



Smarter Testing with Artificial Intelligence

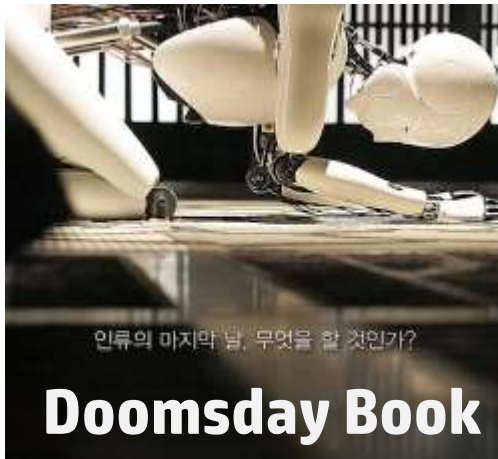
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- **Artificial Intelligence and Testing**
- **Bug Prediction**
- **Static Analysis**
- **Regression Testing**
- **Automated Test Input Generation**
- **Automated Stress Testing**
- **Conclusions**

Artificial Intelligence (AI) in the Cinema



Artificial Intelligence (AI) Works!

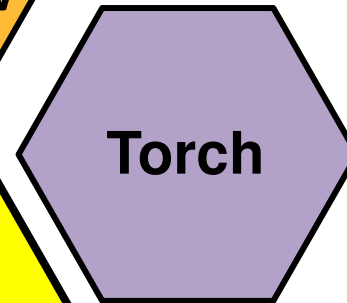
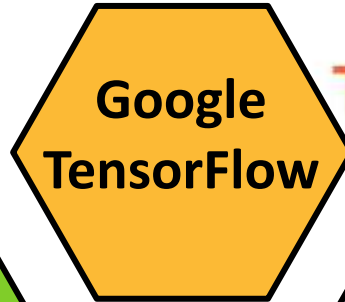
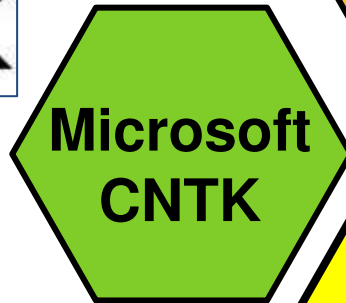


Artificial Intelligence Techniques

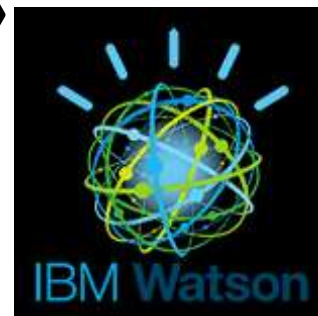
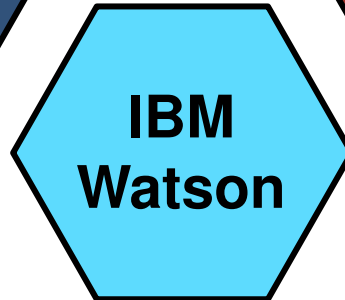
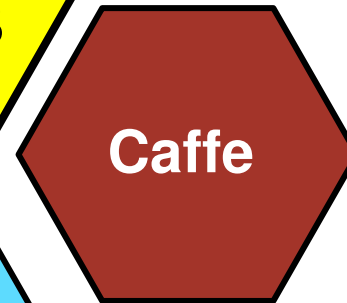
- **Neural Networks**
- **Expert/Knowledge-based Systems**
- **Machine Learning**
- **Fuzzy and Probabilistic Logic**
- **Classification**
- **Search and Optimization**

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

AI Toolkits



theano



AI - Smart Testing Opportunities

**Specification
Testing**

**Bug
Prediction**

**Regression
Testing**

**Stress
Testing**

**Specification-
based Script
Generation**

**Static
Analysis**

**Test Input
Generation**

**Smart Test
Manager**

**Usage
Profiling**

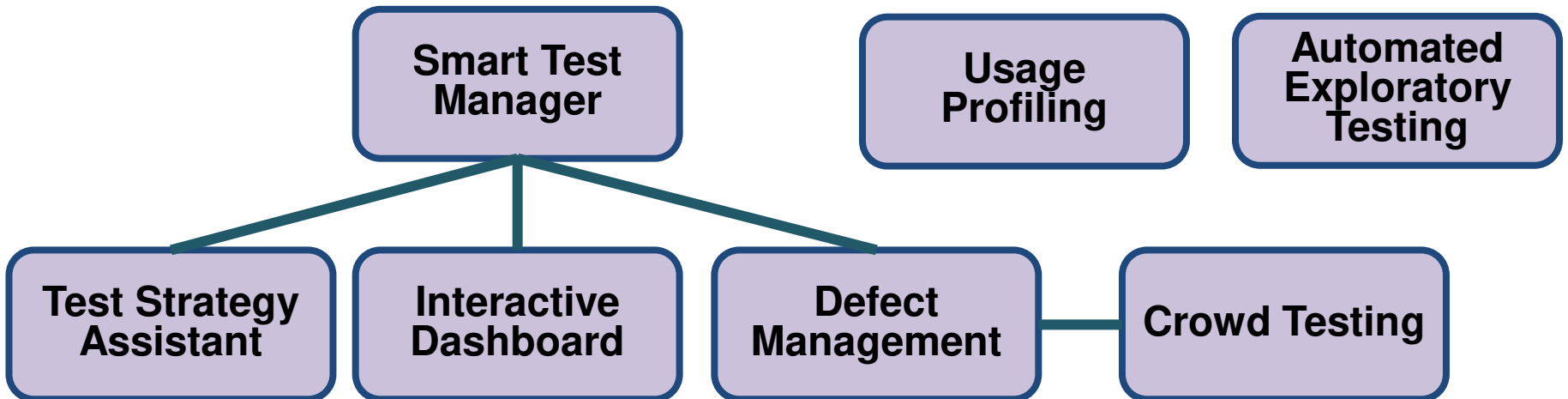
**Automated
Exploratory
Testing**

**Test Strategy
Assistant**

**Interactive
Dashboard**

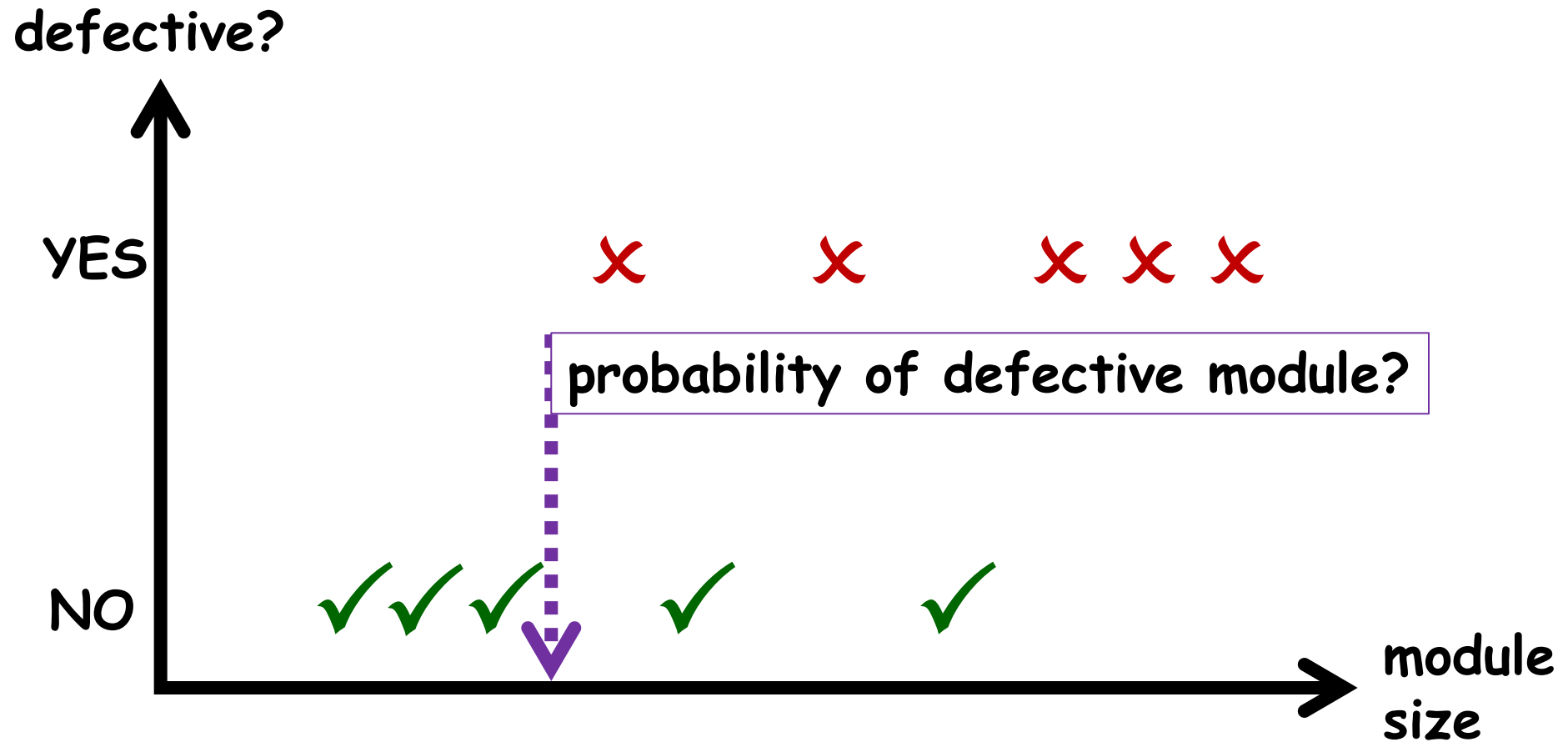
**Defect
Management**

Crowd Testing

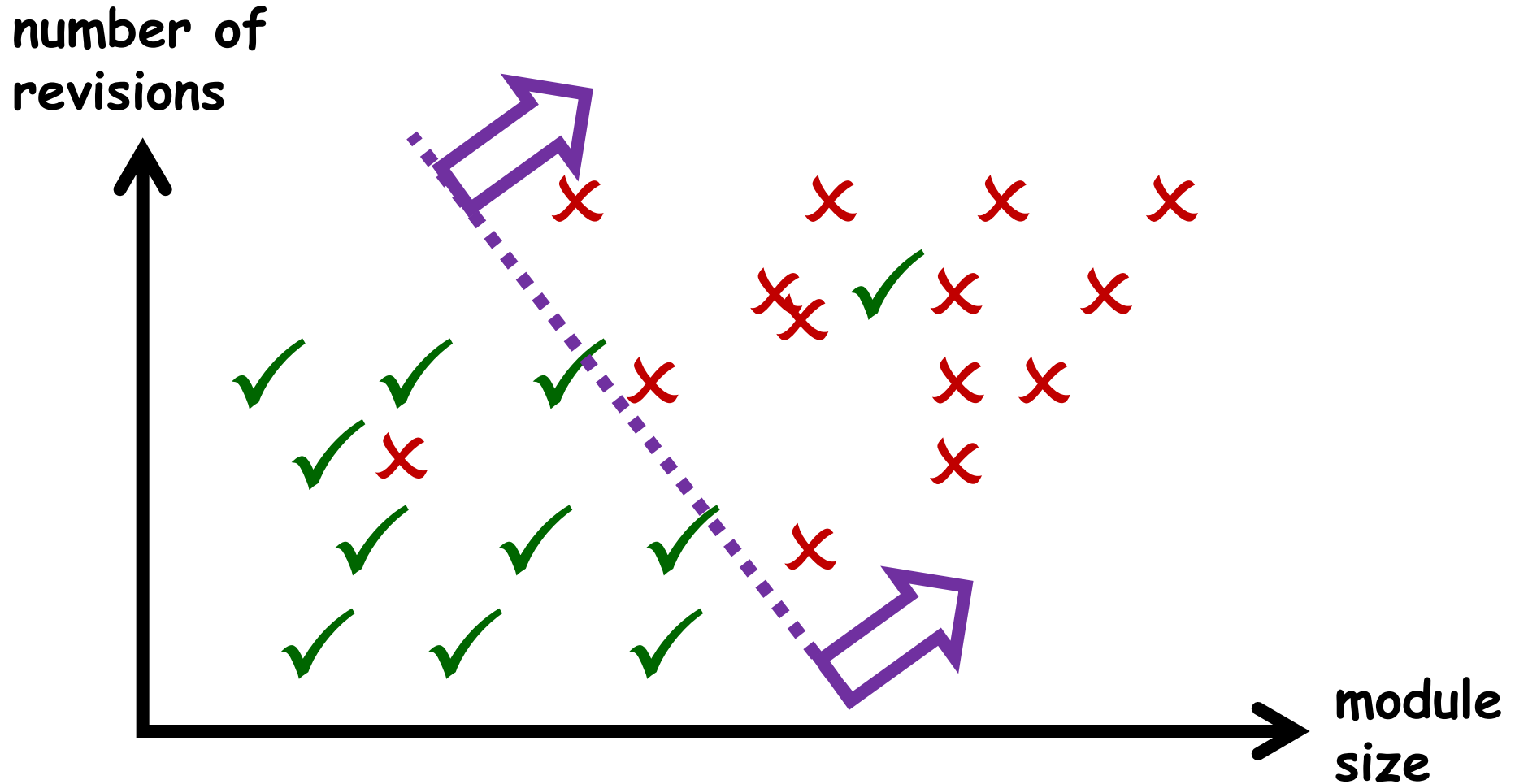


Bug Prediction

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

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

Training Set

these must be different

Input Data Matrix	Module Attributes							Response Data
		A1	A2	A3	A4	A5	A6	Defective?
Example Modules	M99	4	43.1	YES	2	0	138	NO
	M98	7	77.0	YES	1	2	188	YES
	M97	2	13.6	NO	3	0	231	YES
	M96	5	187	NO	2	1	121	NO
	M95	3	154	YES	3	n/a	96	NO

Test Data

Learning Algorithm

Bug Predictor Function

Accuracy

Defective?

Check result

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

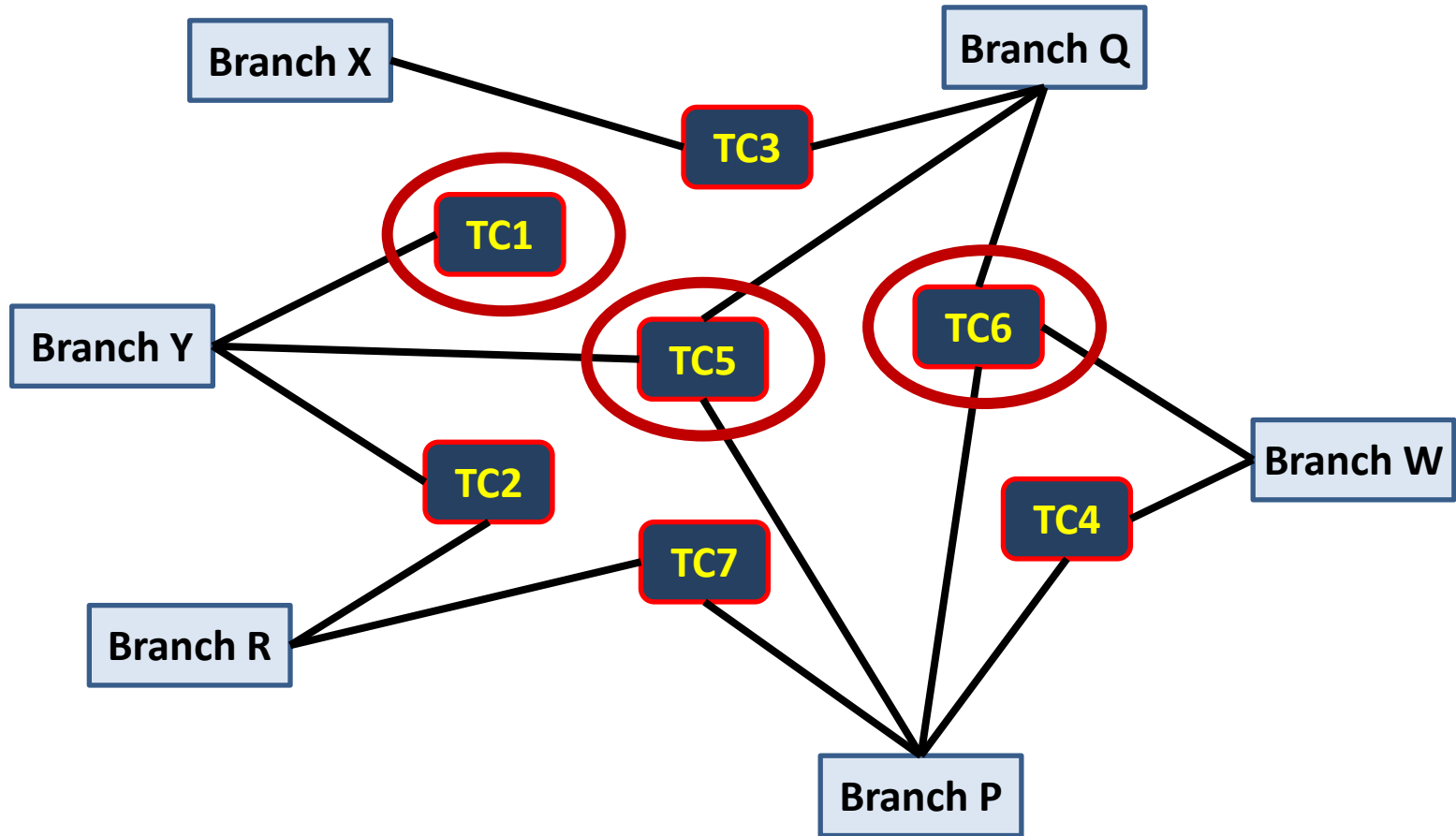


- **Open source**
- **Analyses C, Objective-C and Java**
 - on Android and iOS
- **Fast – can do millions of LOC in a few minutes**
 - ideal for continuous integration
- **Facebook claims that approximately 80% of raised issues are fixed (so are true faults)**
- **Also used by Instagram, Uber, Spotify,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

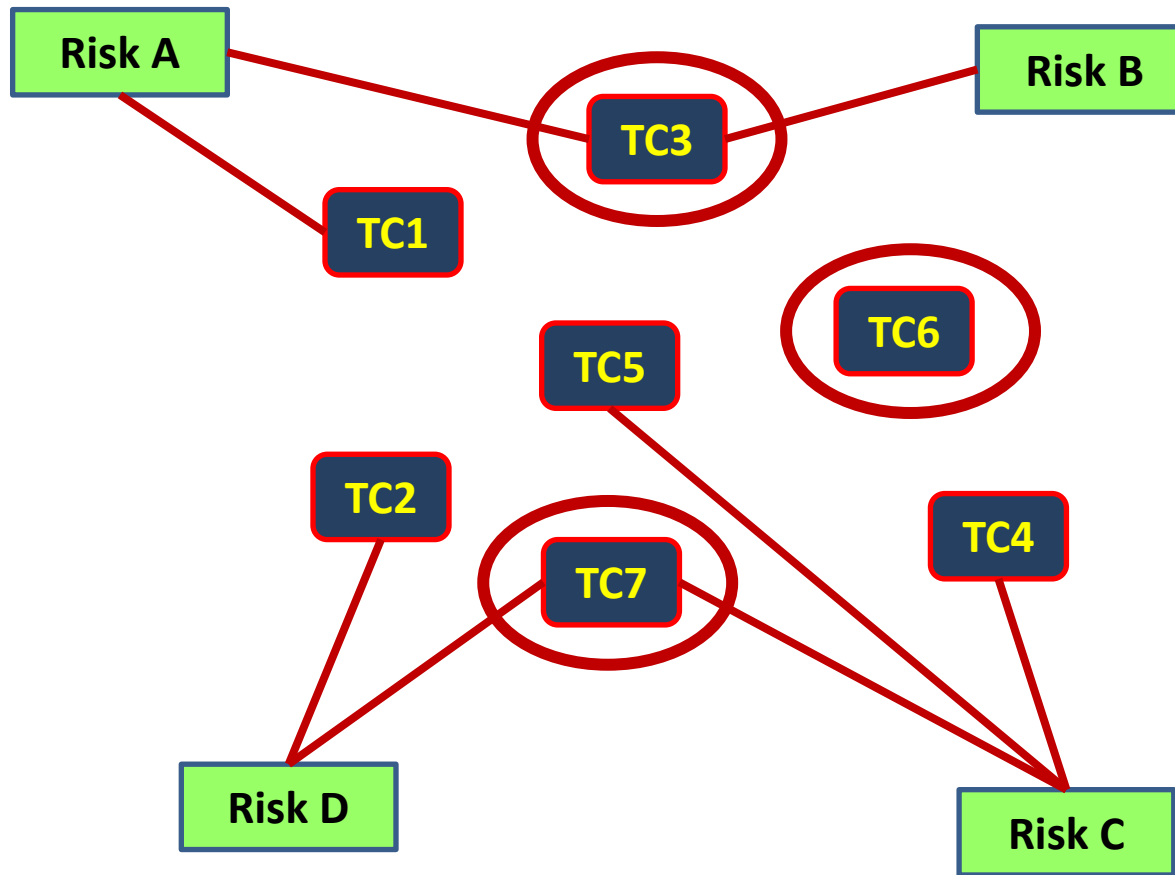


Regression Testing

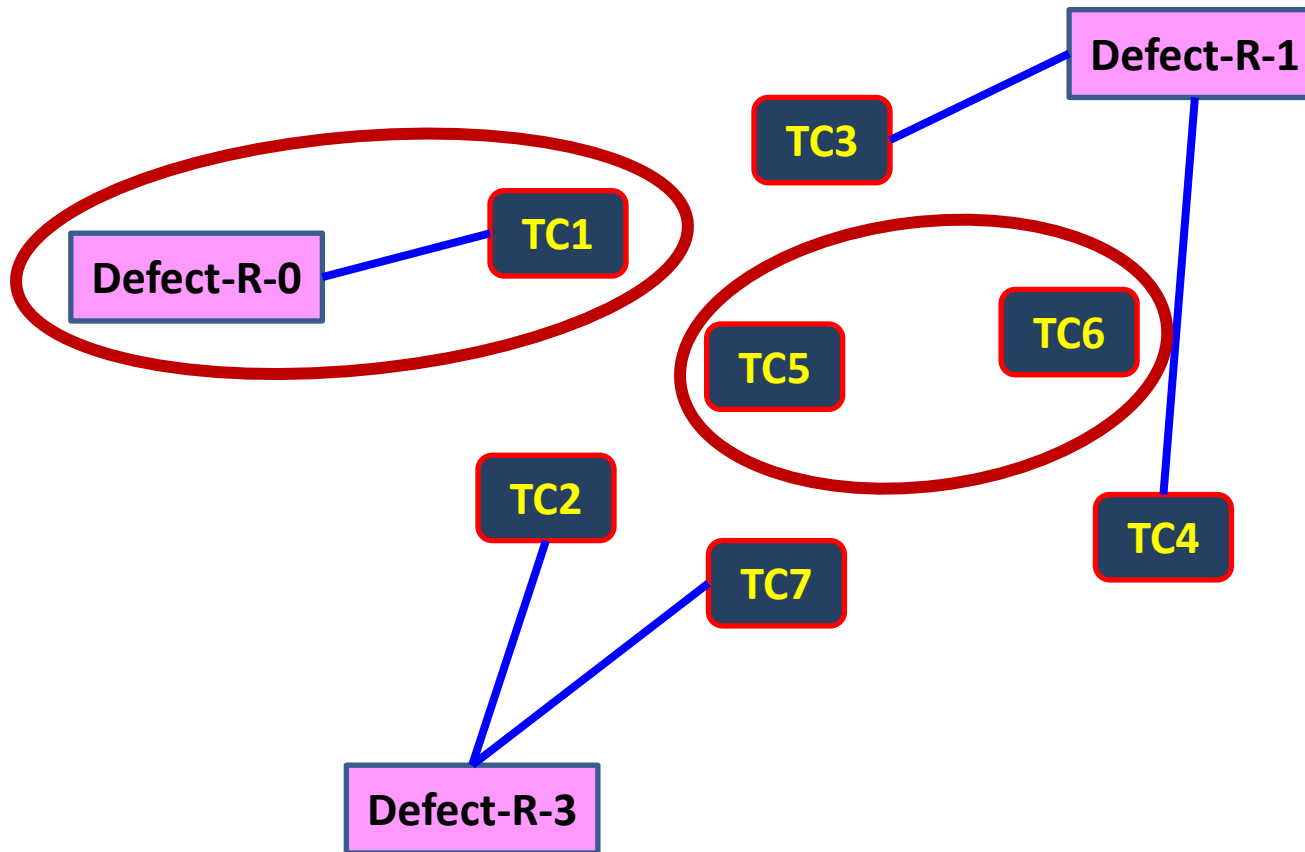
Regression Test Optimization



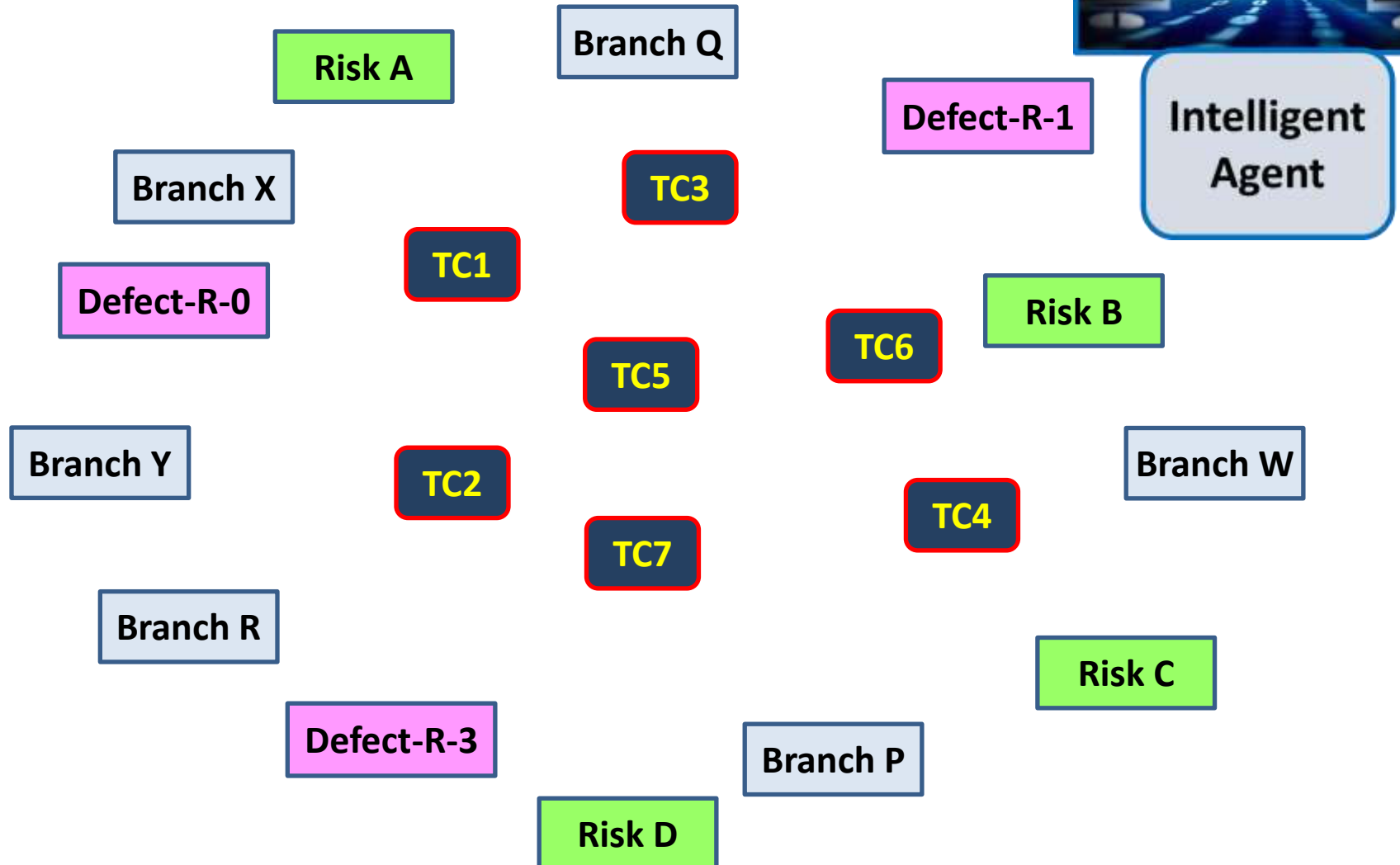
Regression Test Optimization



Regression Test Optimization



Regression Test Selection



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.

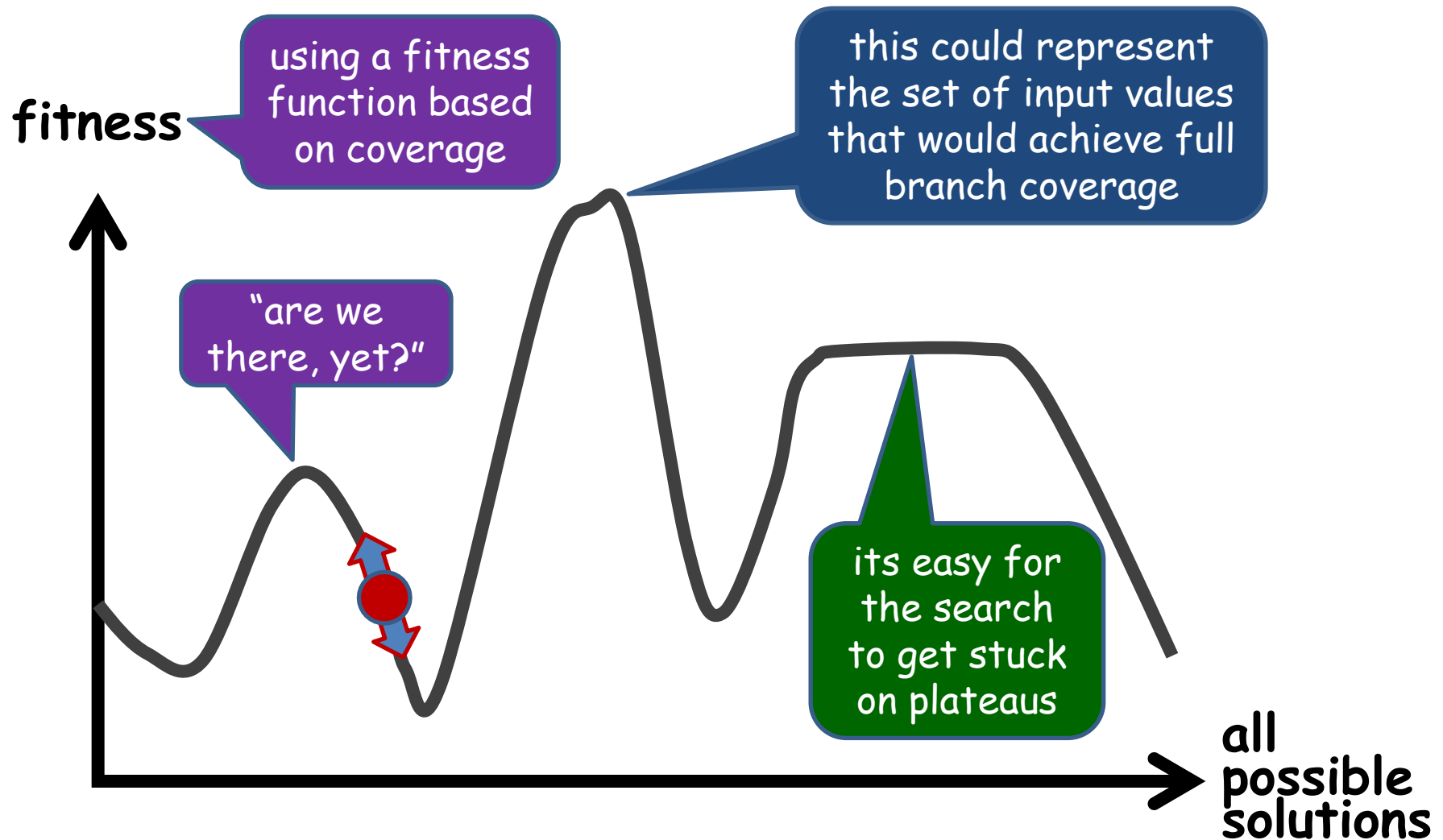
Regression Test Optimization Results

- **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]

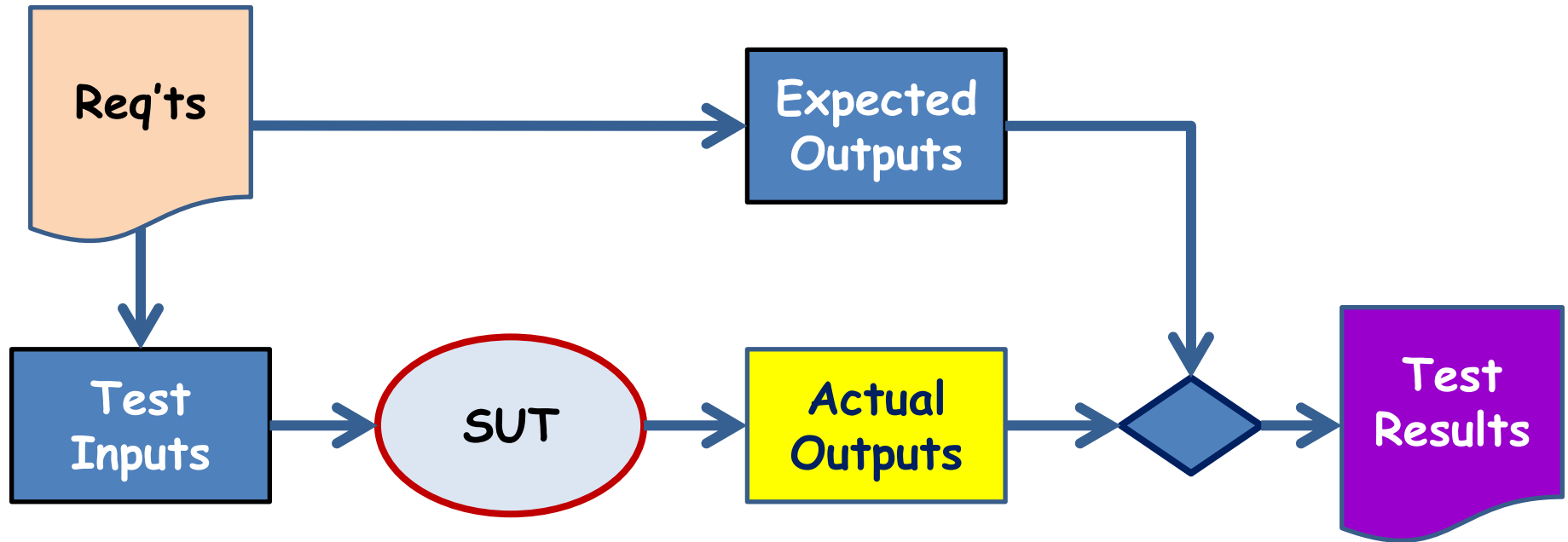
Automated Test Input Generation

Example

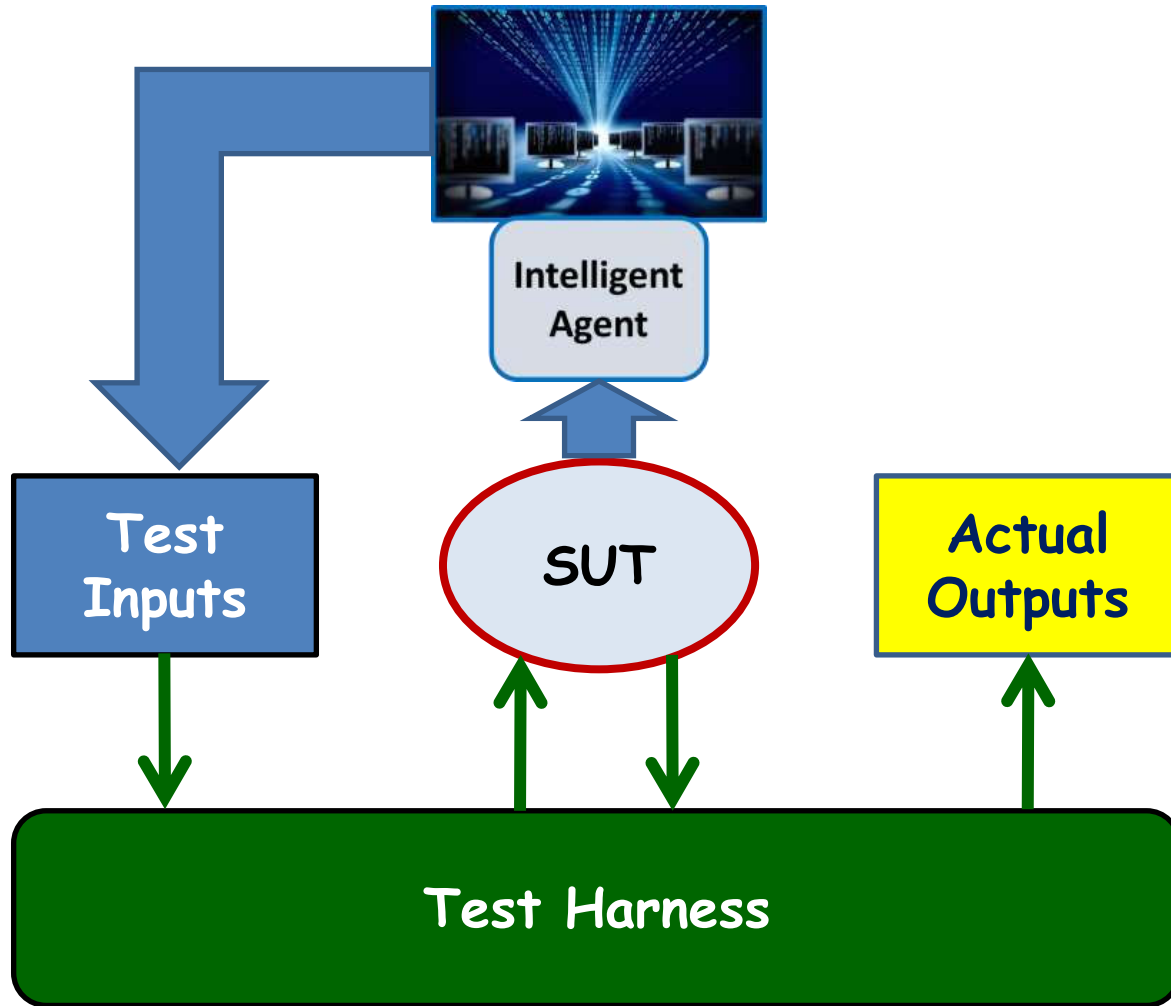
– Searching using a 'Hill Climb' Algorithm



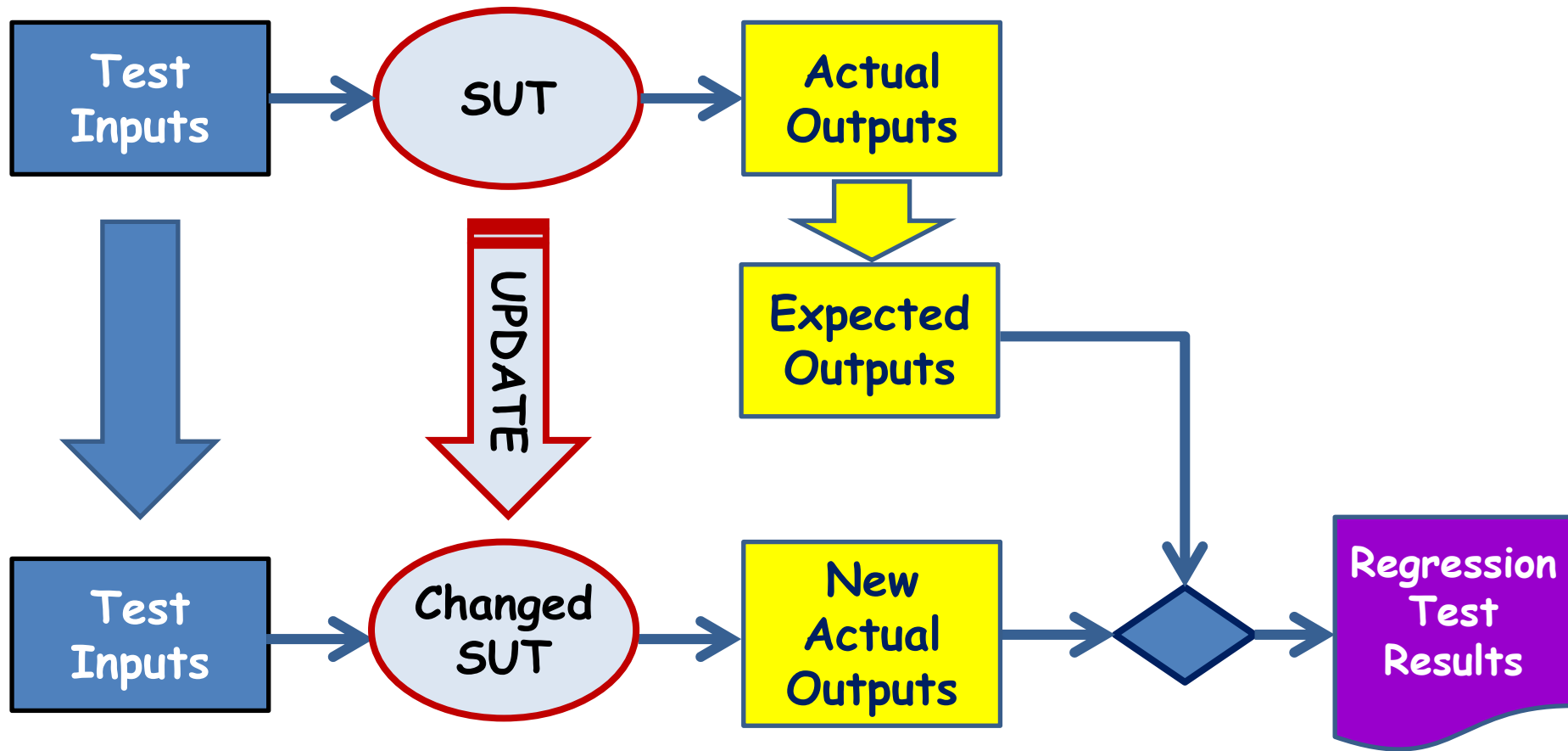
Manual Test Process



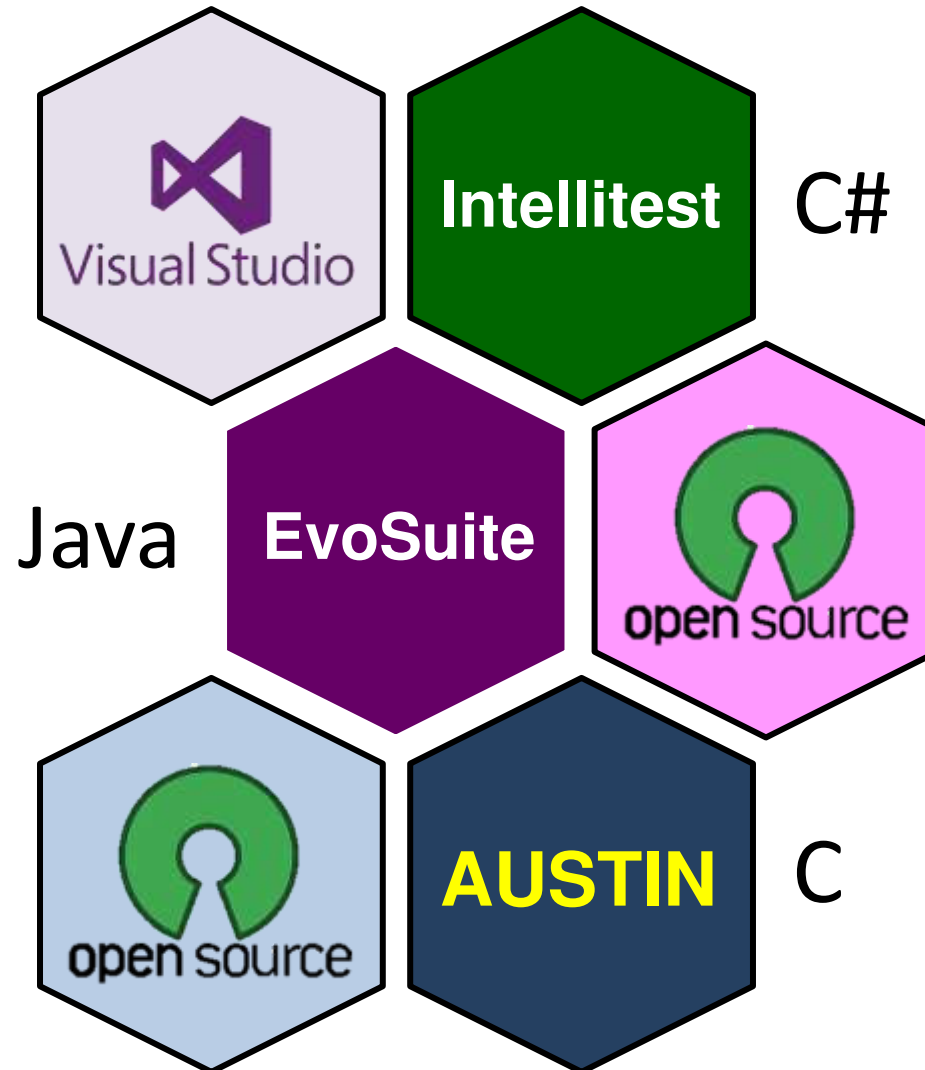
Automated Test Input Generation



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

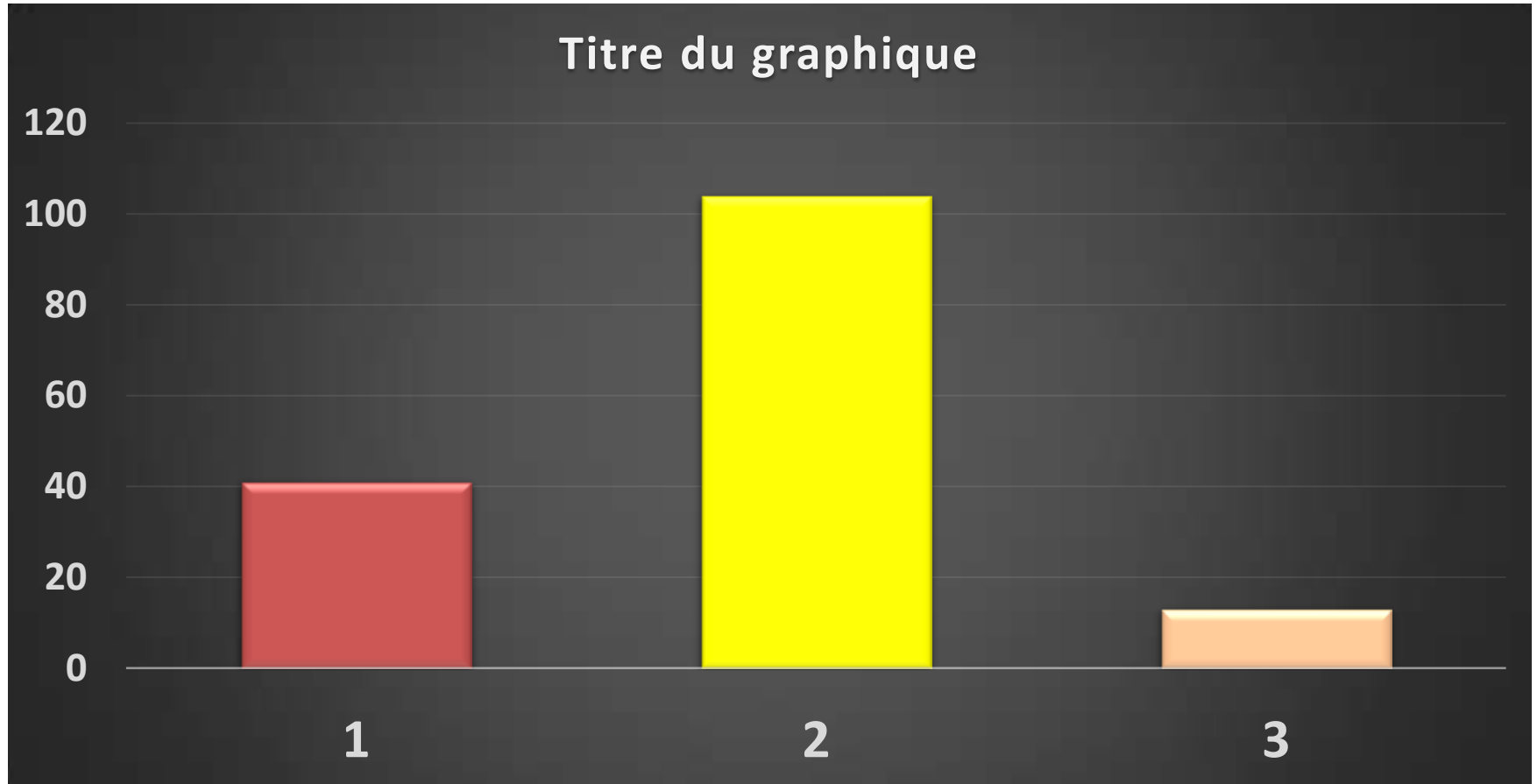
Automated Stress Testing Tools

- **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

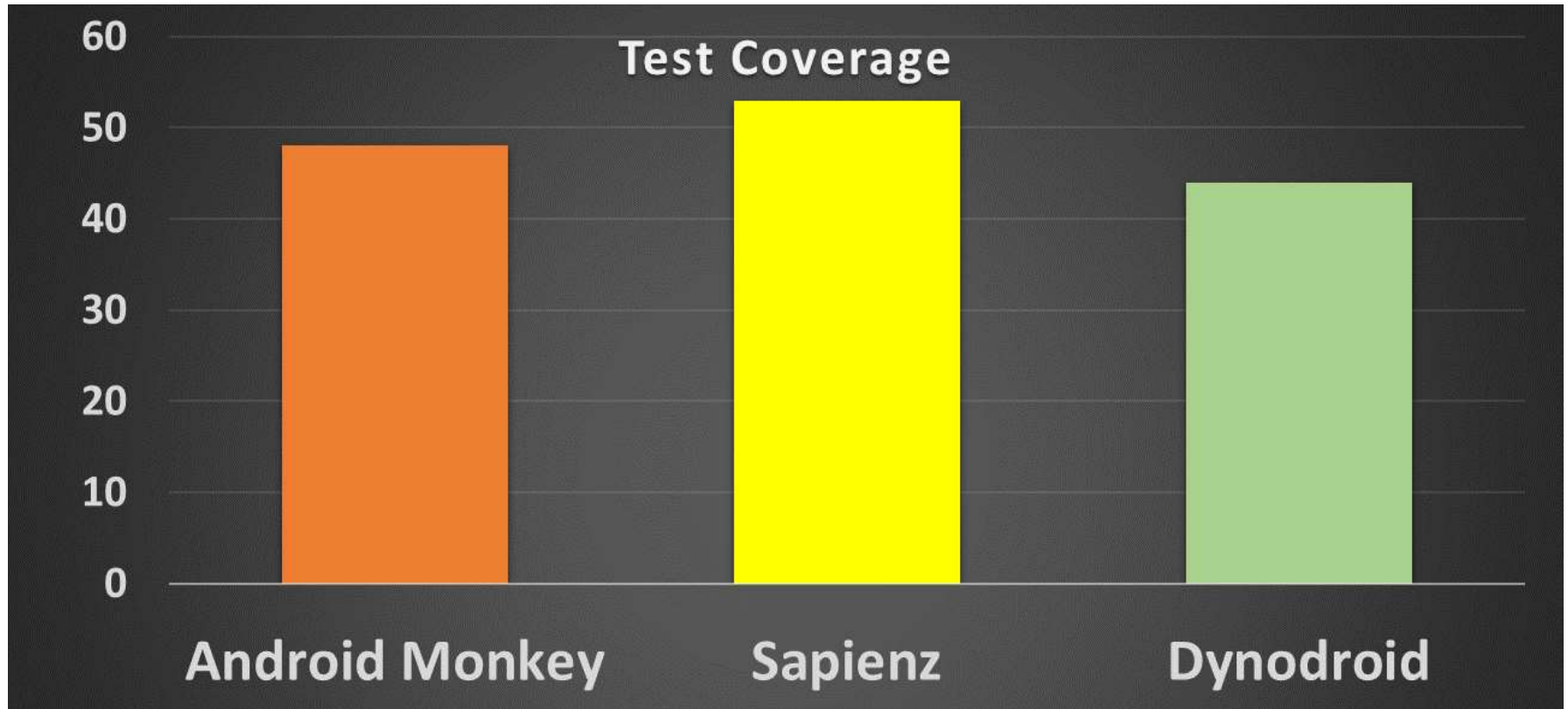
Example - Android Stress Testing Tools

- **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

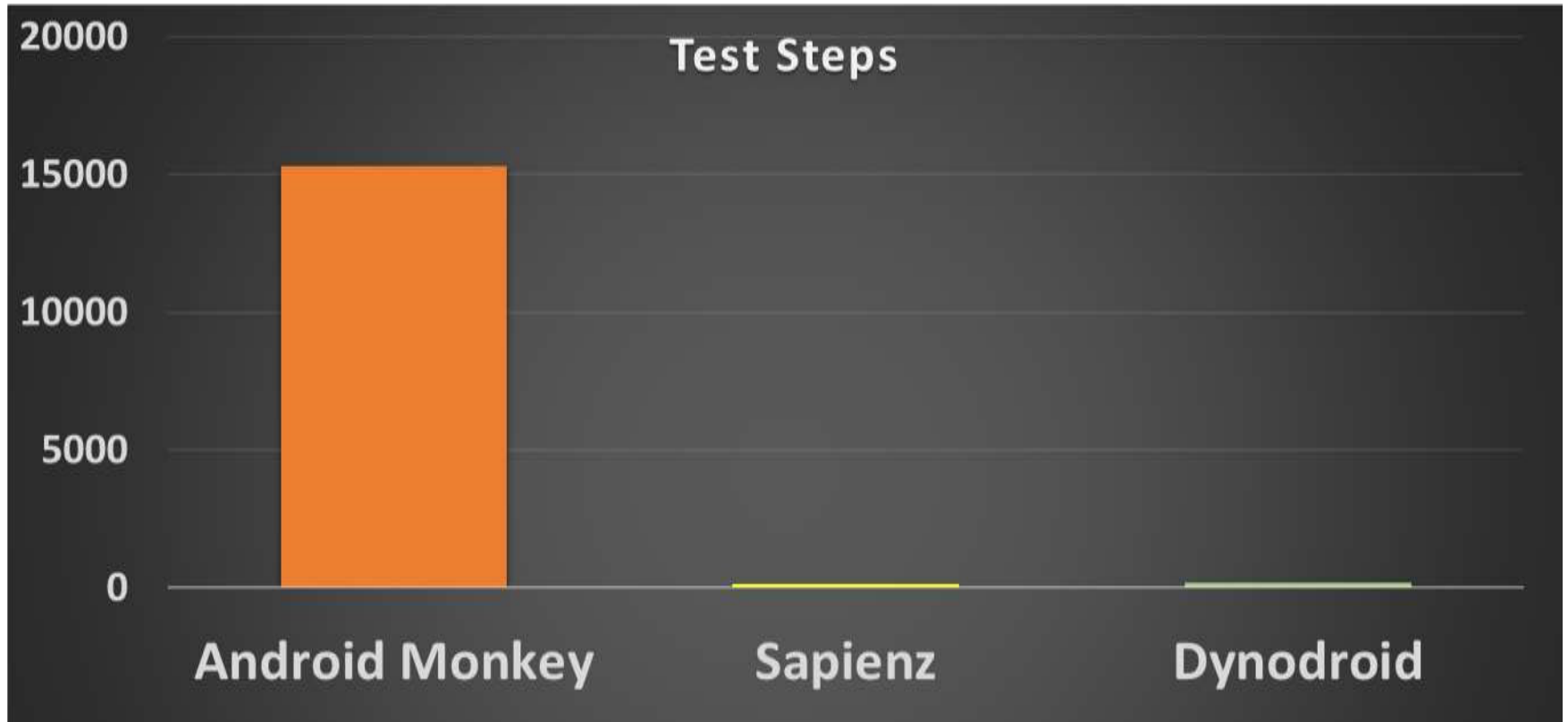
Defect Detection Effectiveness



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 😊



Any Questions?