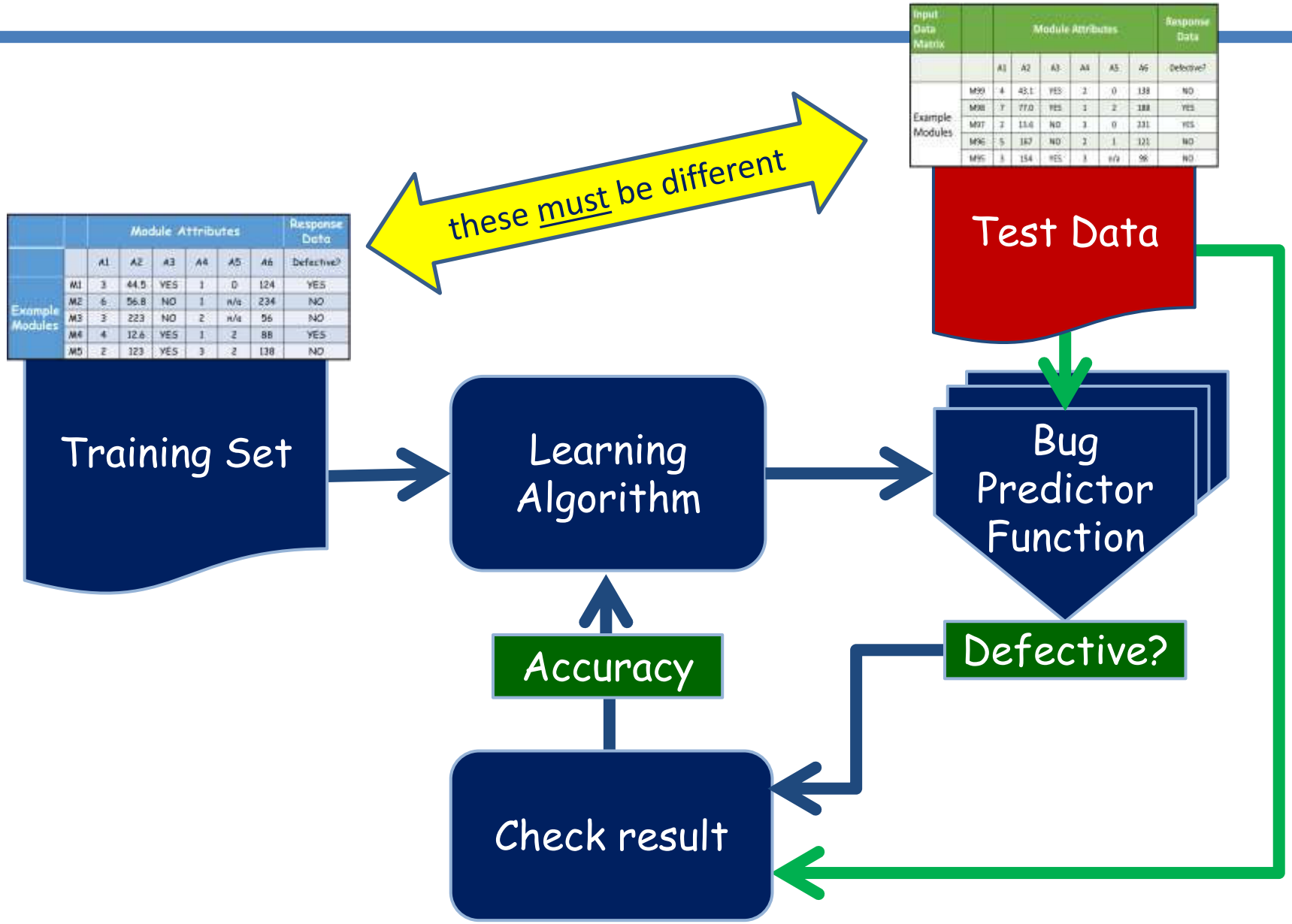
Bug Prediction – Two Attributes



Bug Prediction – Multiple Attributes

Input Data Matrix		Module Attributes						Response Data
		A1	A2	A3	A4	A5	A6	Defective?
Example Modules	M1	3	44.5	YES	1	0	124	YES
	M2	6	56.8	NO	1	n/a	234	NO
	M3	3	223	NO	2	n/a	56	NO
	M4	4	12.6	YES	1	2	88	YES
	M5	2	123	YES	3	2	138	NO

Supervised Learning Process



Bug Prediction Metrics

- **Source code metrics**
  - Lines of code
  - Number of comments
  - Cyclomatic complexity
  - Module dependencies
- **Process metrics**
  - Revisions made to module
  - Times refactored
  - Times fixed / when fixed
  - Lines of code changed (code churn)
  - Module age
- **People and organizational metrics**
  - Number of authors
  - Developer experience

Bug Prediction Results

- **“87% detection rate achieved average with 26% false alarms”**
  - [Tosun, 2010]
- **“73%-95% of faults can be predicted in just 10% of files” (across 7 projects)**
  - [Kim, 2007]
- **Best predictors are:**
  - People and Organizational measures (84%)
  - Module change (80%)
  - Fixed recently (and connected modules)
  - Reused module are more error-prone than new modules
  - Module age

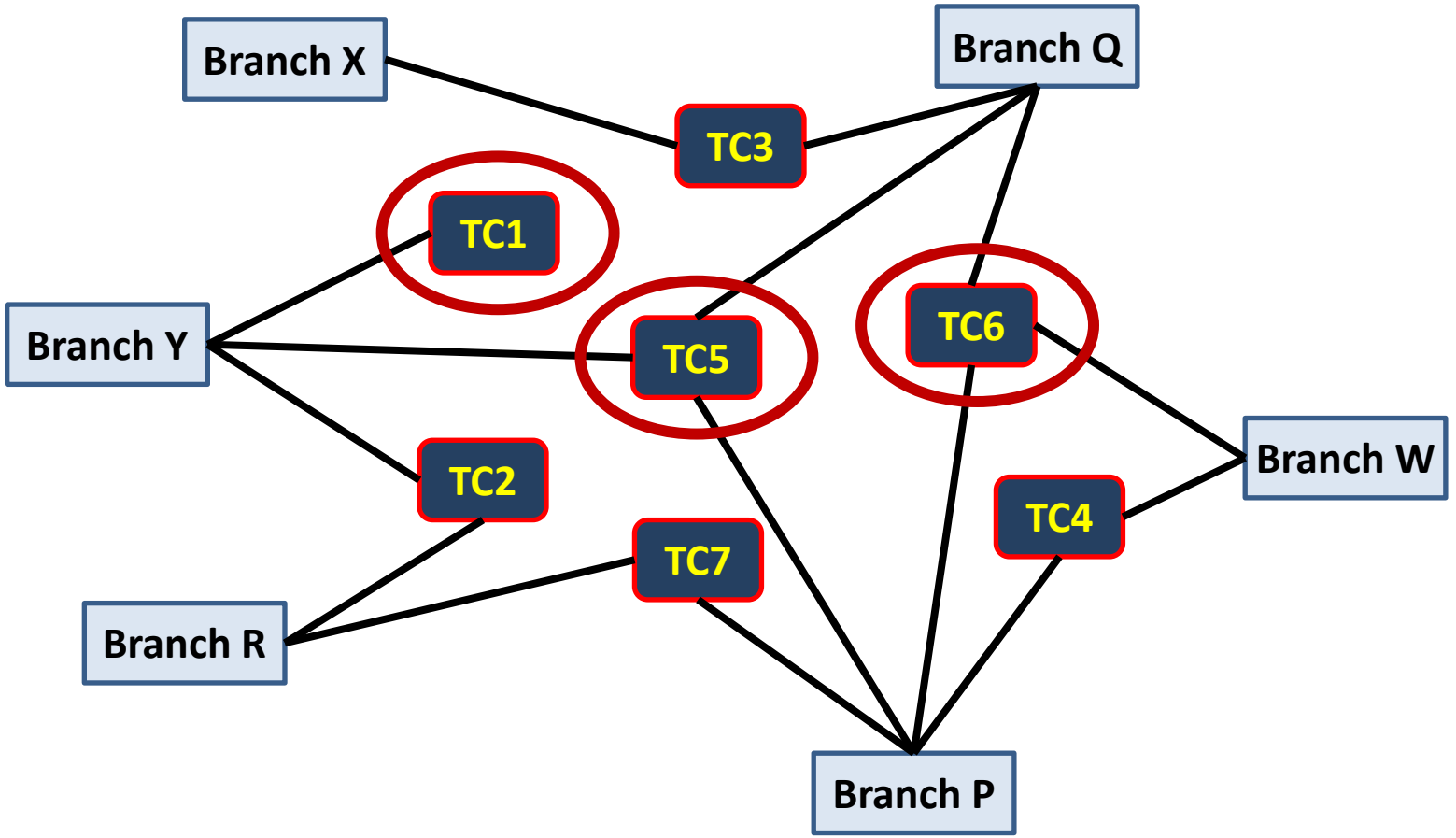
Static Analysis

Static Analysis Tool - Facebook – Infer

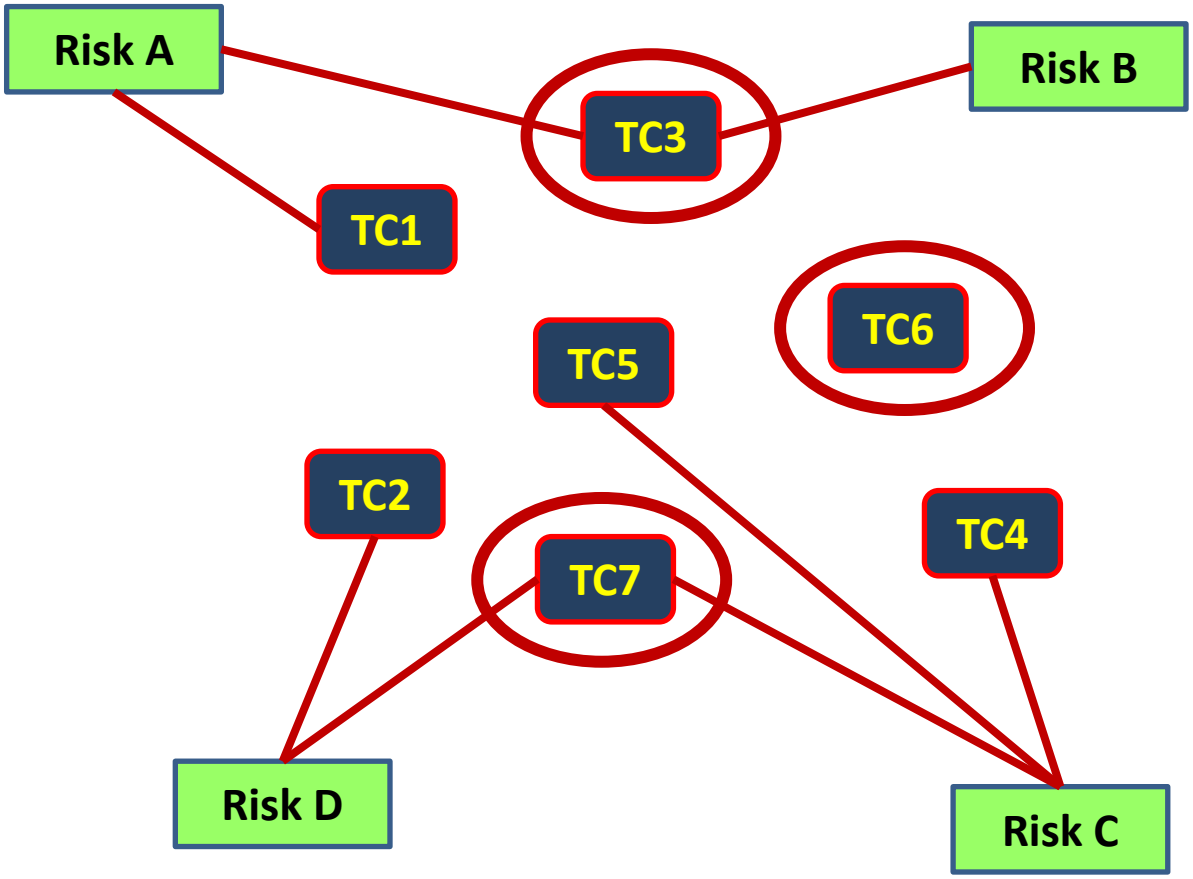
- **Open source**
- **Analyses C, Objective-C and Java**
  - on Android and iOS
- **Fast – can do millions of LOC in a few minutes**
  - ideal for continuous integration
- **Facebook claims that approximately 80% of raised issues are fixed (so are true faults)**
- **Also used by Instagram, Uber, Spotify, etc.**

Regression Testing

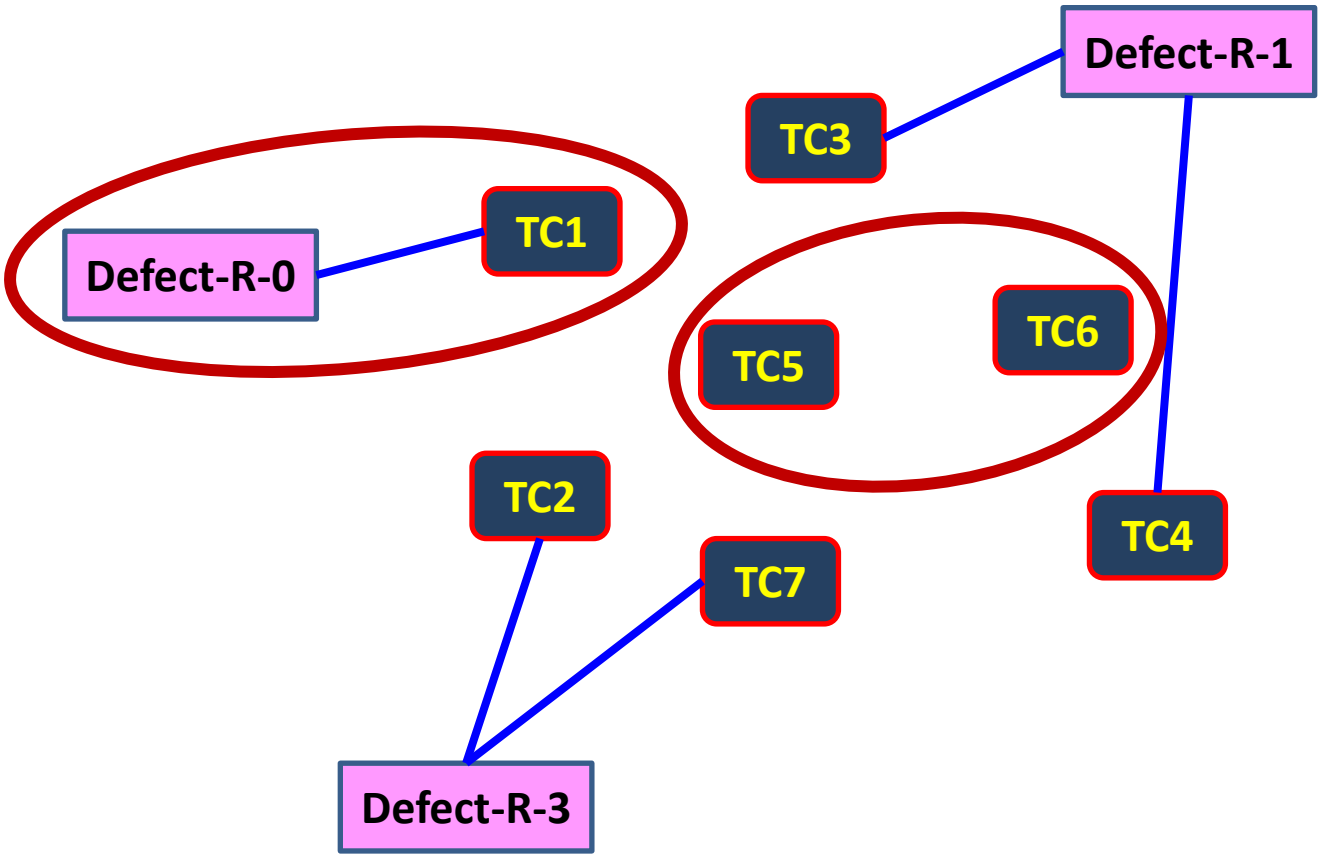
Regression Test Optimization



Regression Test Optimization



Regression Test Optimization



Regression Test Selection

Intelligent Agent

Risk A

Branch Q

Defect-R-1

Branch X

TC3

TC1

Defect-R-0

Risk B

TC6

TC5

Branch Y

TC2

Branch W

TC4

TC7

Branch R

Risk C

Defect-R-3

Branch P

Risk D

Regression Test Prioritization

Intelligent Agent

Regression Test Optimization Criteria

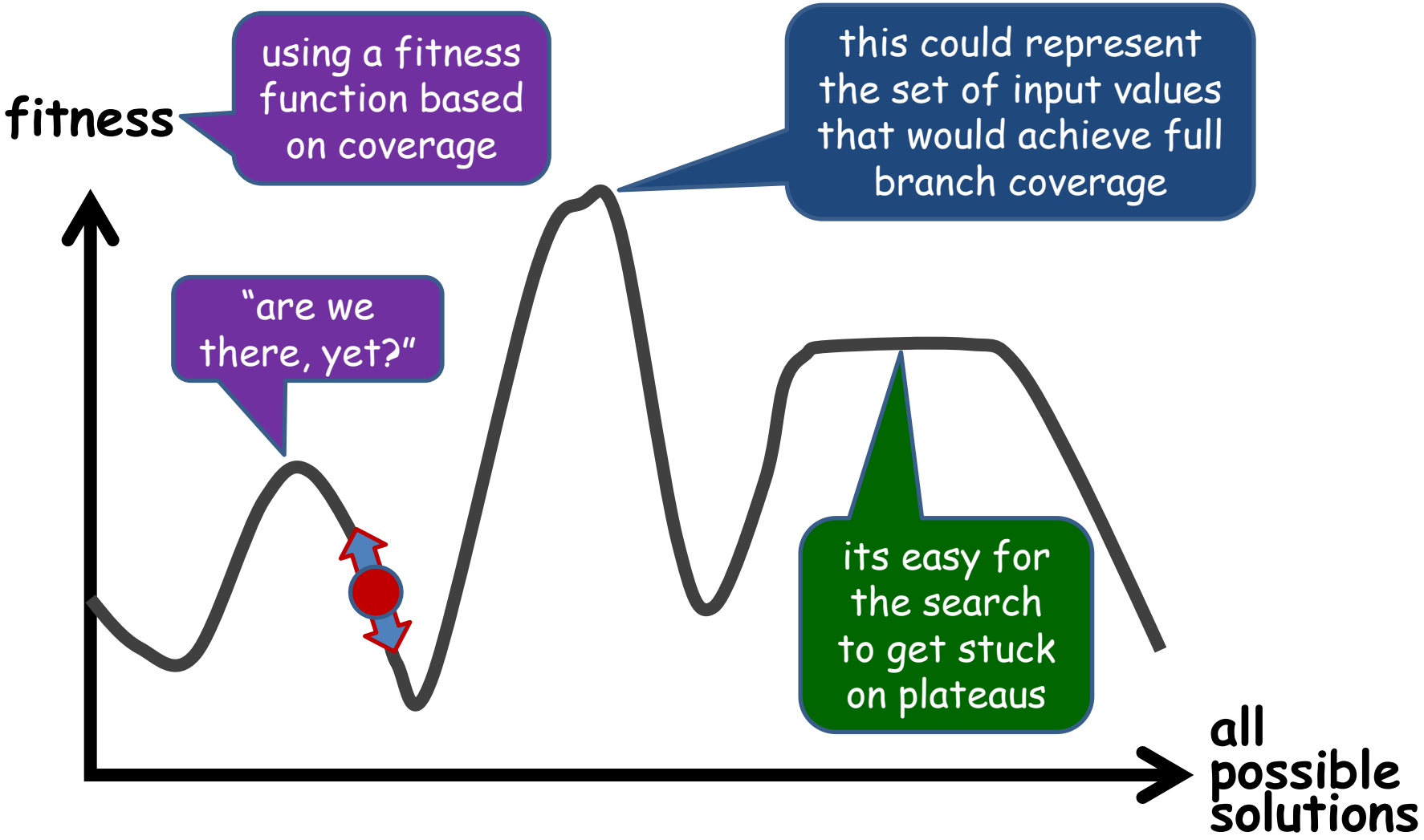
- Tests that found defects previously
- Tests that reduce execution time
- Reduce the number of tests needed
- Tests that achieve full coverage
- Test that exercise recently changed code
- Tests that address high risks
- etc.

Regression Test Optimization Results

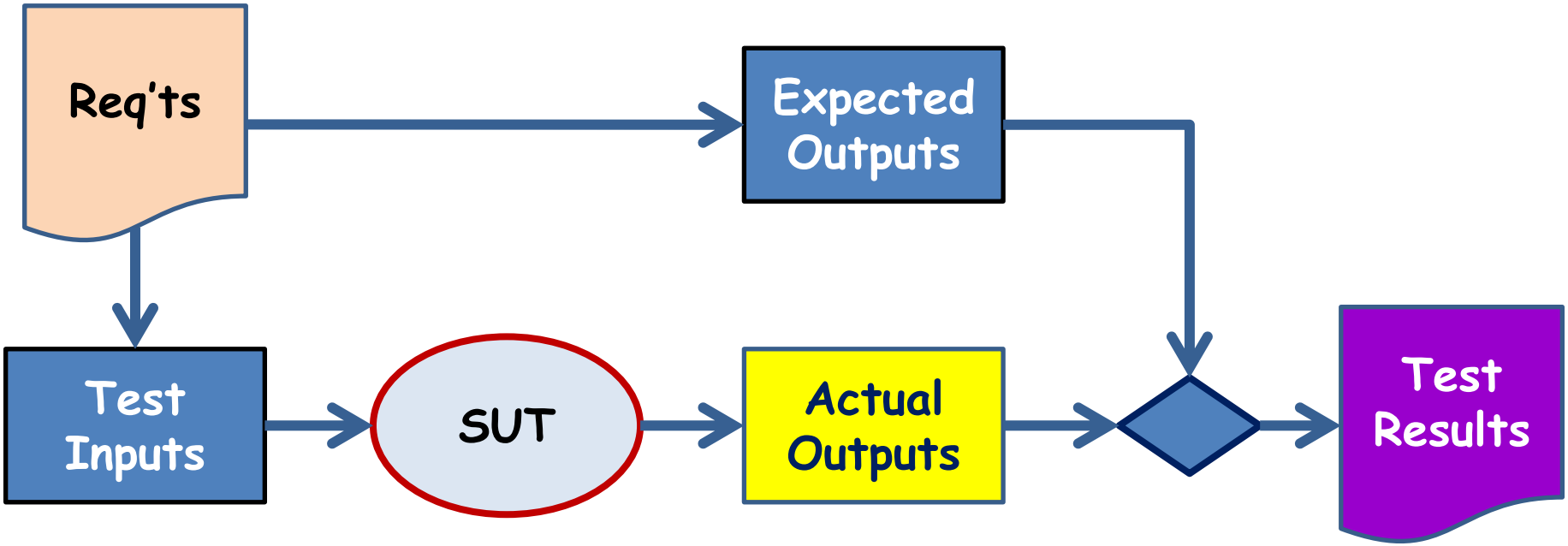
- **The algorithm reduces the test suite data by approximately 50%**
  - [Rai, 2014]
- **The techniques are 40-50% more effective in uncovering the first failure of the changed program**
  - [Jiang, 2009]
- **Average reduction in test suite size of 94% while achieving requirements-based coverage**
  - implemented in:
    - a continuous integration env't with 30 seconds run time
    - implemented at Cisco, Norway
  - [Gotlieb, 2016]

Automated Test Input Generation

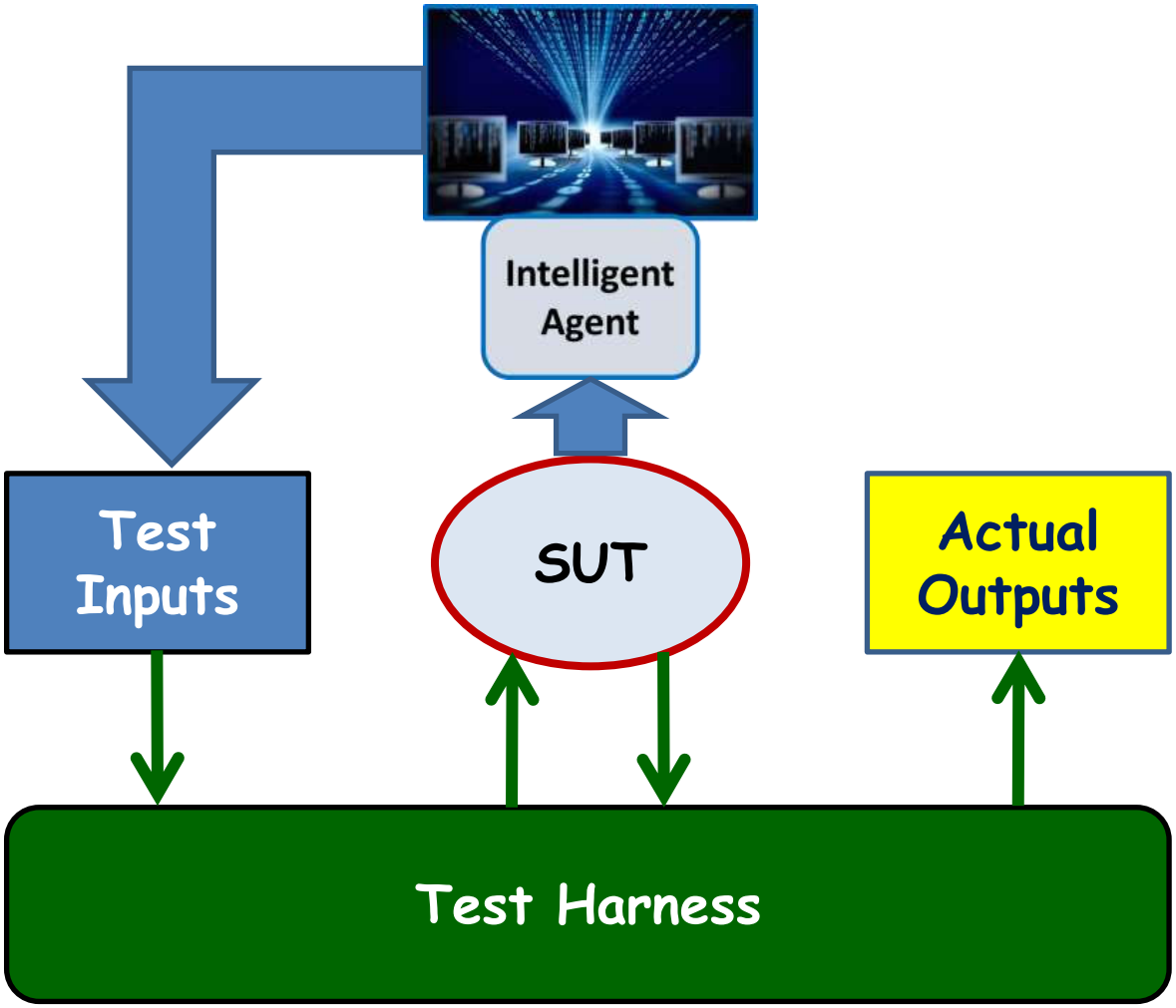
Example
– Searching using a 'Hill Climb' Algorithm



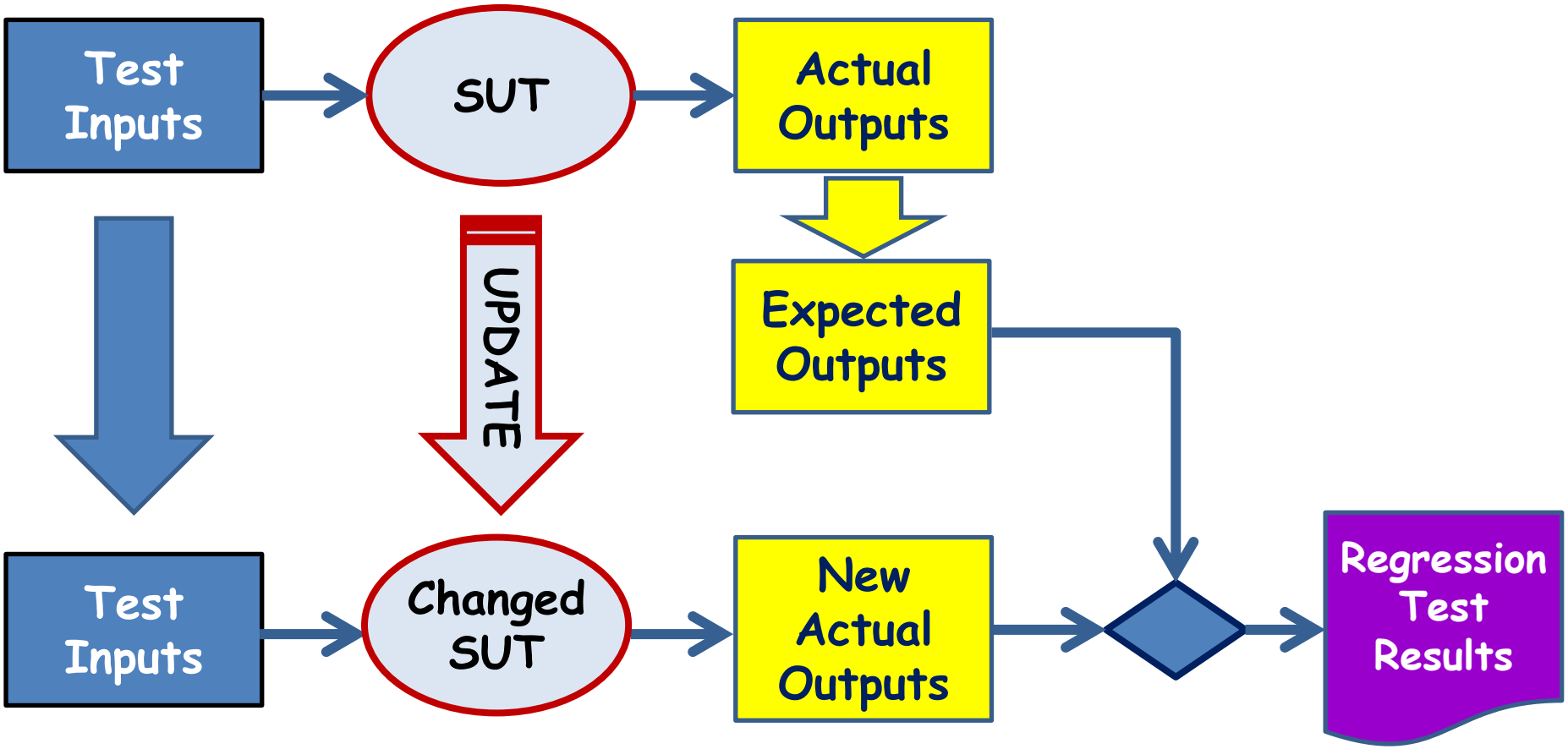
Manual Test Process



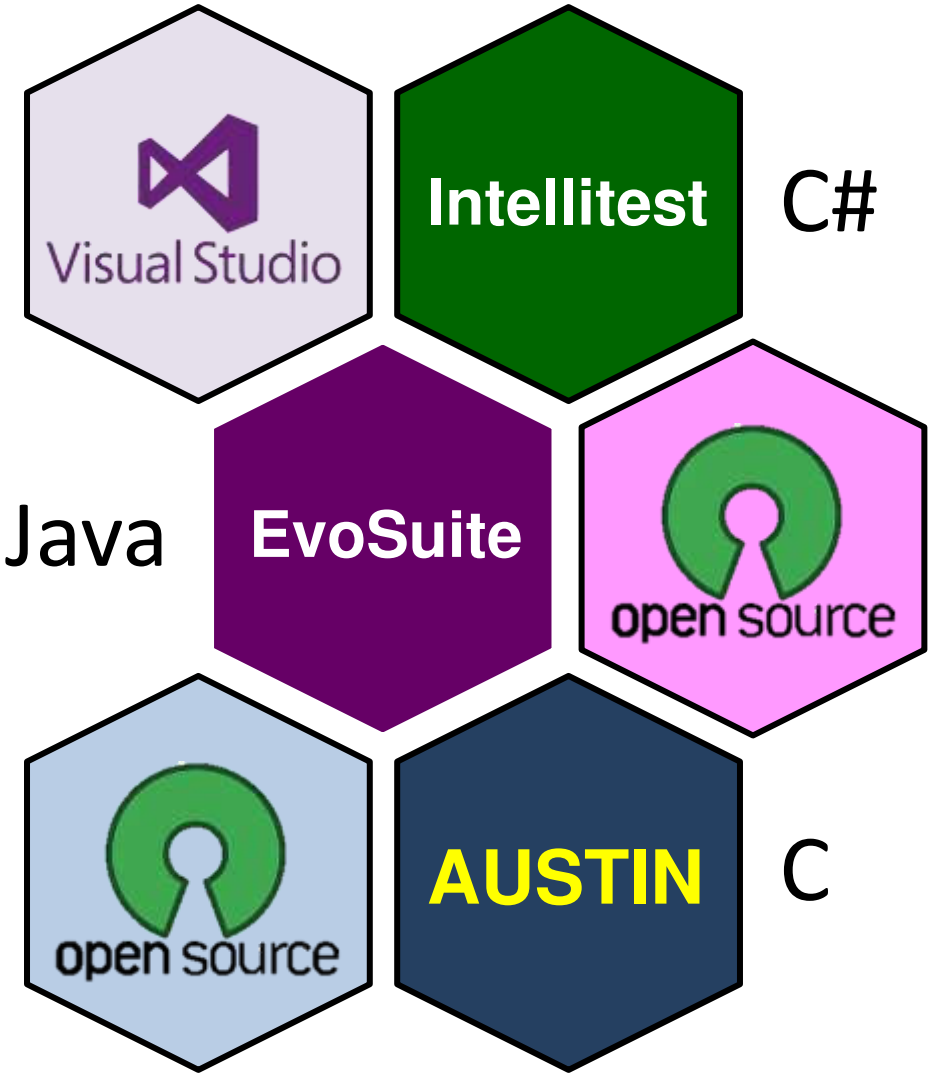
Automated Test Input Generation



Automated Regression Test Case Generation



Example Tools



Automated Test Input Generation - Summary

- **Empirical studies have shown:**
  - tool support can lead to improvements in code coverage of up to 300%
  - that there is no measurable improvement in the number of bugs actually found by developer/testers – even though more branches are covered
- **But, a set of automatically-generated regression tests providing full coverage is an excellent starting point when you change or refactor the code**

- **Danger!!!**
  - testers rely on the tool → little or no black box testing
  - testers use the tool to meet safety-related test standards

Automated Stress Testing

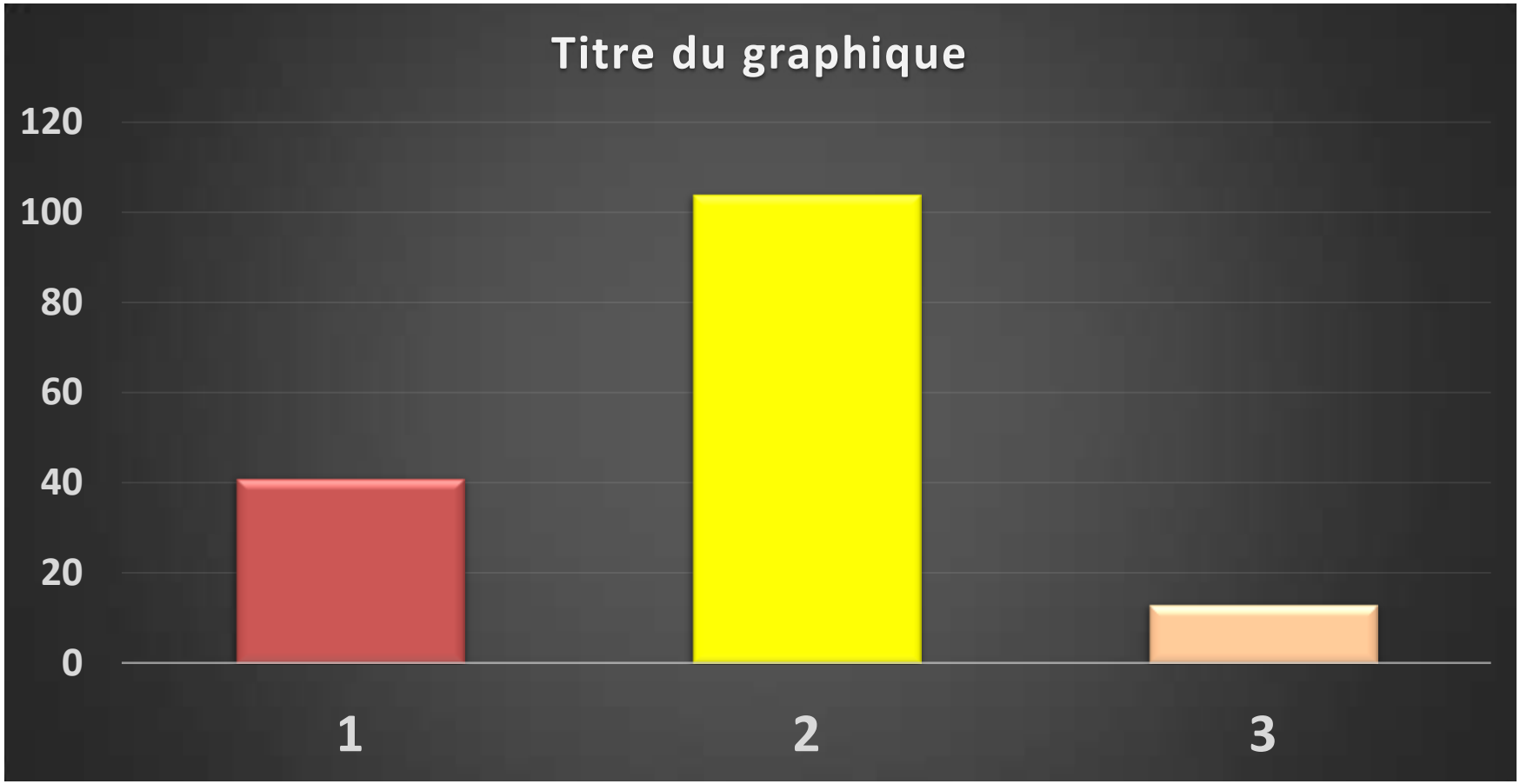
Automated Stress Testing Tools

- **Generate pseudo-random streams of user events such as clicks, touches, or gestures, as well as a number of system-level events**
  - they pretend they are a ‘stupid’ tester
- **Aim to cause an ANR (‘Application Not Responding’) or for the app to simply crash**
  - so test result is easy to observe
- **Require little tester input**
  - except to check-out the reported failures

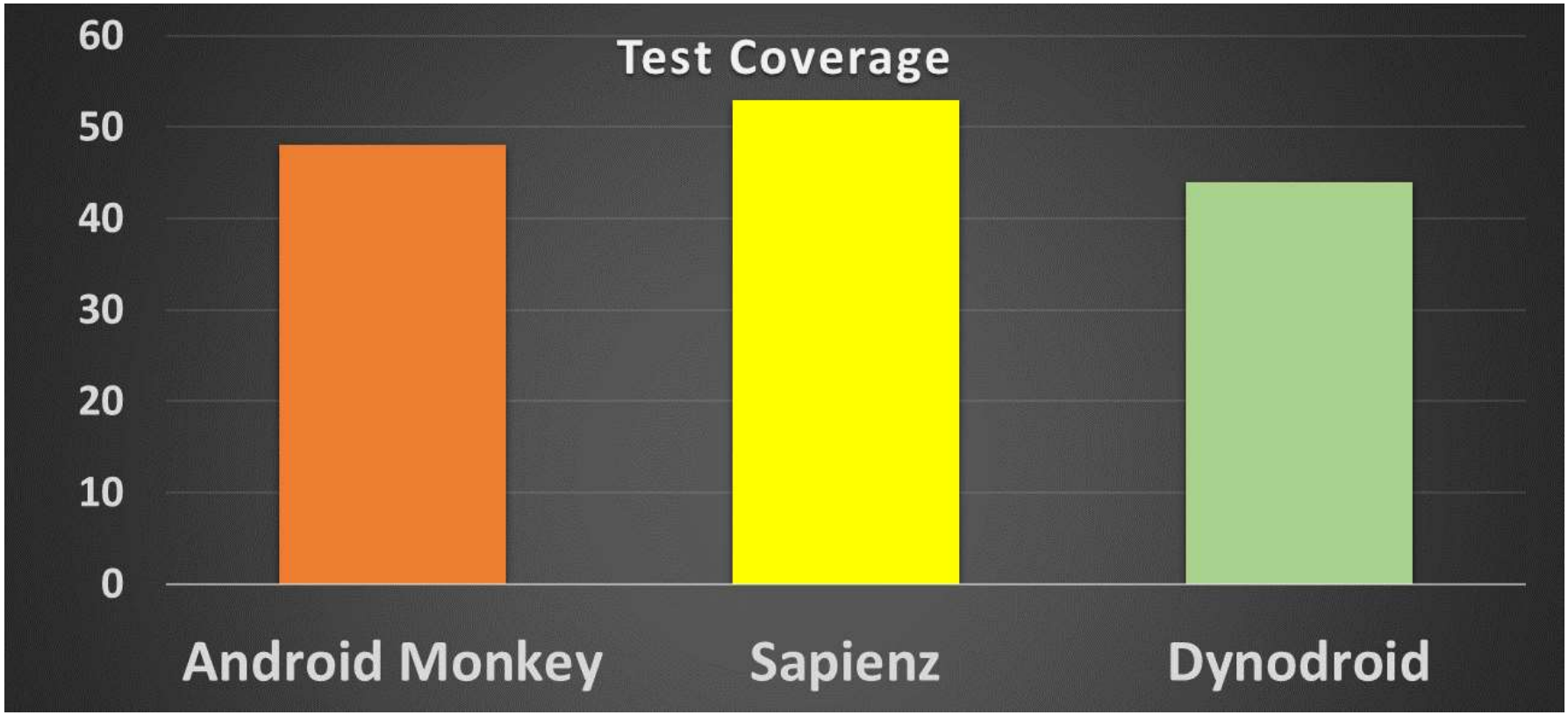
Example - Android Stress Testing Tools

- **Google Monkey**
  - built into the Android development platform - free
  - fuzz testing tool – random inputs
- **Sapienz**
  - open source
  - search-based testing tool
  - when applied to the top 1,000 Google Play apps, Sapienz found 558 unique, previously-unknown faults
- **Dynodroid**
  - open source
  - allows interleaving of human and tool
  - when applied to the top 1,000 Google Play apps, Dynodroid found 6 unique, previously unknown faults

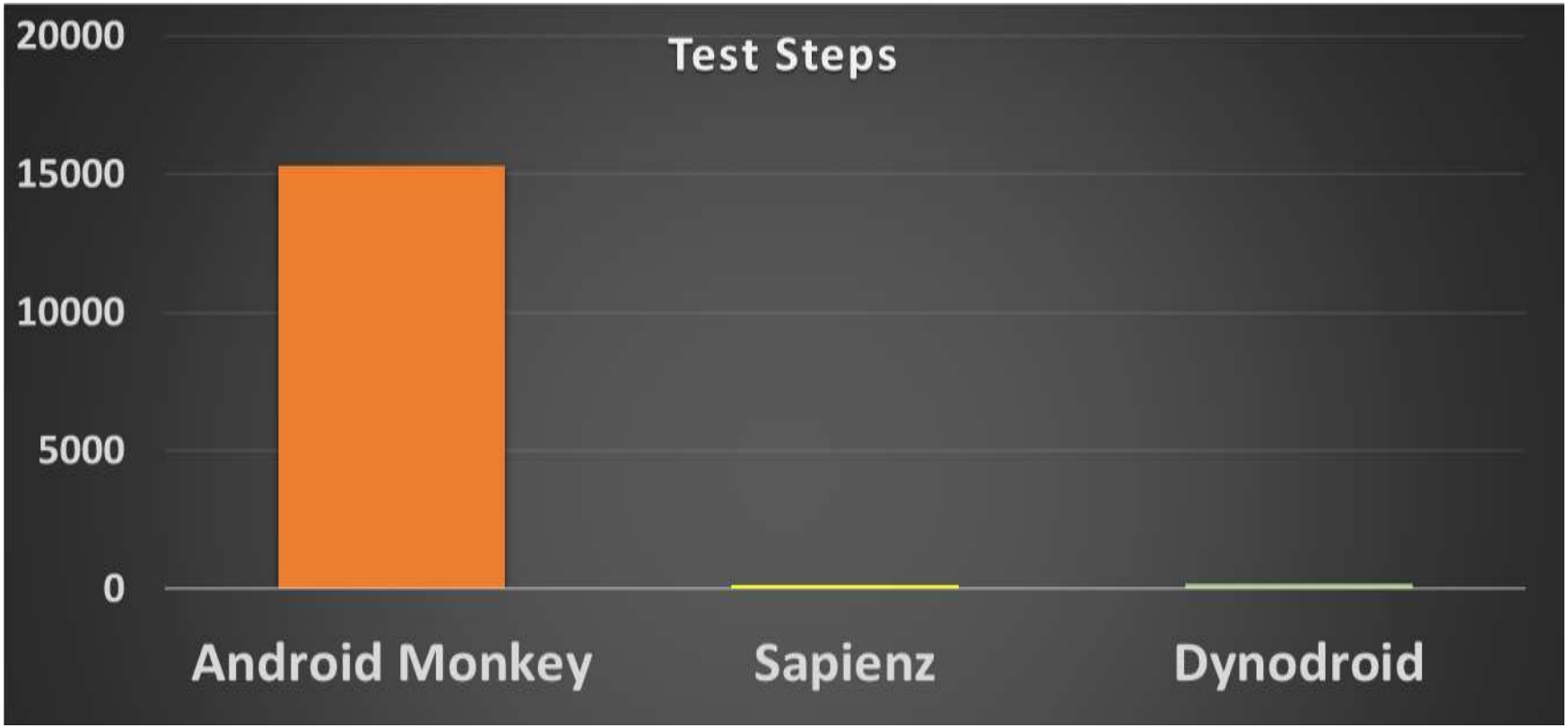
Defect Detection Effectiveness



Test Coverage



Fault Revealing Steps



Conclusions

- Artificial Intelligence and Testing
- Bug Prediction
- Static Analysis
- Regression Testing
- Automated Test Input Generation
- Automated Stress Testing

Thank you for listening ☺