

Cross-Platform Testing and Maintenance of Web and Mobile Applications

ICSE 2014 Doctoral Symposium

Shauvik Roy Choudhary

Advisor: Dr. Alessandro Orso

School of Computer Science, Georgia Tech

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Web



Mobile Web



Mobile

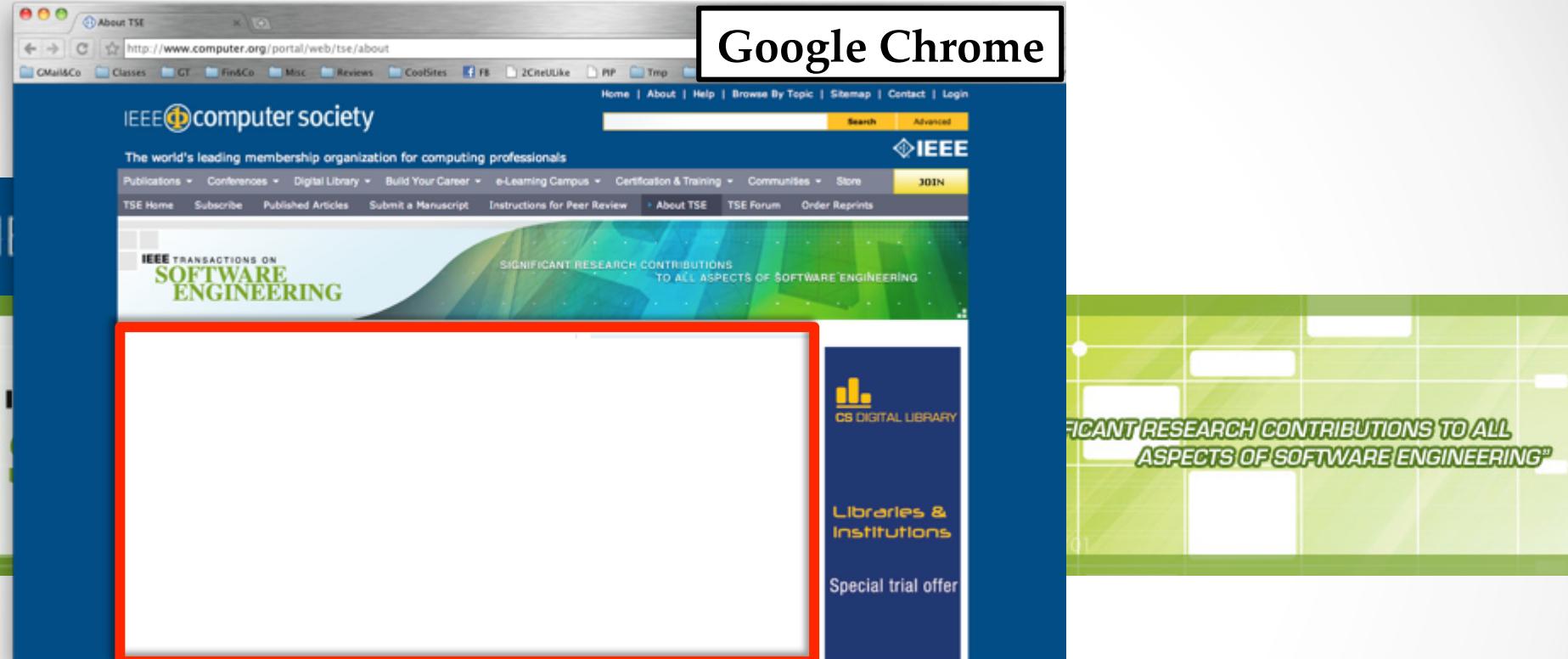


iOS

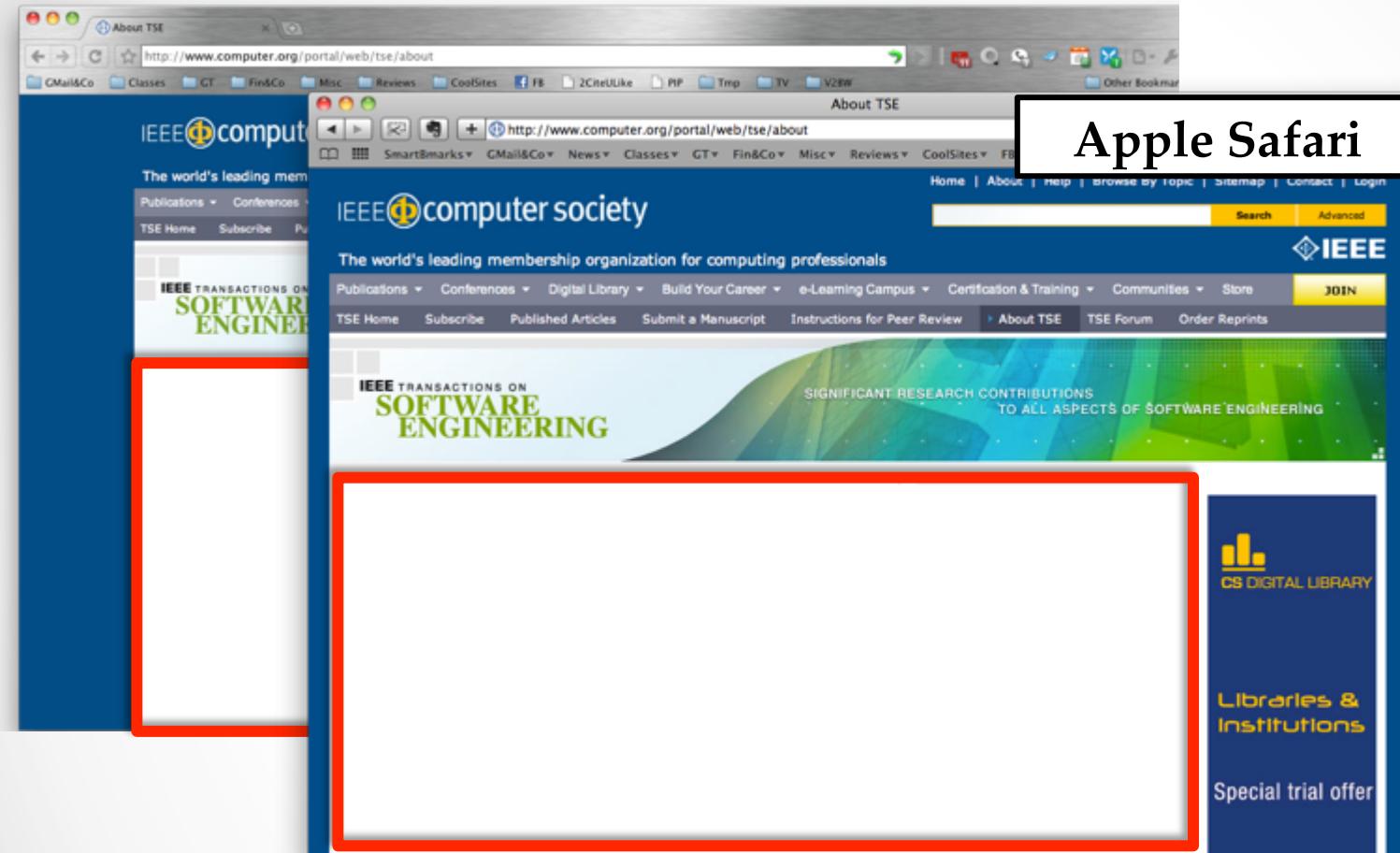


Testing & Maintenance Issues for Multi-platform Applications

I. Inconsistencies



I. Inconsistencies



I. Inconsistencies

The image shows two side-by-side web browser windows. The left window is a Mac OS X browser displaying the IEEE Computer Society website (<http://www.computer.org/portal/web/tse/about>). The right window is Mozilla Firefox displaying the same URL. Both pages show the same content, including the IEEE logo, the "IEEE Transactions on Software Engineering" journal cover, and the "Scope of TSE" section. The "Scope of TSE" section contains a detailed paragraph about the journal's focus and scope. The Mozilla Firefox window has a red border around the "Scope of TSE" section, highlighting the inconsistency where the content appears identical but is presented in different contexts.

About TSE - Mozilla Firefox

<http://www.computer.org/portal/web/tse/about>

IEEE computer society

The world's leading membership organization for computing professionals

Scope of TSE

IEEE Transactions on Software Engineering (TSE) is an archival journal published bimonthly. We are interested in well-defined theoretical results and empirical studies that have potential impact on the construction, analysis, or management of software. The scope of this Transactions ranges from the mechanisms through the development of principles to the application of those principles to specific environments. Since the journal is archival, it is assumed that the ideas presented are important, have been well analyzed, and/or empirically validated and are of value to the software engineering research or practitioner community. Specific topic areas include: a) development and maintenance methods and models, e.g., techniques and principles for the specification, design, and implementation of software systems, including notations and process models; b) assessment methods, e.g., software tests and validation, reliability models, test and diagnosis procedures, software redundancy and design for error control, and the measurements and evaluation of various aspects of the process and product; c) software project management, e.g., productivity factors, cost models, schedule and organizational issues, standards; d) tools and environments, e.g., specific tools, integrated tool environments including the associated architectures, databases, and parallel and distributed processing issues; e) system issues, e.g., hardware-software trade-off; and f) state-of-the-art surveys that provide a synthesis and comprehensive review of the historical development of one particular area of interest.

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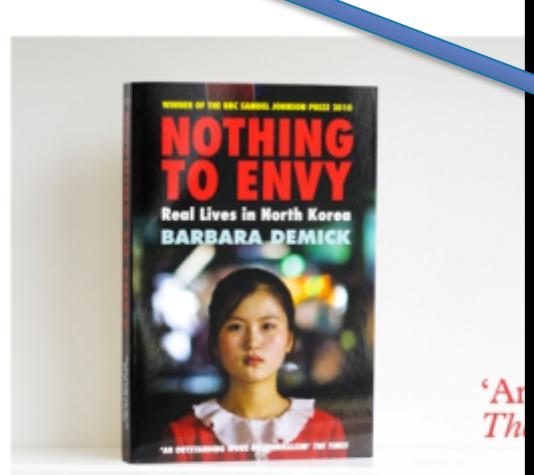
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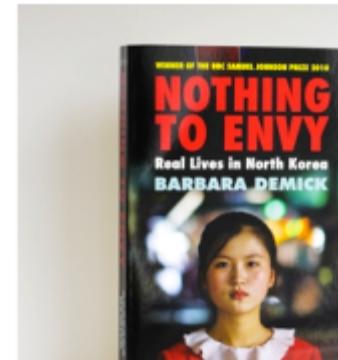
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II. Missing Features

MyWordpress 6 0 + New View Post Howdy, admin

Dashboard Screen Options ▾ Help ▾

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All Posts Add New Categories Tags

Media

Pages

Comments

Appearance

Plugins 1

Users

Tools

Settings

Collapse menu

Edit Post Hello world!

Permalink: http://apps.shauvik.com/wp/?p=1 Change Permalinks View Post

Add Media Visual Text

Tripleodeon
Just another WordPress weblog

Welcome start blog

it, then

Edit post

Title: Simple 'on-server' mobile AJAX

Status: Published

Content:

```
--OR--  
"How your mobile site may  
not be much more  
complicated than building  
one with a data API or AJAX"
```

Apply

You can use HTML tags to format your post. Use <!--more--> to indicate the end of the teaser.

Path: p Word count at 2:09 pm

Powered by the WordPress Mobile Pack | Theme designed by [dot](#) Switch to our desktop site

Publish Preview Changes

Status: Published [Edit](#)

Visibility: Public [Edit](#)

Published on: Feb 14, 2014 @ 14:09 [Edit](#)

Move to Trash Update

Format

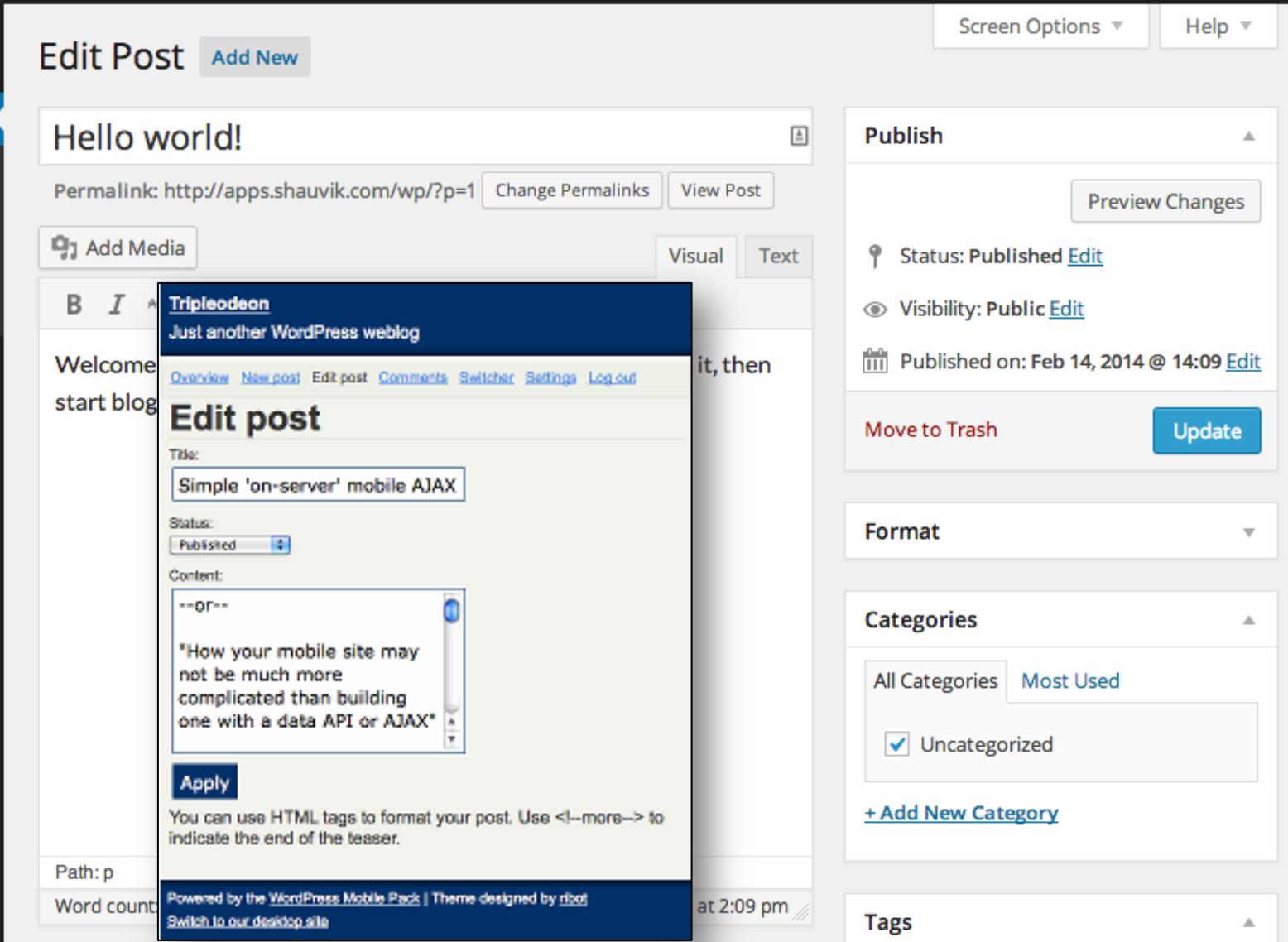
Categories

All Categories Most Used

Uncategorized

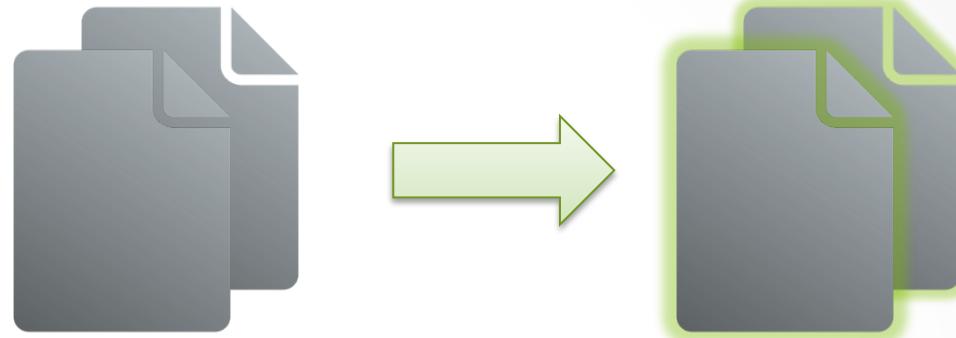
+ Add New Category

Tags

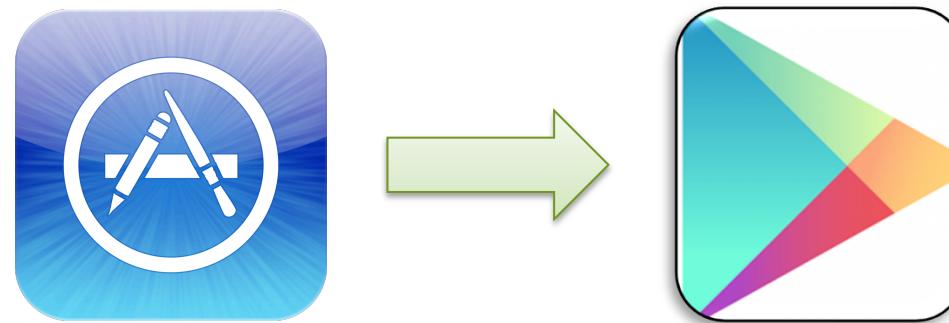


III. Costly Test Migration

Test Suite



Mobile App



Platform



How can we address
these problems?

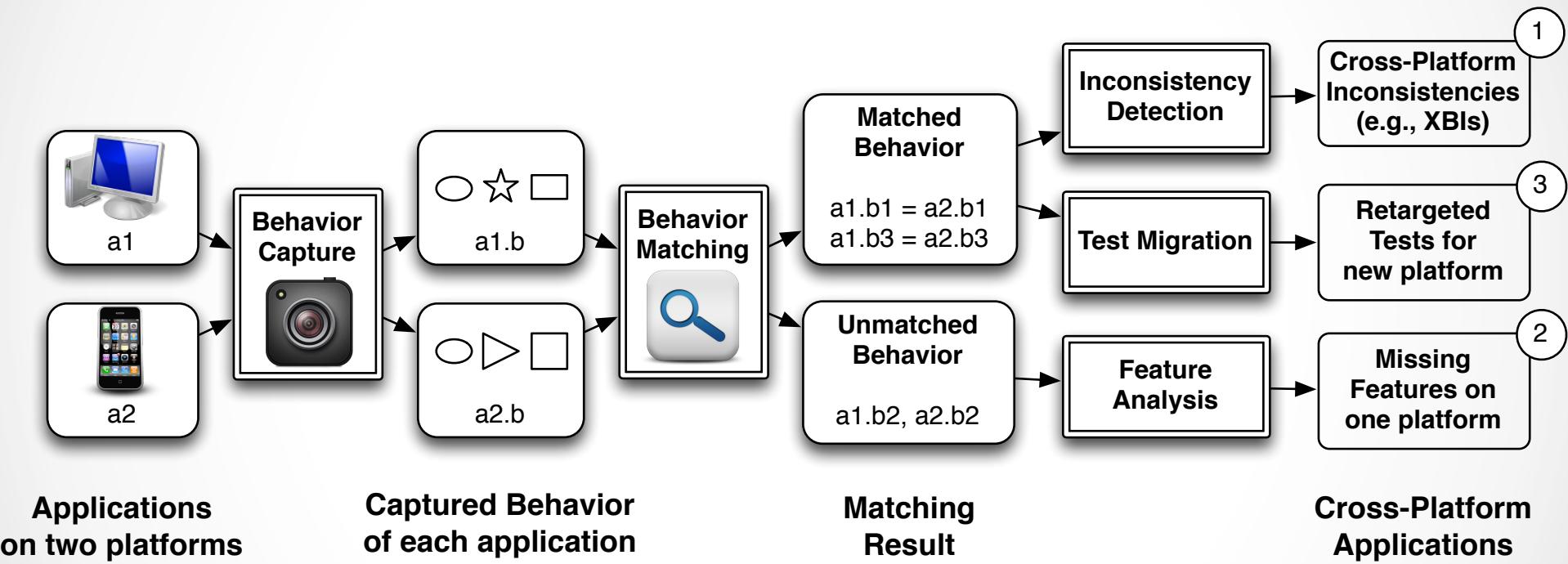
Proposed Thesis

Key Insight: Analyze cross-platform application behavior to address the issues

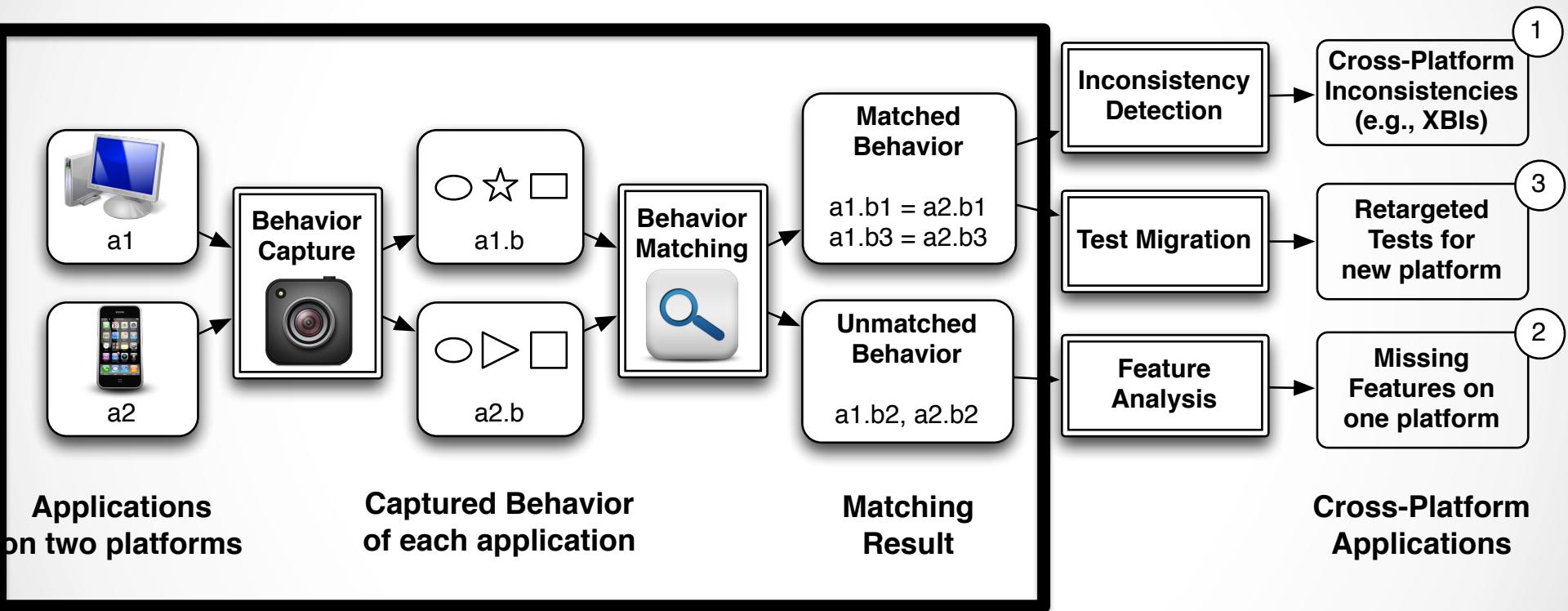
Challenge: Significant difference in cross-platform behavior. Match behavior despite legitimate differences.

Thesis: Approximate behavior-matching algorithms and abstractions can be used to automate cross-platform testing and maintenance.

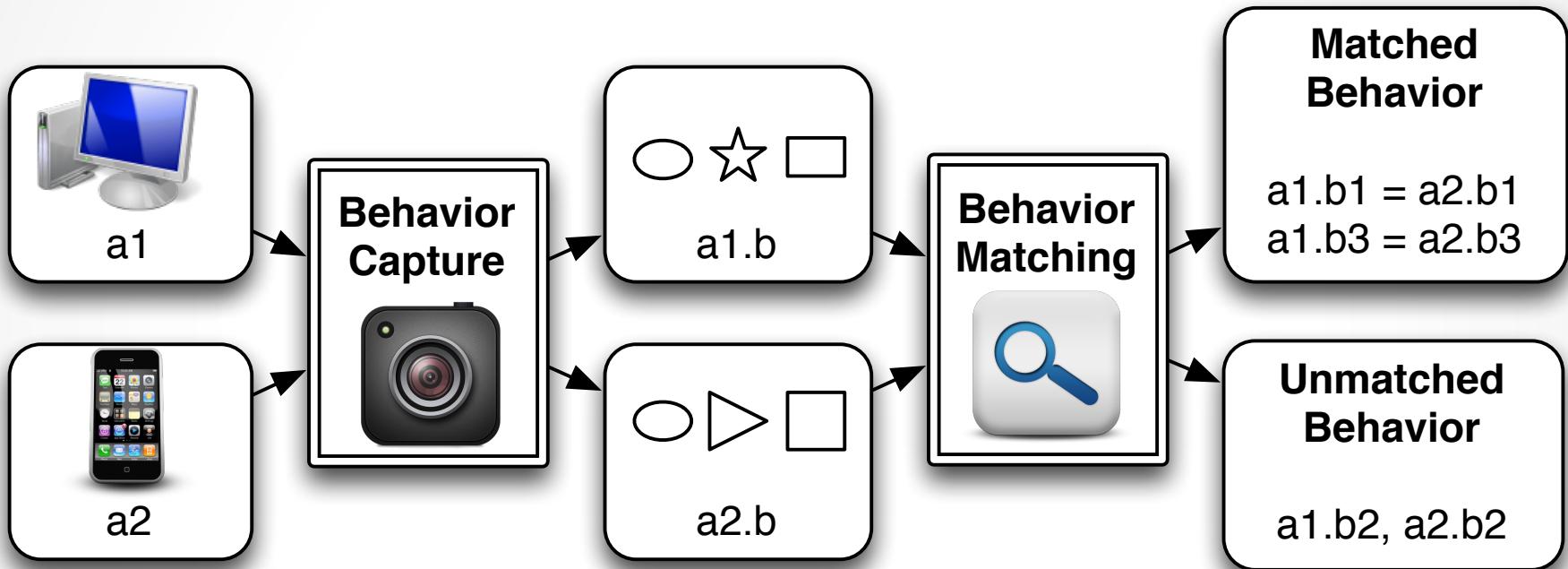
Overall Approach



Overall Approach



Overall Approach

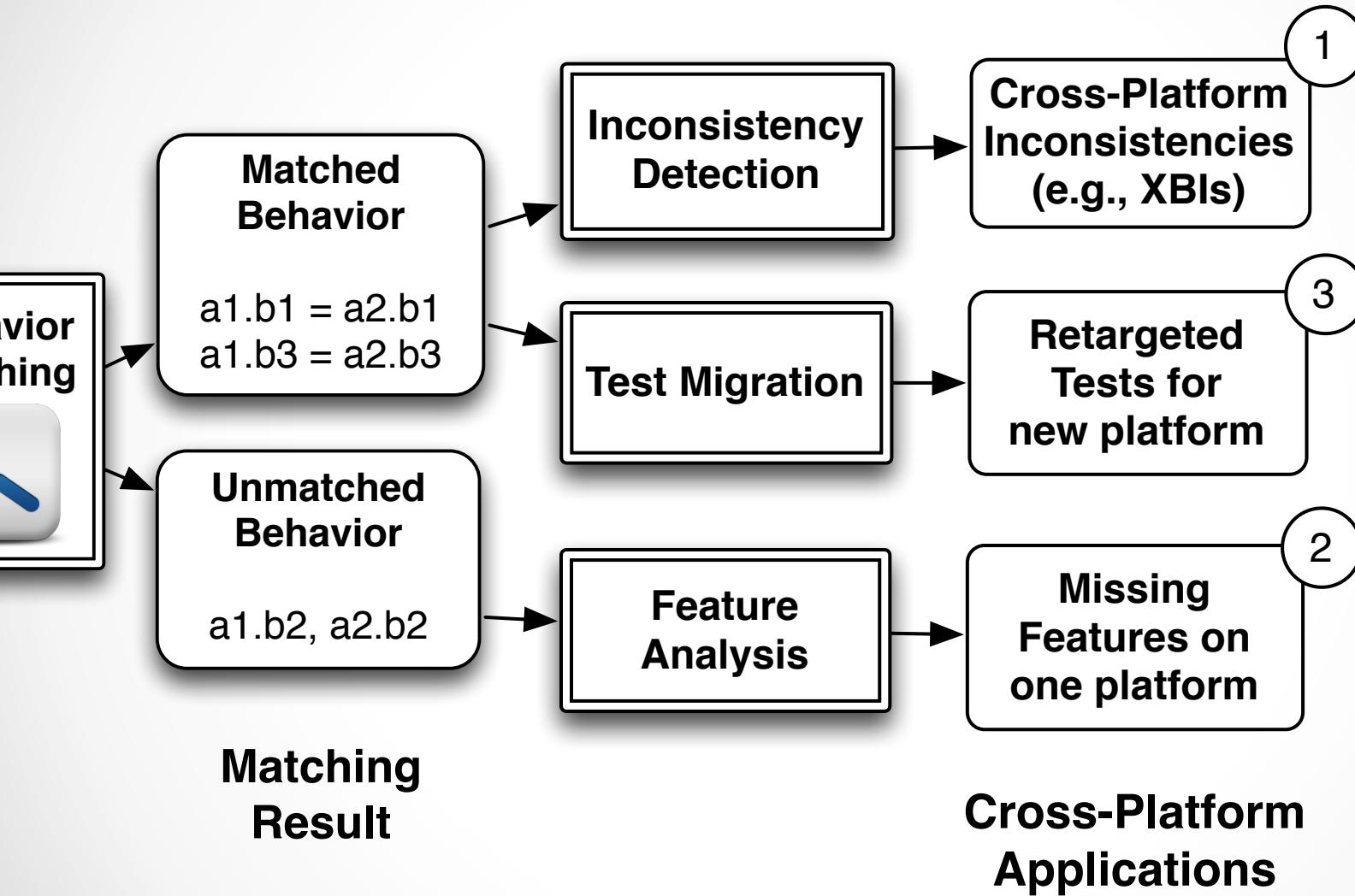


Applications
on two platforms

Captured Behavior
of each application

Matching
Result

Overall Approach

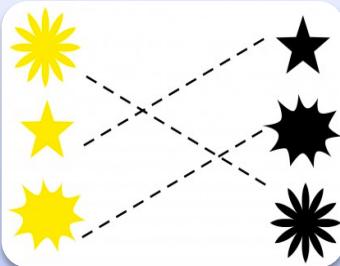


Research Outline



Cross-Browser Testing

- WebDiff [ICSM'10],
CrossCheck [ICST'12], X-PERT [ICSE'13]



Feature Mapping

- FMAP [ISSTA'14]



Test-suite Migration

- Remaining work in progress

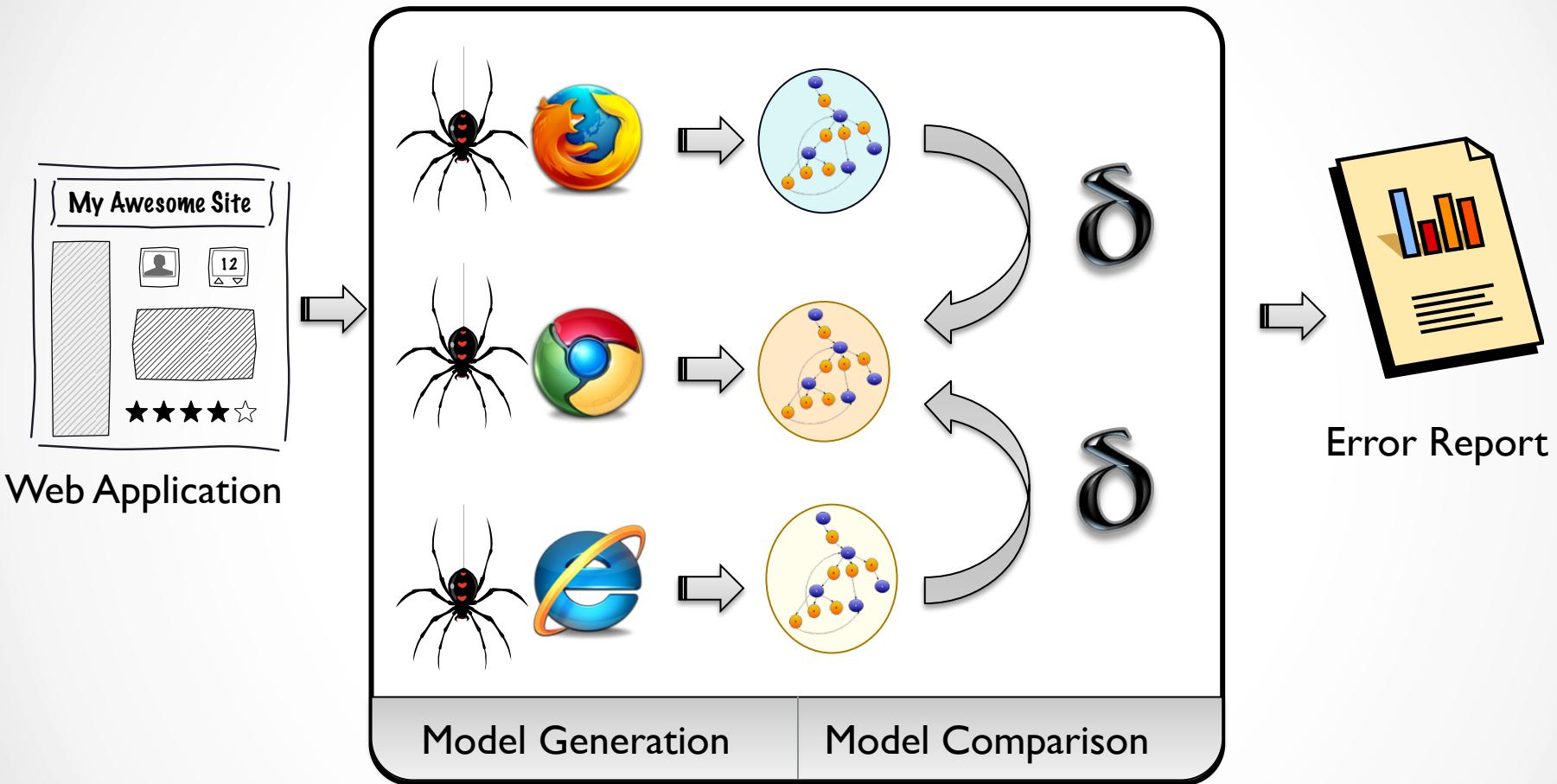


Cross-Browser Incompatibility Detection (for web applications)

WebDiff [ICSM'10], **CrossCheck** [ICST'12], **X-PERT** [ICSE'13]



Approach Overview

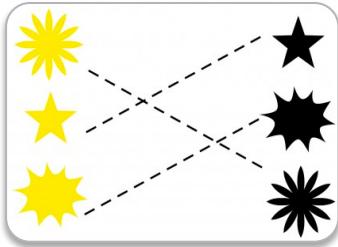


Effectiveness

77% Precision and 95% Recall

Improvement over state-of-art

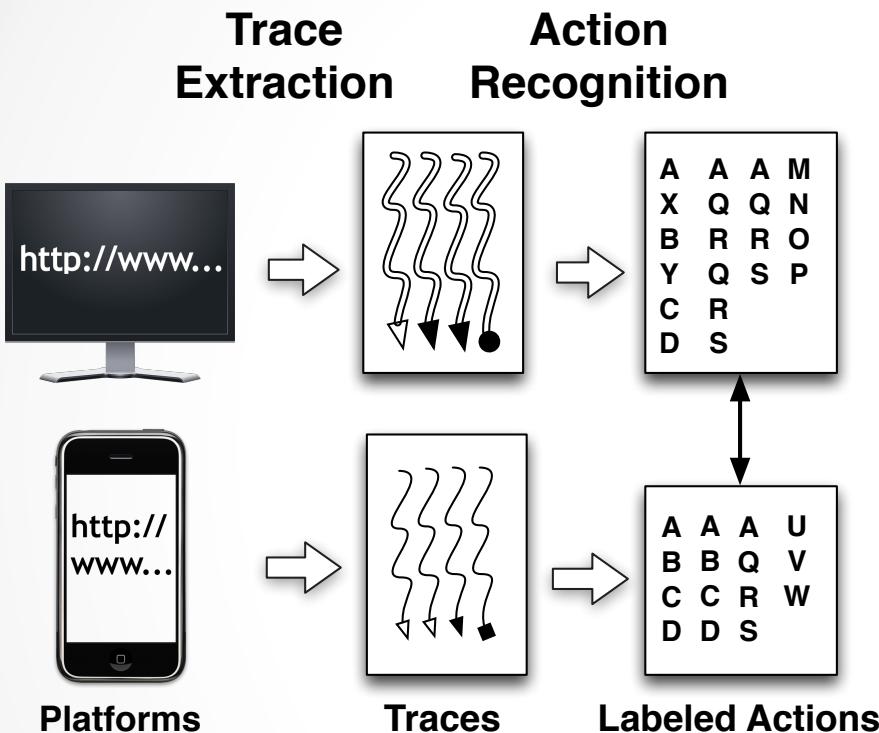
45% \uparrow Precision & 14% \uparrow Recall



Feature Mapping Across Platforms (for desktop & mobile web apps)

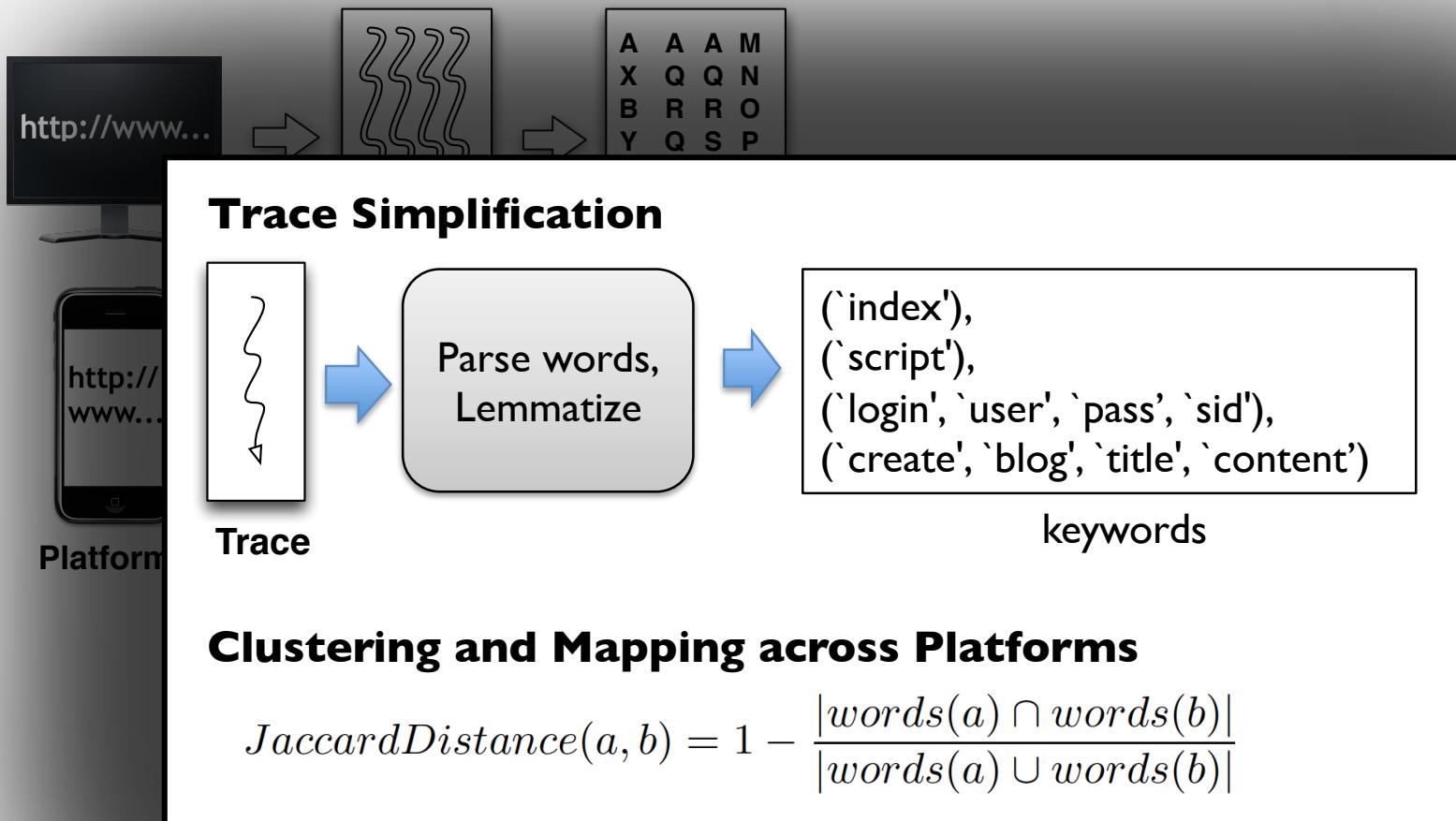
FMAP [ISSTA'14]

Approach Overview

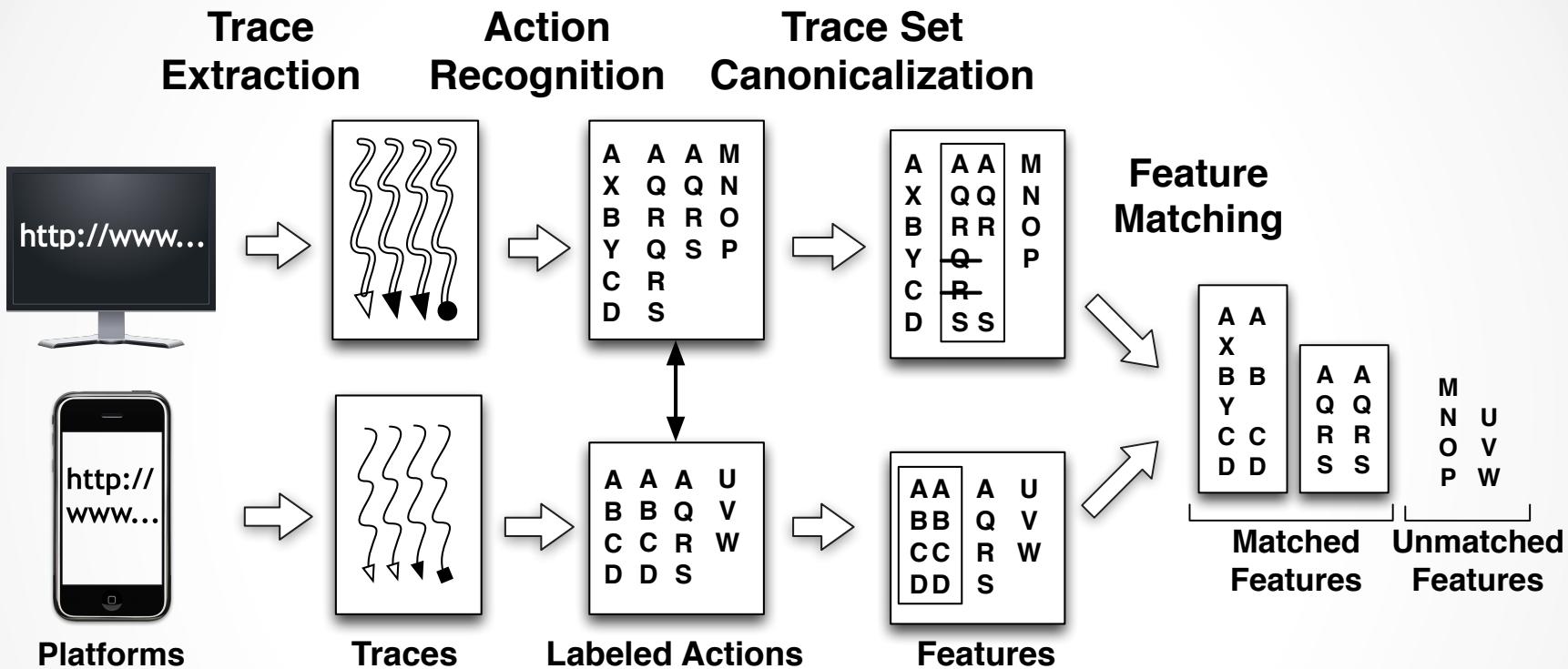


Approach Overview

Trace Extraction Action Recognition



Approach Overview



Action recognition F-Score:
97.8% (Desktop) vs 99.6% (Mobile)

Overall Effectiveness:
86.3% vs 51.5% (baseline)

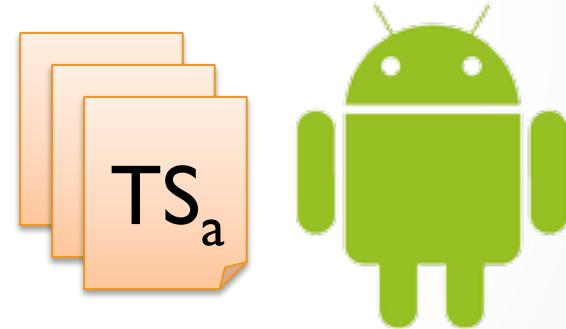
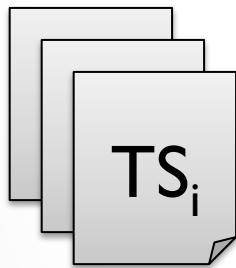


Cross-platform Test Migration (for mobile apps)

Remaining Work

Problem

- **Given:** Test Suite (TS_i) for App on Platform 1
- **Task:** Generate corresponding Test Suite, (TS_a) for the same App on Platform 2

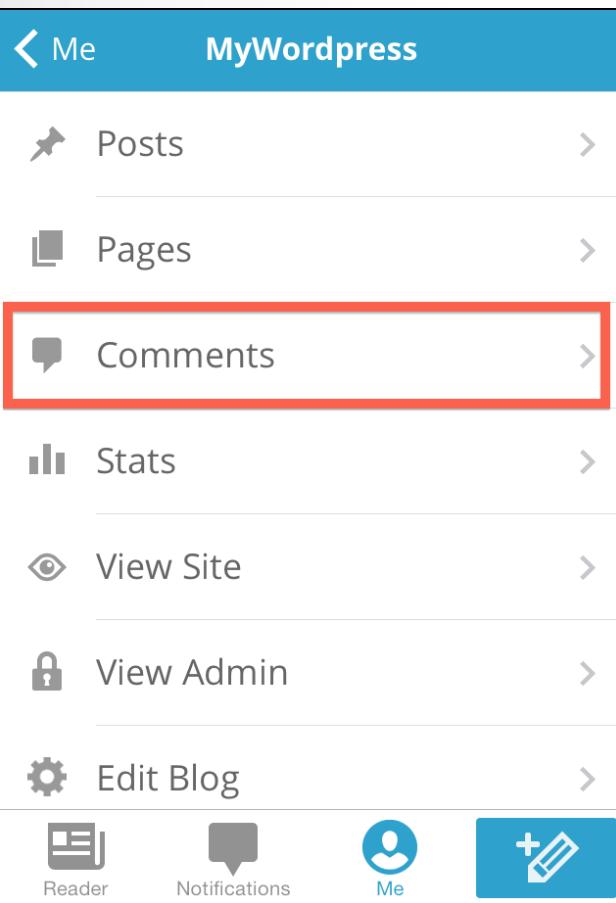


$TS = \text{Set of TC}$

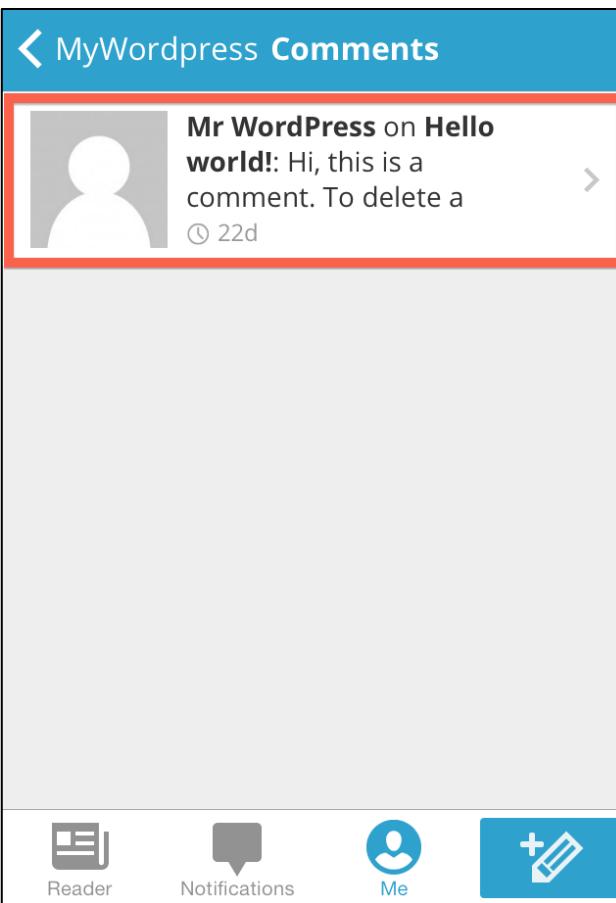
$TC = [a_1, a_2, \dots a_N, \text{Oracle.assert}()]$

Action is $[\text{ActionType}, \text{Selector}, \text{Data}]$

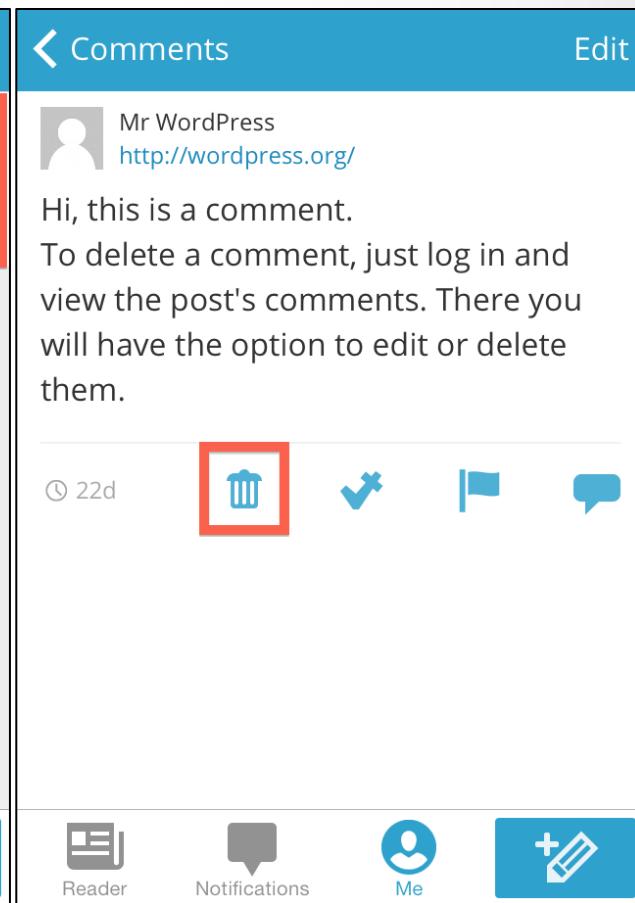
Example Test on iOS



tap “Comments”

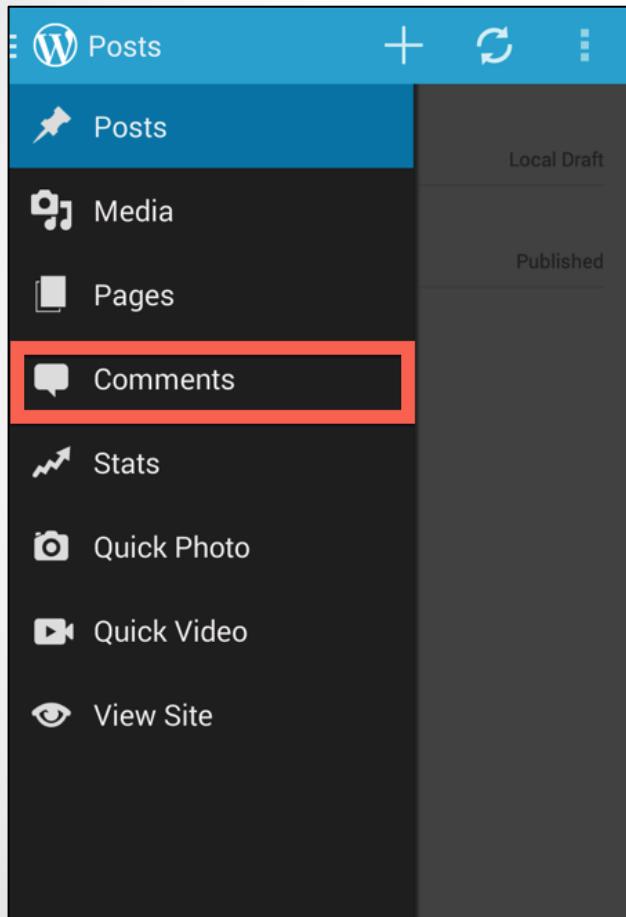


tap cell[0]

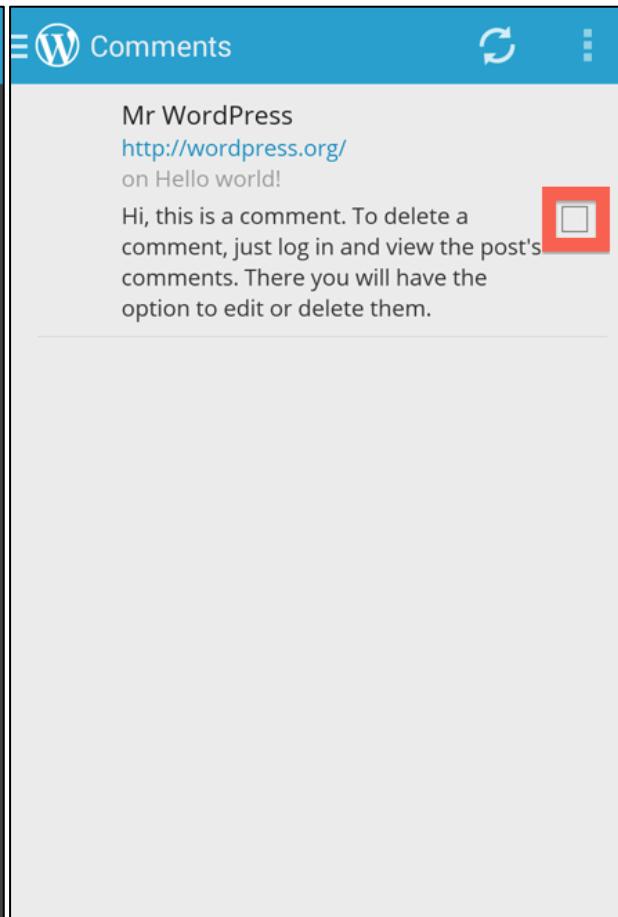


tap “icon delete”

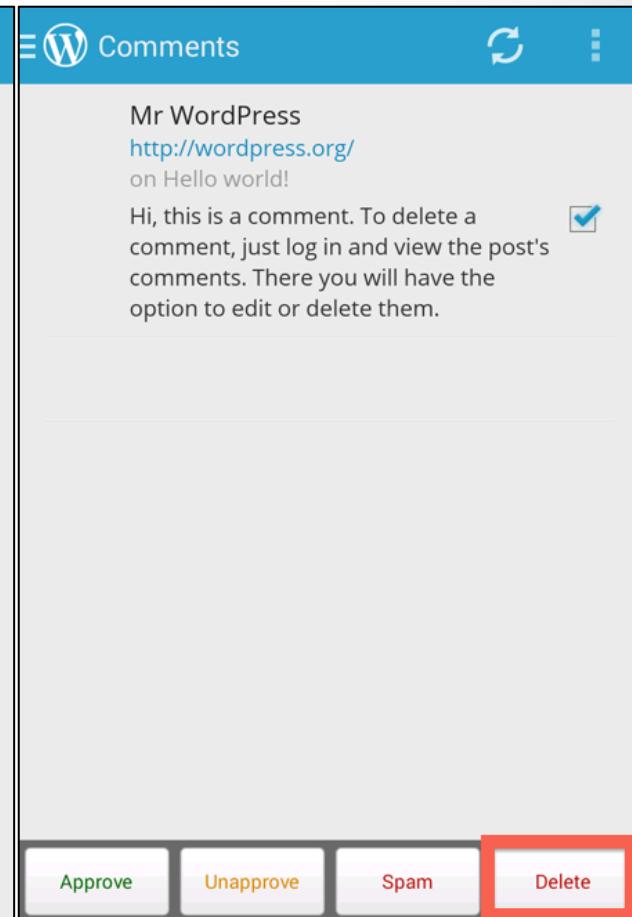
Example Test on Android



tap “Comments”

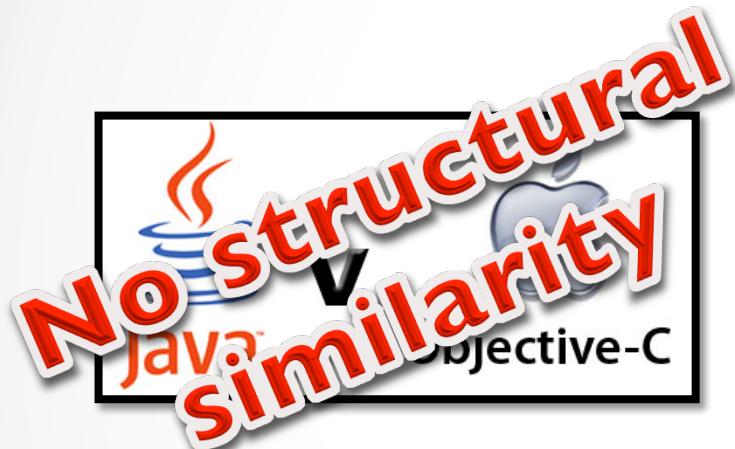


tap checkBox[0]

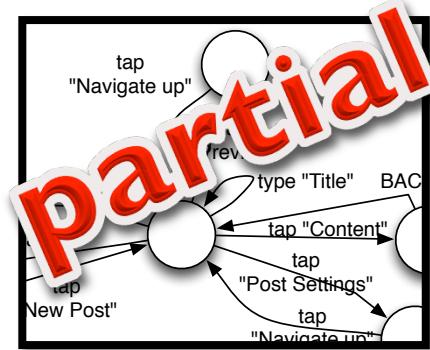


tap “Delete”

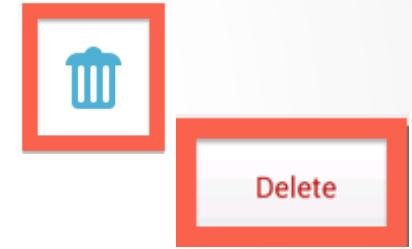
Challenges



Independently developed
(In different languages & frameworks)



Automated Behavior Exploration

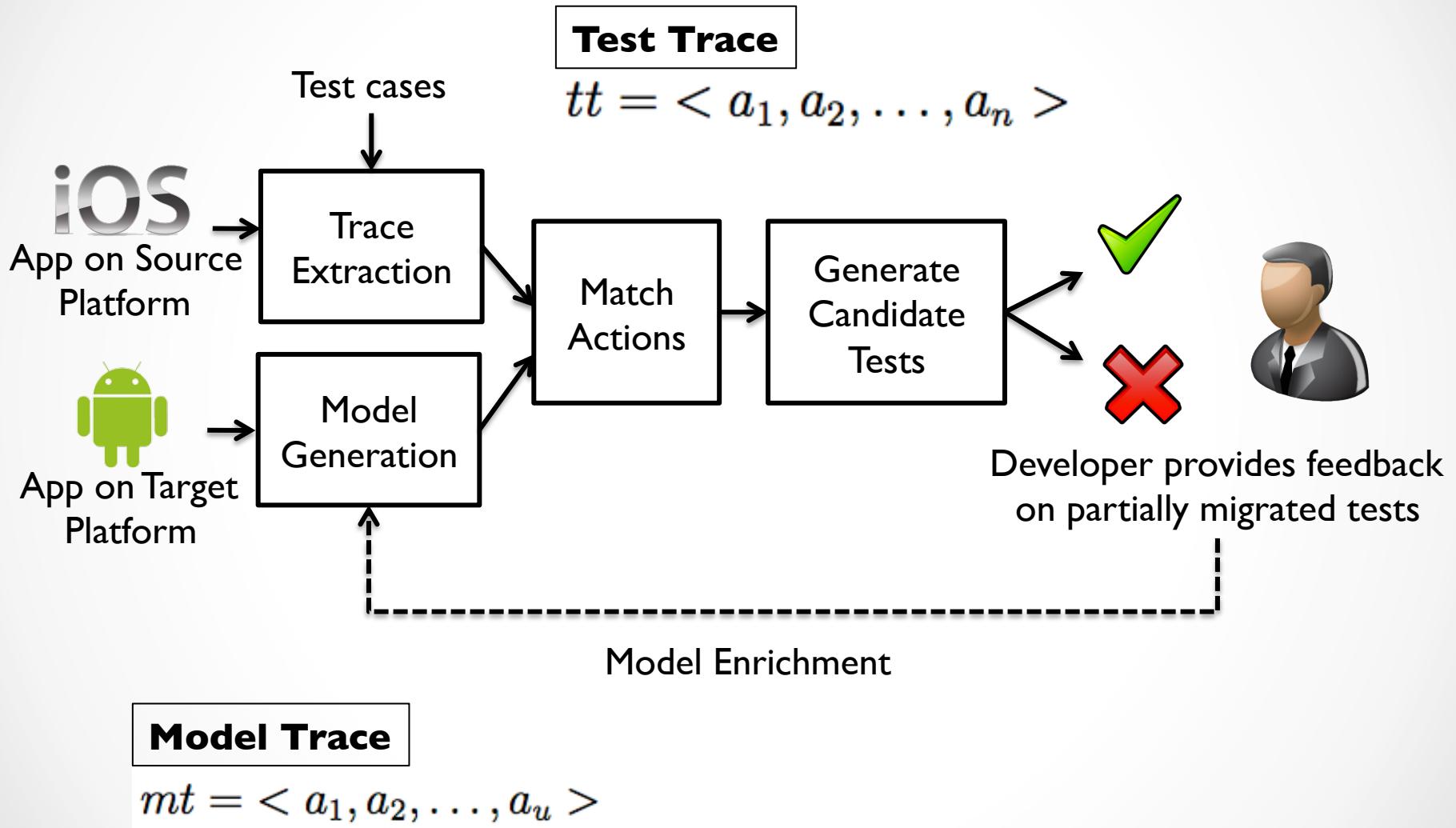


Same actions
Different Widgets

Assumptions

- **Action correspondence:** If actions are present across platforms, they have a 1-1 correspondence
- **Action ordering:** The matched actions appear in same order in matched use cases
- The test cases given to translate, have **implementations on both platforms**

High-level Overview



Action Matching as an Optimization Problem

- Given: Test traces for Platform 1 $tt = a_{1,1}, a_{1,2}, \dots, a_{1,m}$
Model for Platform 2 $mt = \langle a_1, a_2, \dots, a_u \rangle$

- Formulation:

$$\max \sum_{a_1 \in \Sigma tt_i} |Map(a_1)| \quad \text{Profit function}$$

Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{\varepsilon \cup \Sigma\} \quad a_1 \& a_2 \text{ from platforms } p_1 \& p_2$
- $|Map(a)| = 0 \text{ if } a \text{ is mapped to } \varepsilon \text{ and } 1 \text{ otherwise}$
- $(Map(a_{1,i}) = a_{2,x}) \wedge (Map(a_{1,j}) = a_{2,y}) \wedge (a_{1,i} < a_{1,j}) \wedge (a_{2,x} \neq \varepsilon) \wedge (a_{2,y} \neq \varepsilon)$
 $\implies (a_{2,x} < a_{2,y}) \wedge (\{\forall a_{2,z} \mid (a_{2,x} < a_{2,z} < a_{2,y})\} \wedge \{\exists a_{1,k} \mid (Map(a_{1,k}) = a_{2,z})\}) \rightarrow (a_{1,i} < a_{1,k} < a_{1,j})$

Action Matching as an Optimization Problem

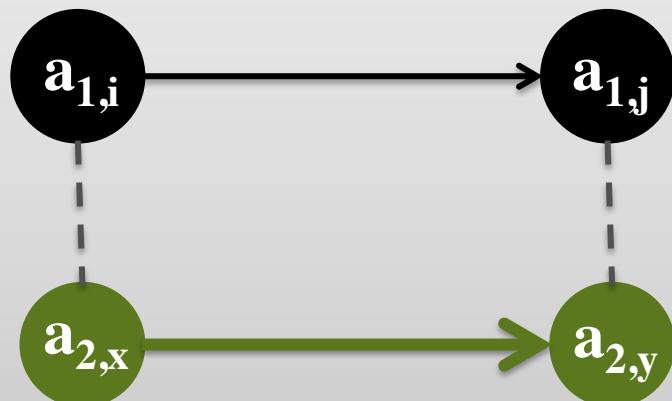
- Given: Test traces for Platform 1
Model for Platform 2
- Formulation:

Ordering Constraint
On matched actions

$$\max \sum_{a_1 \in \Sigma}$$

Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{\varepsilon \cup \text{Actions}\}$
- $|Map(a)| = 0$ if a is mapped to ε



- $(Map(a_{1,i}) = a_{2,x}) \wedge (Map(a_{1,j}) = a_{2,y}) \wedge (a_{1,i} < a_{1,j}) \wedge (a_{2,x} \neq \varepsilon) \wedge (a_{2,y} \neq \varepsilon)$

$$\Rightarrow (a_{2,x} < a_{2,y}) \wedge (\{\forall a_{2,z} \mid (a_{2,x} < a_{2,z} < a_{2,y})\} \wedge \{\exists a_{1,k} \mid (Map(a_{1,k}) = a_{2,z})\}) \rightarrow (a_{1,i} < a_{1,k} < a_{1,j})$$

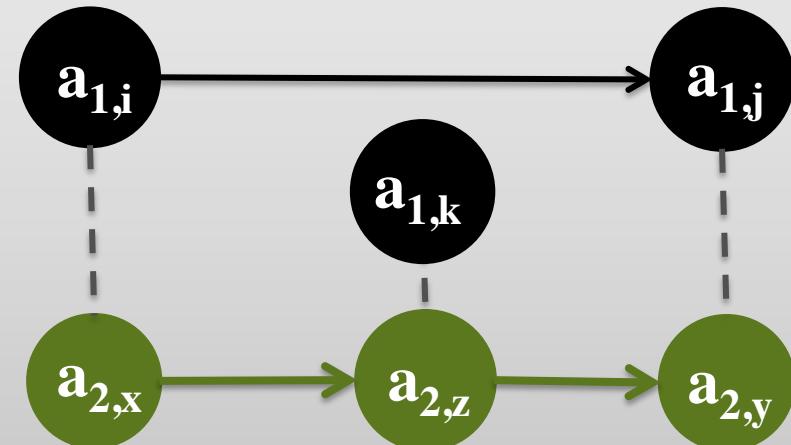
Action Matching as an Optimization Problem

- Given: Test traces for iOS
Model for Android
- Formulation:

Such that

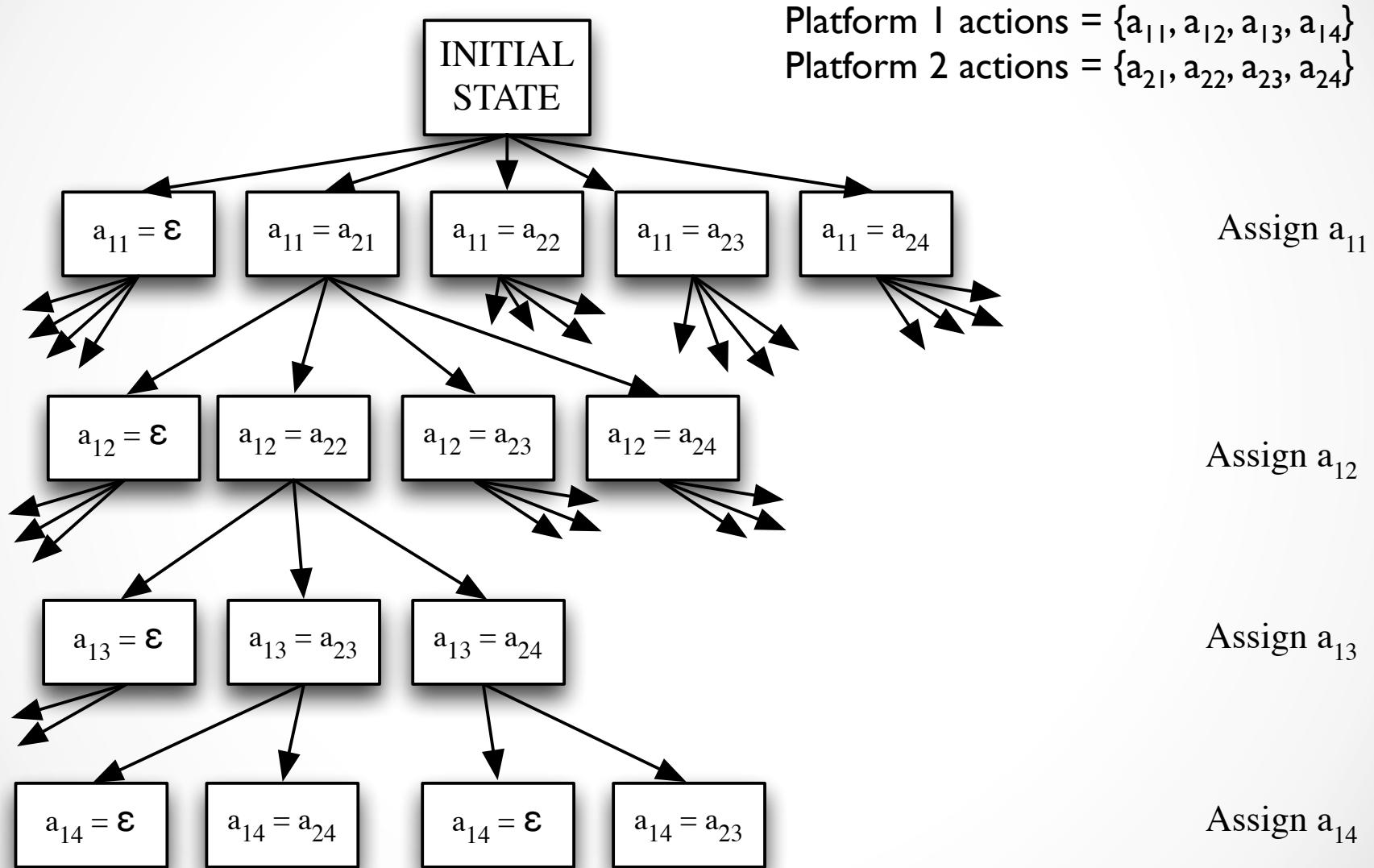
- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{a_{2,x}, a_{2,y}, a_{2,z}\}$
- $|Map(a)| = 0$ if a is mapped

No Invalid Ordering
b/w matched actions



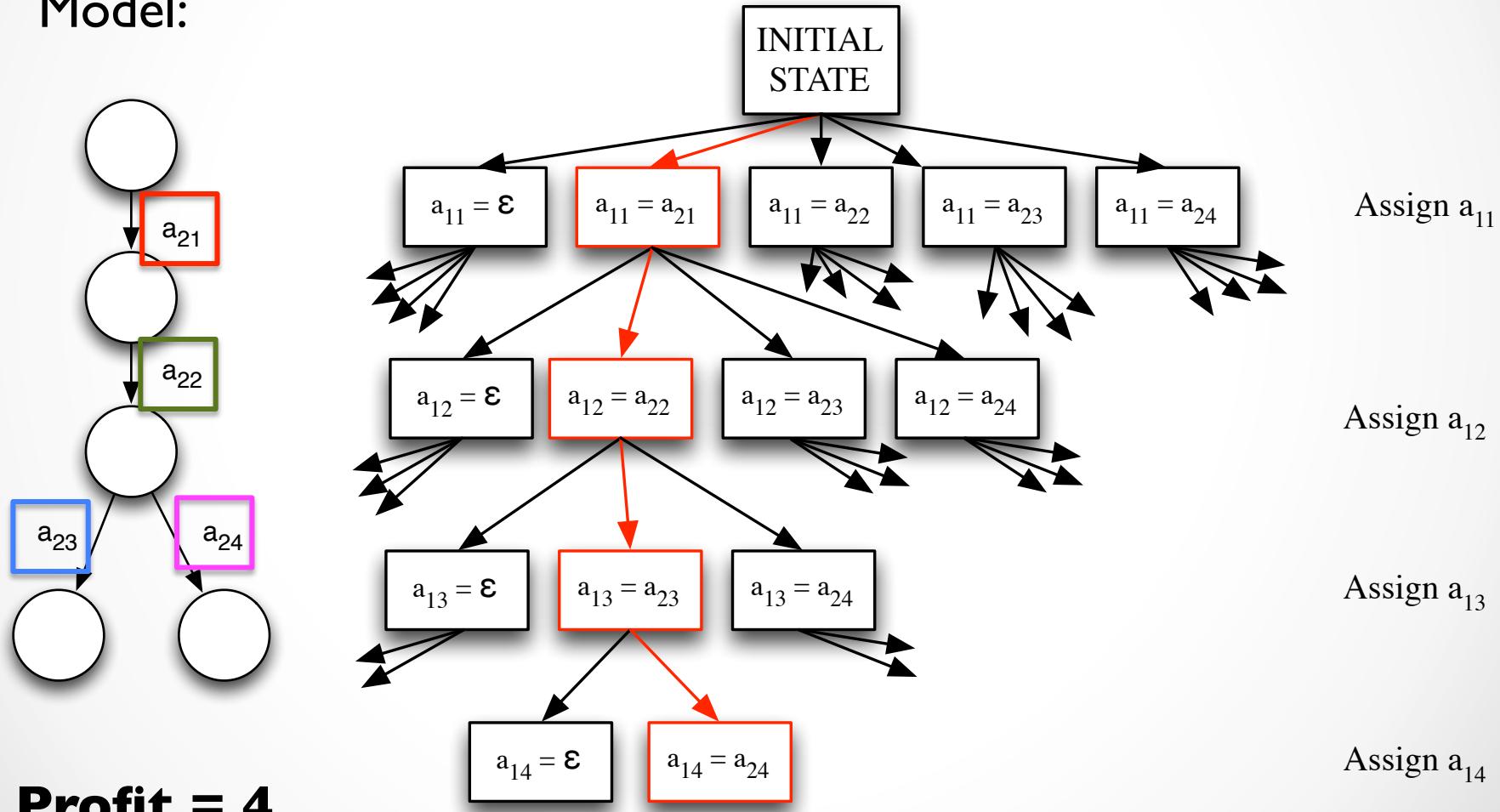
- $(Map(a_{1,i}) = a_{2,x}) \wedge (Map(a_{1,j}) = a_{2,y}) \wedge (a_{1,i} < a_{1,j}) \wedge (a_{2,x} \neq \varepsilon) \wedge (a_{2,y} \neq \varepsilon)$
- $$\Rightarrow (a_{2,x} < a_{2,y}) \wedge (\{\forall a_{2,z} \mid (a_{2,x} < a_{2,z} < a_{2,y})\} \wedge \{\exists a_{1,k} \mid (Map(a_{1,k}) = a_{2,z})\}) \rightarrow$$
- $(a_{1,i} < a_{1,k} < a_{1,j})$

Branch & Bound Strategy



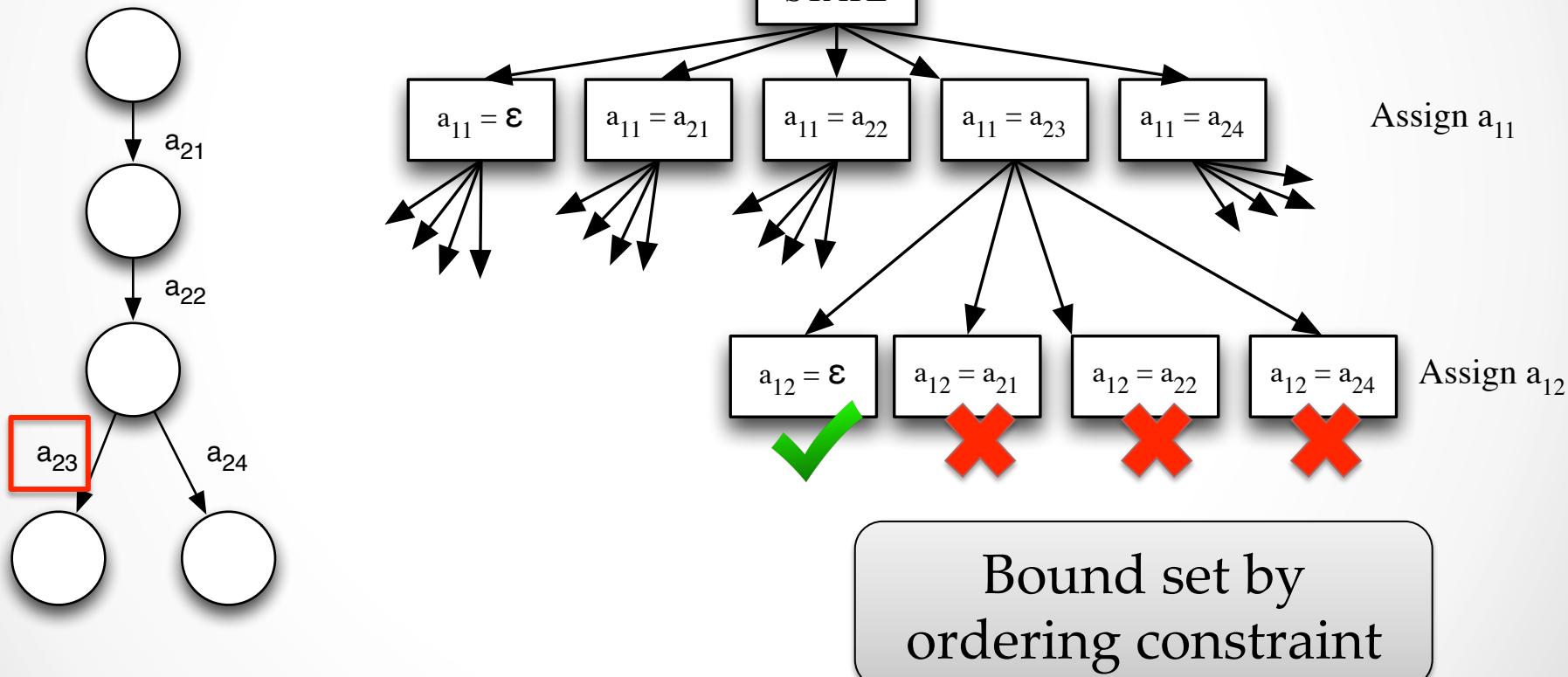
Branch & Bound Strategy

- Test traces: $\langle a_{11}, a_{12}, a_{13} \rangle$ $\langle a_{11}, a_{12}, a_{14} \rangle$
- Model:



Branch & Bound Strategy

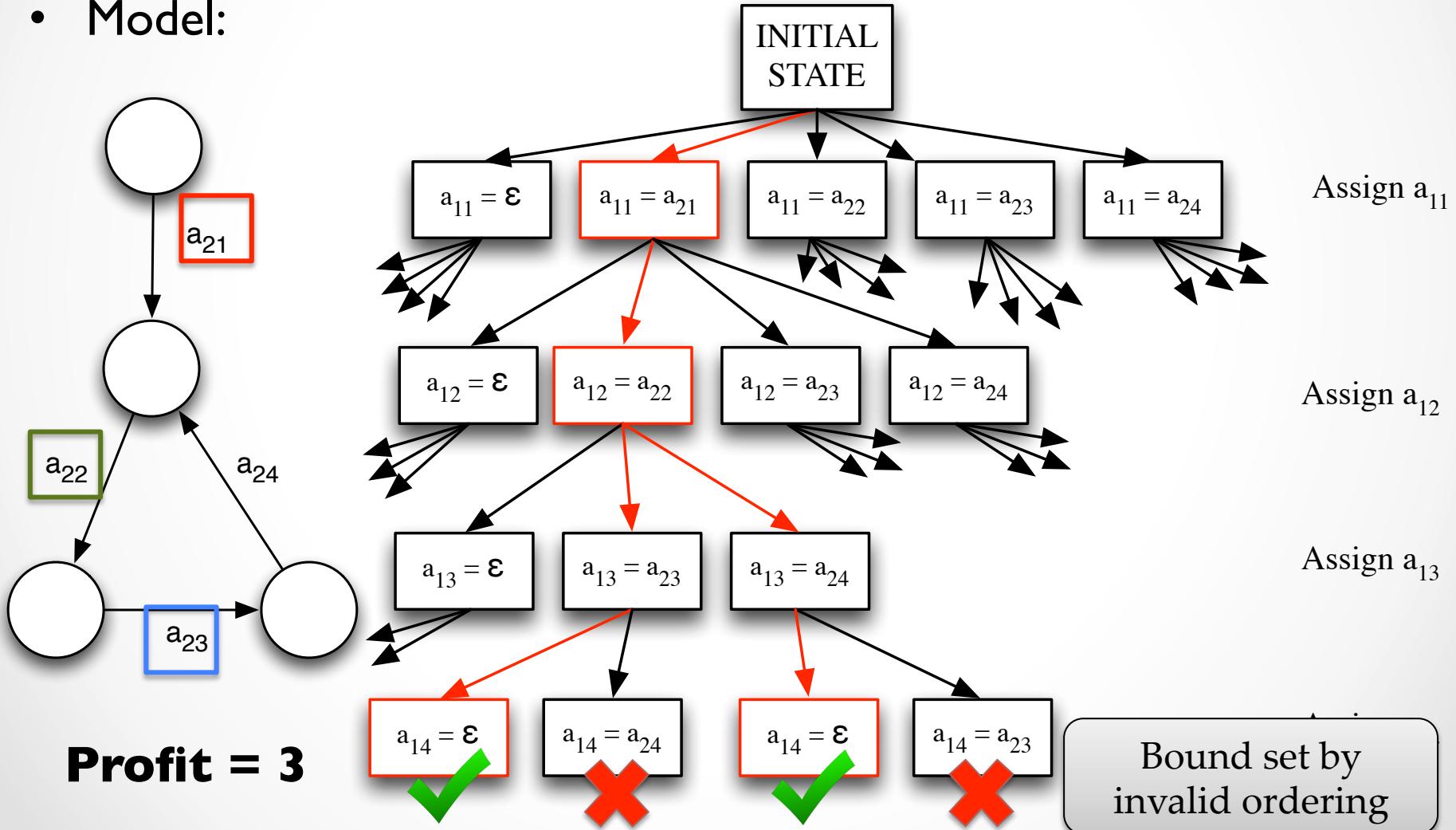
- Test traces: $\langle a_{11}, a_{12}, a_{13} \rangle$ $\langle a_{11}, a_{12}, a_{14} \rangle$
- Model:



Profit = 1

Branch & Bound Strategy

- Test traces: $\langle a_{11}, a_{12}, a_{13} \rangle$ $\langle a_{11}, a_{12}, a_{14} \rangle$
- Model:



Evaluation (TBD)

Tool: MigraTest - Implementation of the technique

Subjects: Apps with iOS and Android versions

Source Test-suite: Recruit humans to develop tests

Research Questions:

RQ1 (Effectiveness) : Can MigraTest effectively migrate test cases from one platform to another ?

RQ2 (Quality) : Do migrated tests hide or reveal any issues in the app on the target platform ?

Plan

Semester	Tasks
Summer 2014	Attend ICSE 2014 Doctoral Symposium
	Conduct Evaluation for <i>Test Migration</i>
Fall 2014	Submit <i>Test Migration</i> to top conferences
	Write the dissertation
Spring 2015	Graduate

Summary

Web & Mobile Applications



Problem Space



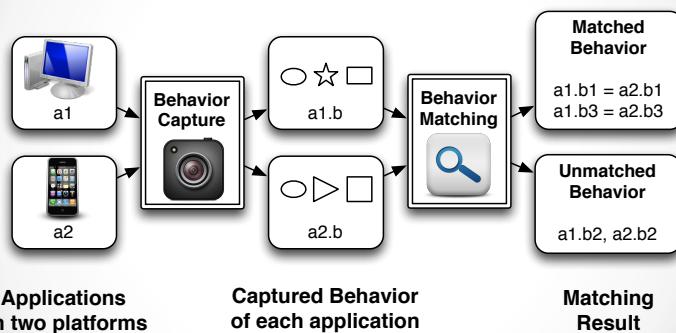
Feature Mapping



Test-suite Migration



Overall Approach



Progress

- Cross Browser Testing**
 - **Published:** WebDiff [ICSM'10], CrossCheck [ICST'12], X-PERT [ICSE'13]
 - **Accepted:** X-PERT Tool paper [ISSTA'14]
- Feature Mapping**
 - **Accepted:** FMAP [ISSTA'14]
- Test Migration**
 - **In Progress:** Problem formulation, Evaluation