

Cross-Platform Testing and Maintenance of Web and Mobile Applications

ICSE 2014 Doctoral Symposium

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Web & Mobile Applications



Web

MobileWeb

Mobile

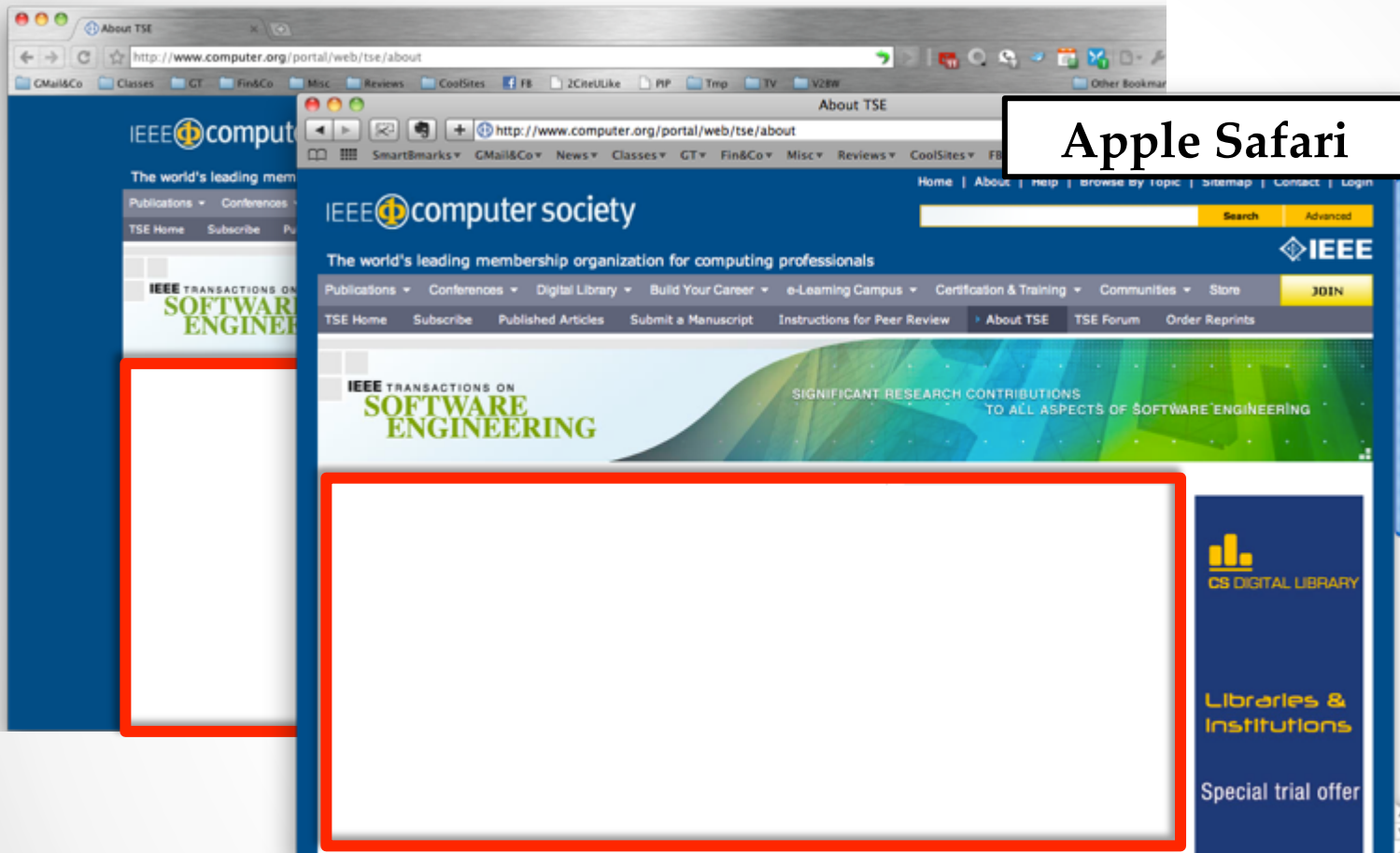


Testing & Maintenance Issues for Multi-platform Applications

I. Inconsistencies



I. Inconsistencies



I. Inconsistencies

The image displays a screenshot of the IEEE Computer Society website, illustrating inconsistencies between different browser views. The main browser window (Mozilla Firefox) shows the 'About TSE' page, which includes the IEEE logo, navigation links, and a search bar. The page content is divided into sections: 'Scope of TSE', 'Contact Information', and 'Editorial Board'. The 'Scope of TSE' section describes the journal's focus on software engineering research. The 'Contact Information' section lists the Editor-in-Chief, Bashar Nuseibeh, and the TSE Publication Coordinator, IEEE Computer Society. The 'Editorial Board' section lists the Editor-in-Chief, Bashar Nuseibeh, and Associate Editors, including Antonia Bertolino, Marsha Chechik, Jane Cleland-Huang, Elisabetta Di Nitto, and Phyllis Frankl. A red box highlights the 'About TSE' page, and a yellow box highlights the 'Contact Information' section. The text 'Mozilla Firefox' is overlaid on the right side of the browser window. The text 'CS DIGITAL LIBRARY' and 'Libraries & Institutions' are visible in the bottom right corner. The text 'Special trial offer' and 'Learn More' are also visible in the bottom right corner.

Mozilla Firefox

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SIGNIFICANT RESEARCH CONTRIBUTIONS TO ALL ASPECTS OF SOFTWARE ENGINEERING

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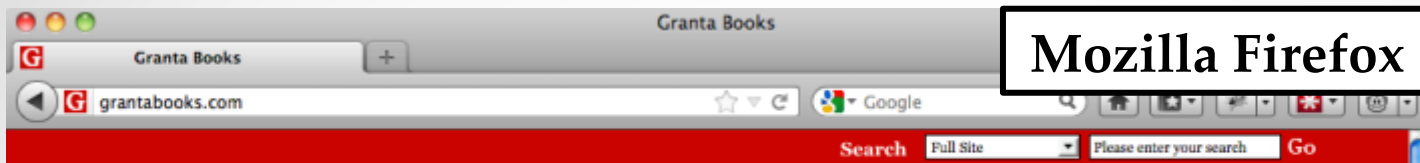
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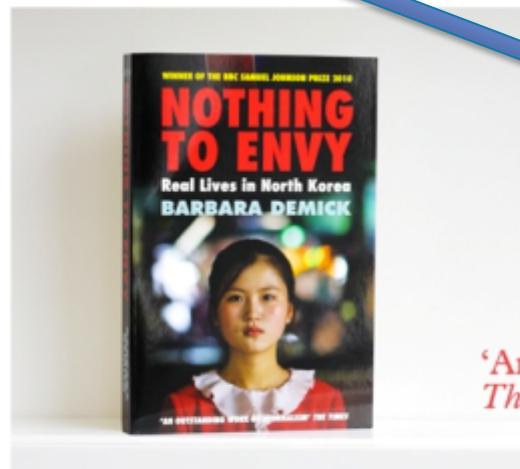
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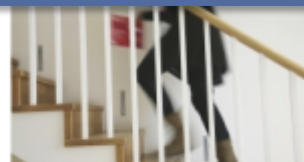
Internet Explorer



'An
The

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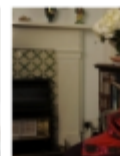
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Don't miss the Athill discussion 'Instead of a Friend, on Ration Hour'.

II. Missing Features

The screenshot shows the WordPress 'Edit Post' interface. The top navigation bar includes the WordPress logo, 'MyWordPress', a refresh icon, '6' comments, '0' likes, '+ New', and 'View Post'. The user 'Howdy, admin' is logged in. The left sidebar contains the 'Dashboard' and 'Posts' sections. The 'Posts' section is active, showing 'All Posts', 'Add New', 'Categories', and 'Tags'. The main content area is titled 'Edit Post' and shows the post title 'Hello world!'. Below the title is the 'Permalink' field with the URL 'http://apps.shauvik.com/wp/?p=1' and buttons for 'Change Permalinks' and 'View Post'. There is an 'Add Media' button and tabs for 'Visual' and 'Text' editing. A modal preview window is overlaid on the main content, showing a mobile view of a blog post titled 'Tripleodeon' with the subtitle 'Just another WordPress weblog'. The preview includes a 'Welcome' message, a 'Simple 'on-server' mobile AJAX' title, a 'Published' status, and a content area with a placeholder image and text. The preview also shows a 'Move to Trash' button and an 'Update' button. The right sidebar contains the 'Publish' section with 'Status: Published', 'Visibility: Public', and 'Published on: Feb 14, 2014 @ 14:09'. Below this is the 'Format' section, followed by 'Categories' (with 'Uncategorized' selected) and 'Tags'.

MyWordPress 6 0 + New View Post Howdy, admin

Dashboard Posts

All Posts Add New Categories Tags

Media Pages Comments Appearance Plugins 1 Users Tools Settings Collapse menu

Edit Post Add New

Hello world!

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

Add Media Visual Text

B I A

Welcome start blog

it, then

Tripleodeon Just another WordPress weblog

Overview New post Edit post Comments Switcher Settings Log out

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

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

at 2:09 pm

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

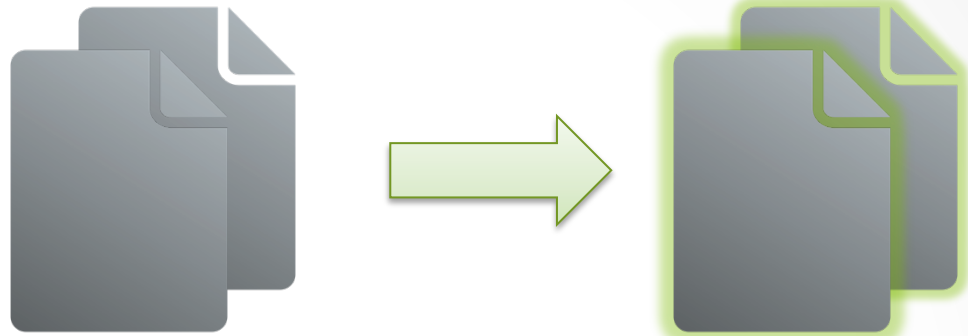
☒ Uncategorized

+ Add New Category

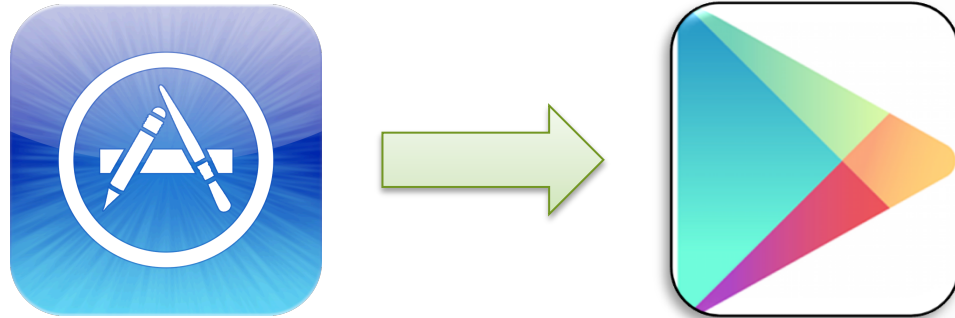
Tags

III. Costly Test Migration

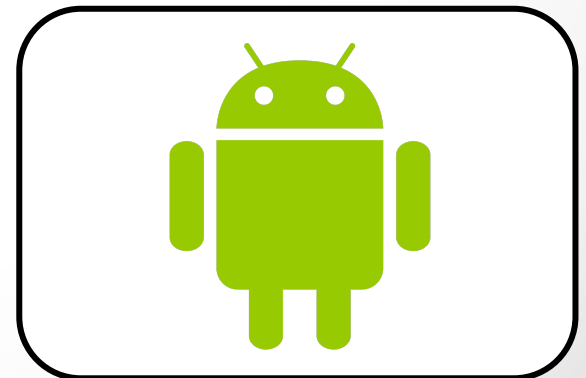
Test Suite



Mobile
App



Platform



How can we address
these problems?

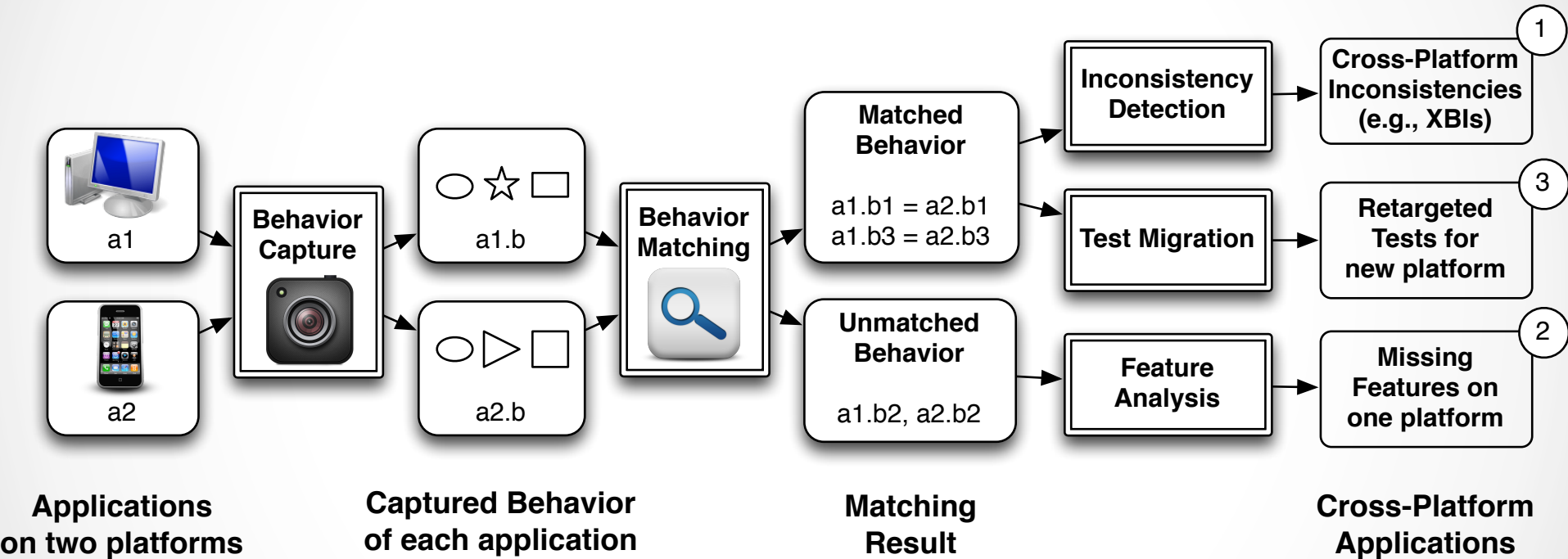
Proposed Thesis

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

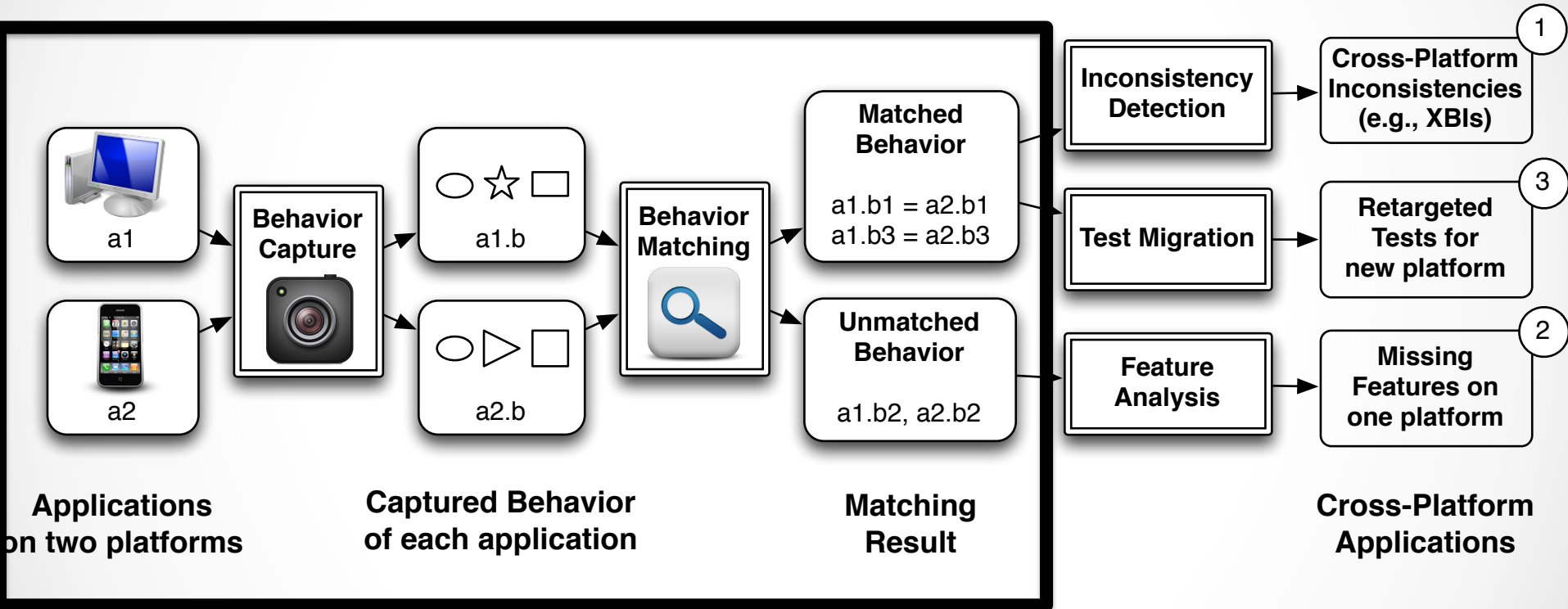
Challenge: **Significant difference** in cross-platform behavior. Match behavior despite legitimate differences.

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

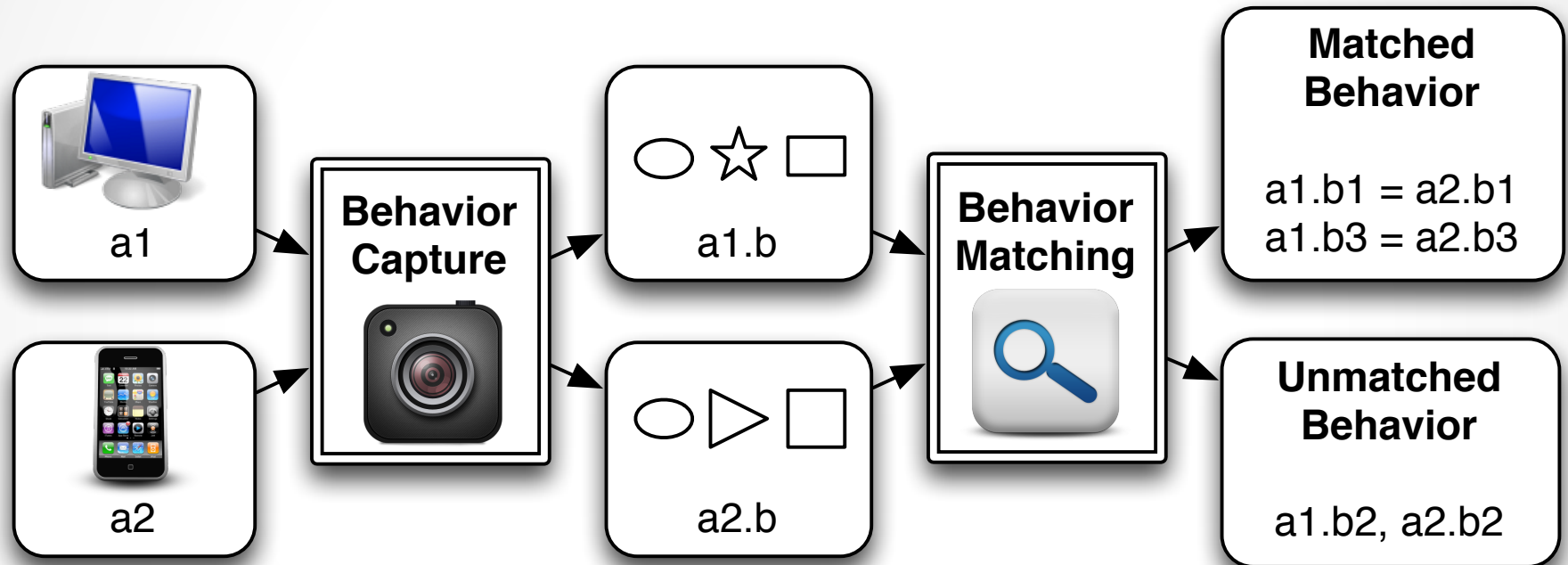
Overall Approach



Overall Approach



Overall Approach

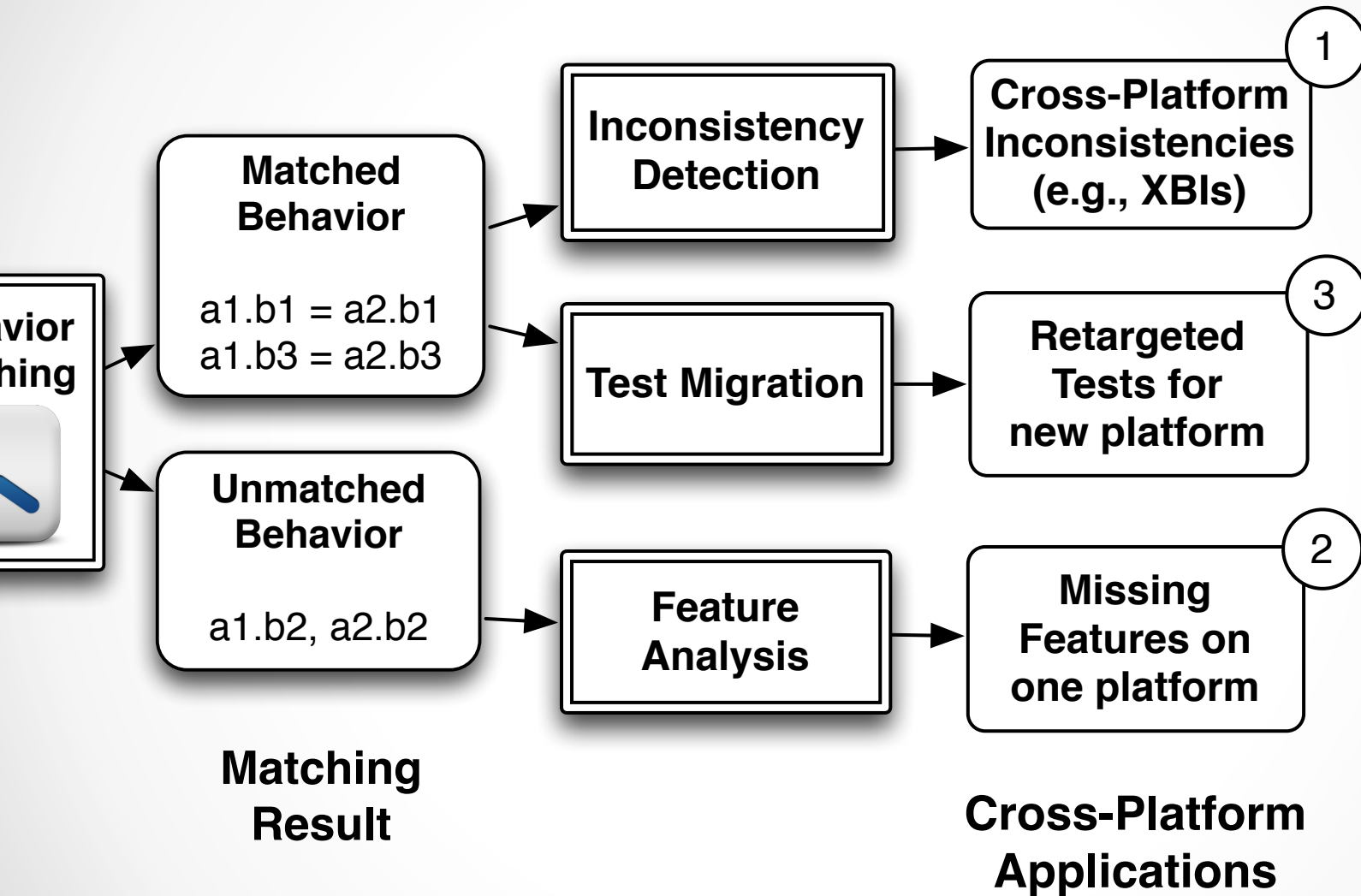


**Applications
on two platforms**

**Captured Behavior
of each application**

**Matching
Result**

Overall Approach

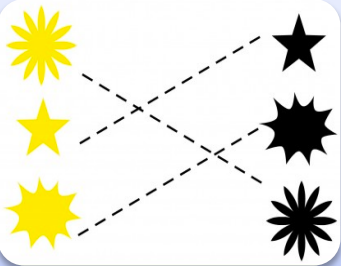


Research Outline



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

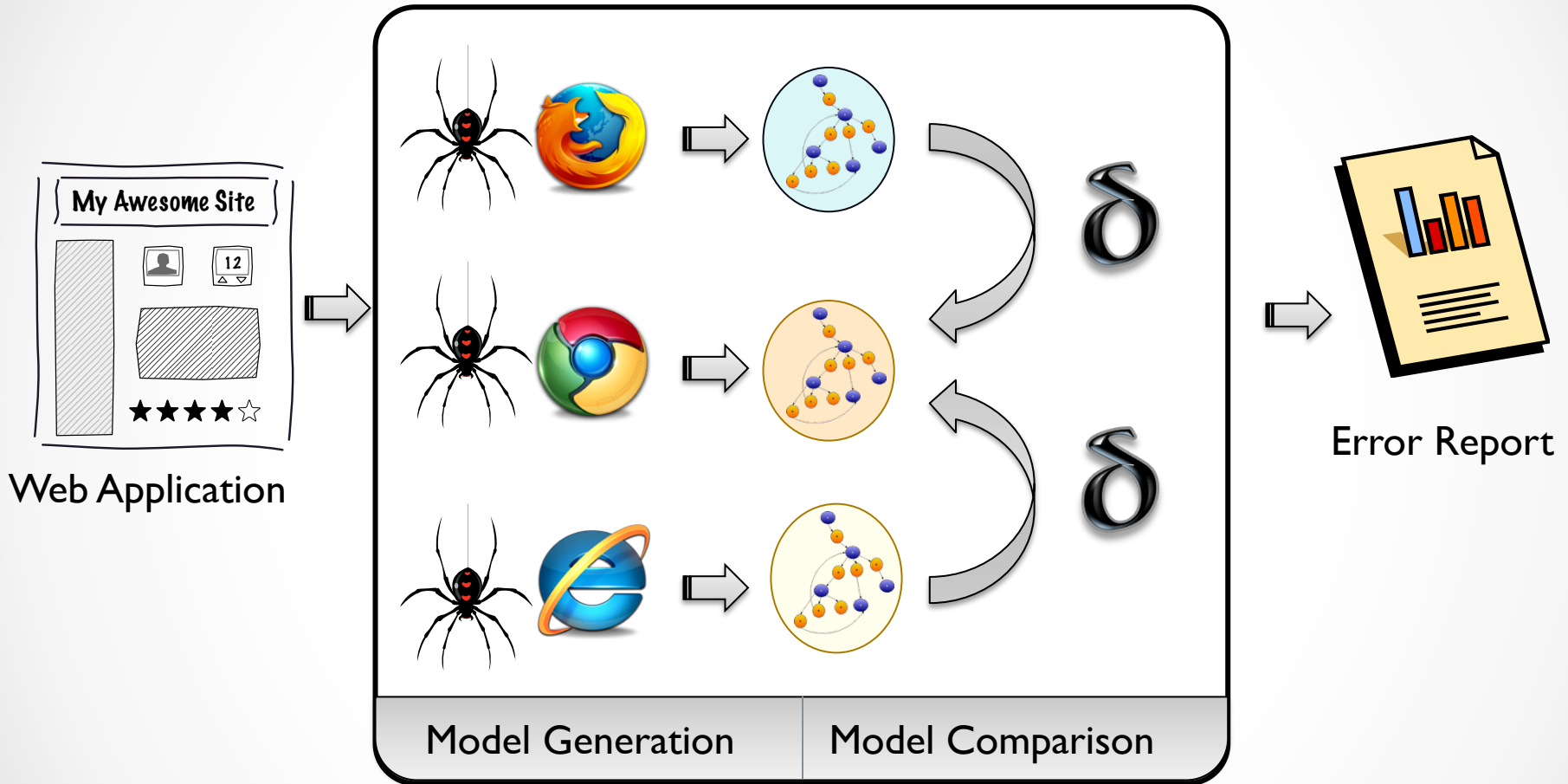


Cross-Browser Incompatibility Detection (for web applications)

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



Approach Overview

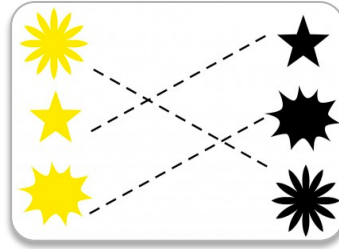


Effectiveness

77% Precision and **95%** Recall

Improvement over state-of-art

45%↑ Precision & **14%↑** Recall

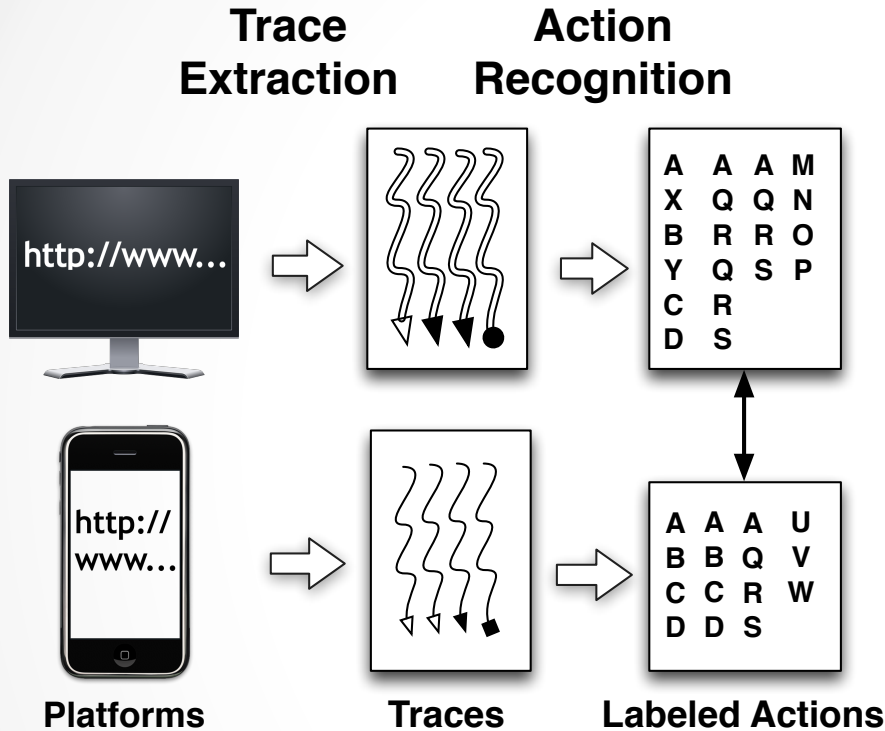


Feature Mapping Across Platforms

(for desktop & mobile web apps)

FMAP [ISSTA'14]

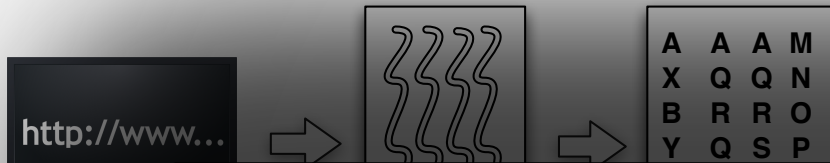
Approach Overview



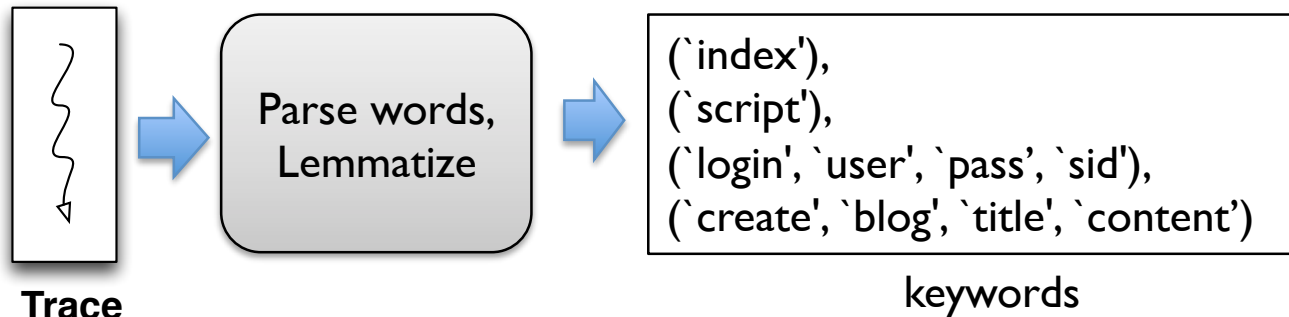
Approach Overview

Trace
Extraction

Action
Recognition



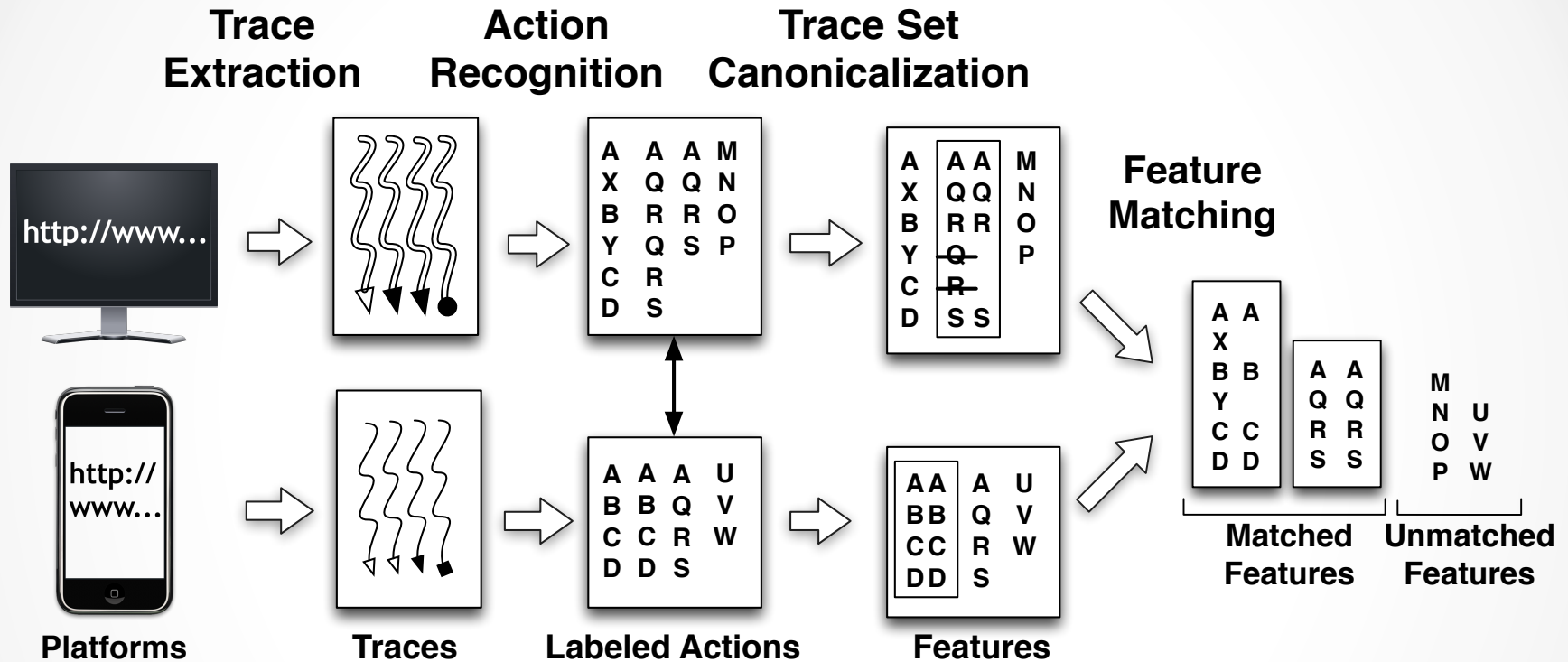
Trace Simplification



Clustering and Mapping across Platforms

$$JaccardDistance(a, b) = 1 - \frac{|words(a) \cap words(b)|}{|words(a) \cup words(b)|}$$

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

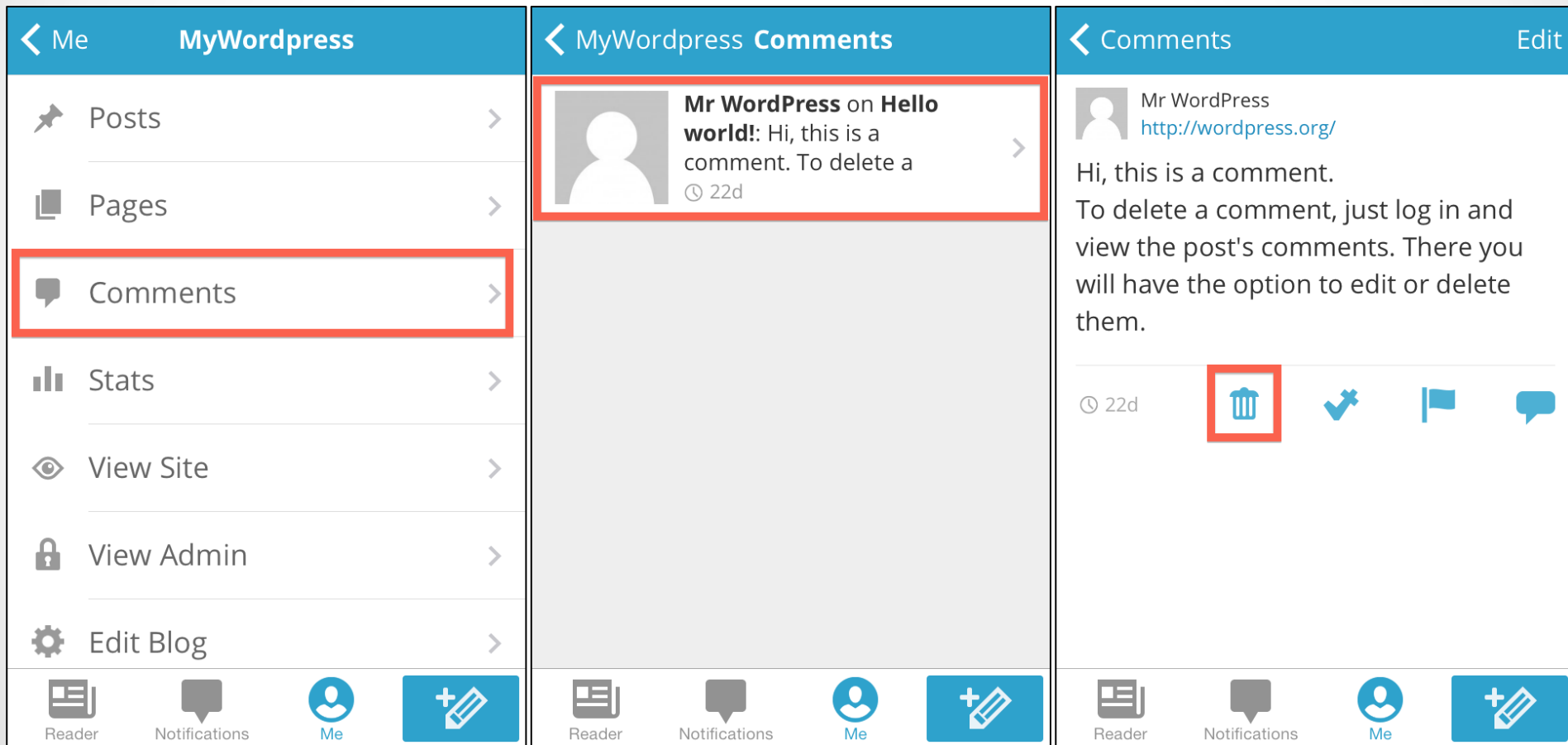


TS = Set of TC

TC = [a_1 , a_2 , ... a_N , Oracle.assert()]

Action is [ActionType, Selector, Data]

Example Test on iOS

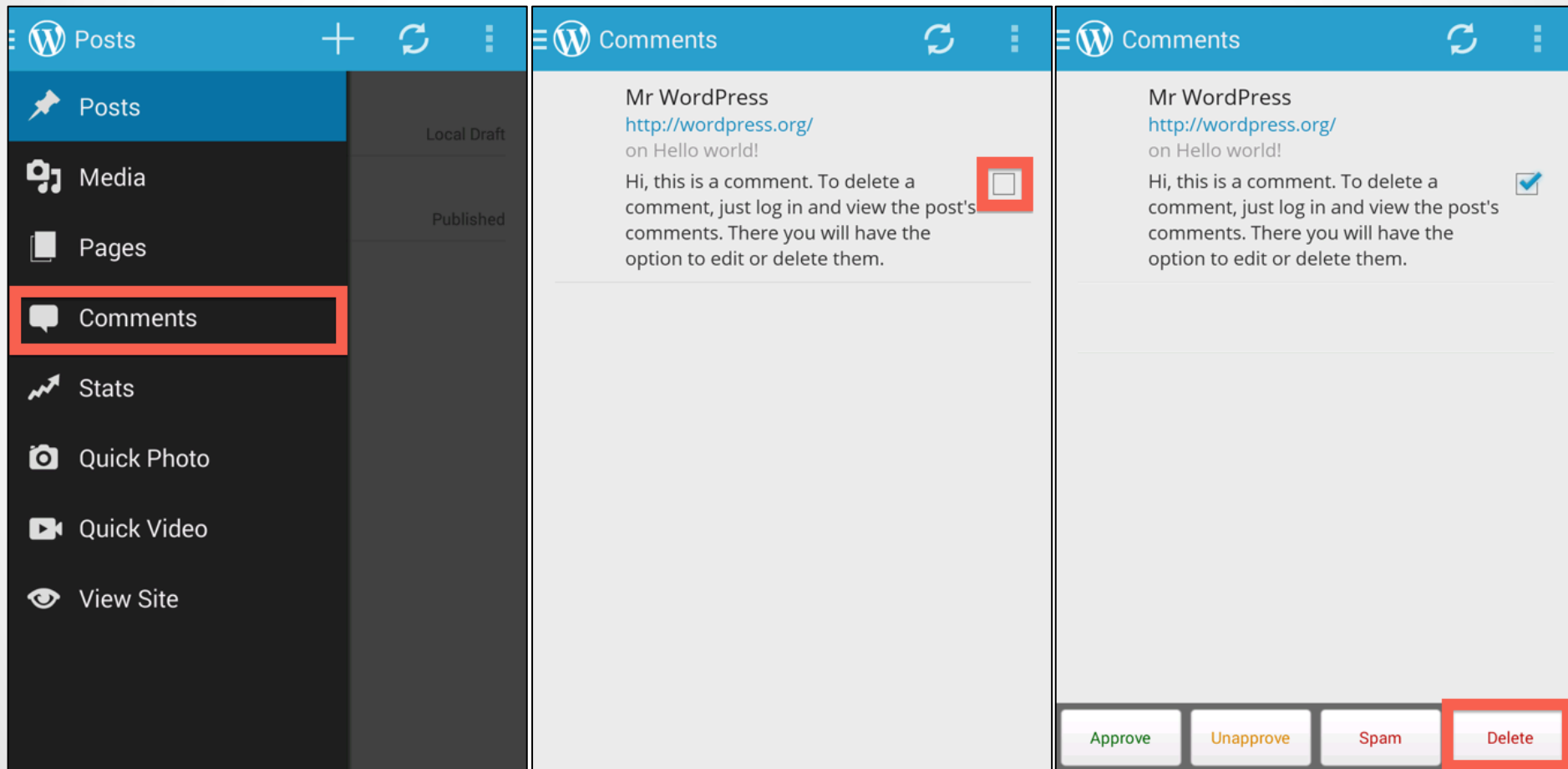


tap “Comments”

tap cell[0]

tap “icon delete”

Example Test on Android



tap “Comments”

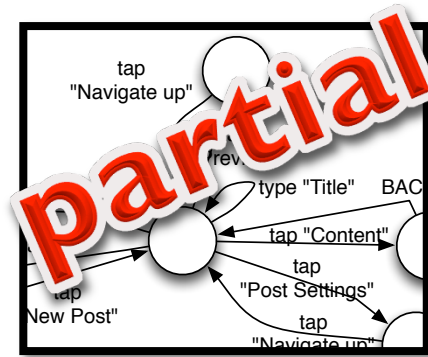
tap checkBox[0]

tap “Delete”

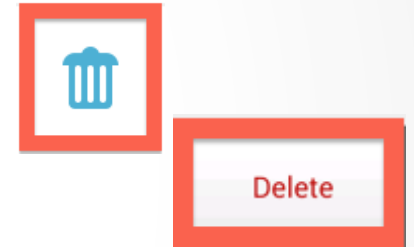
Challenges



**Independently
developed**
(In different languages
& frameworks)



**Automated
Behavior
Exploration**

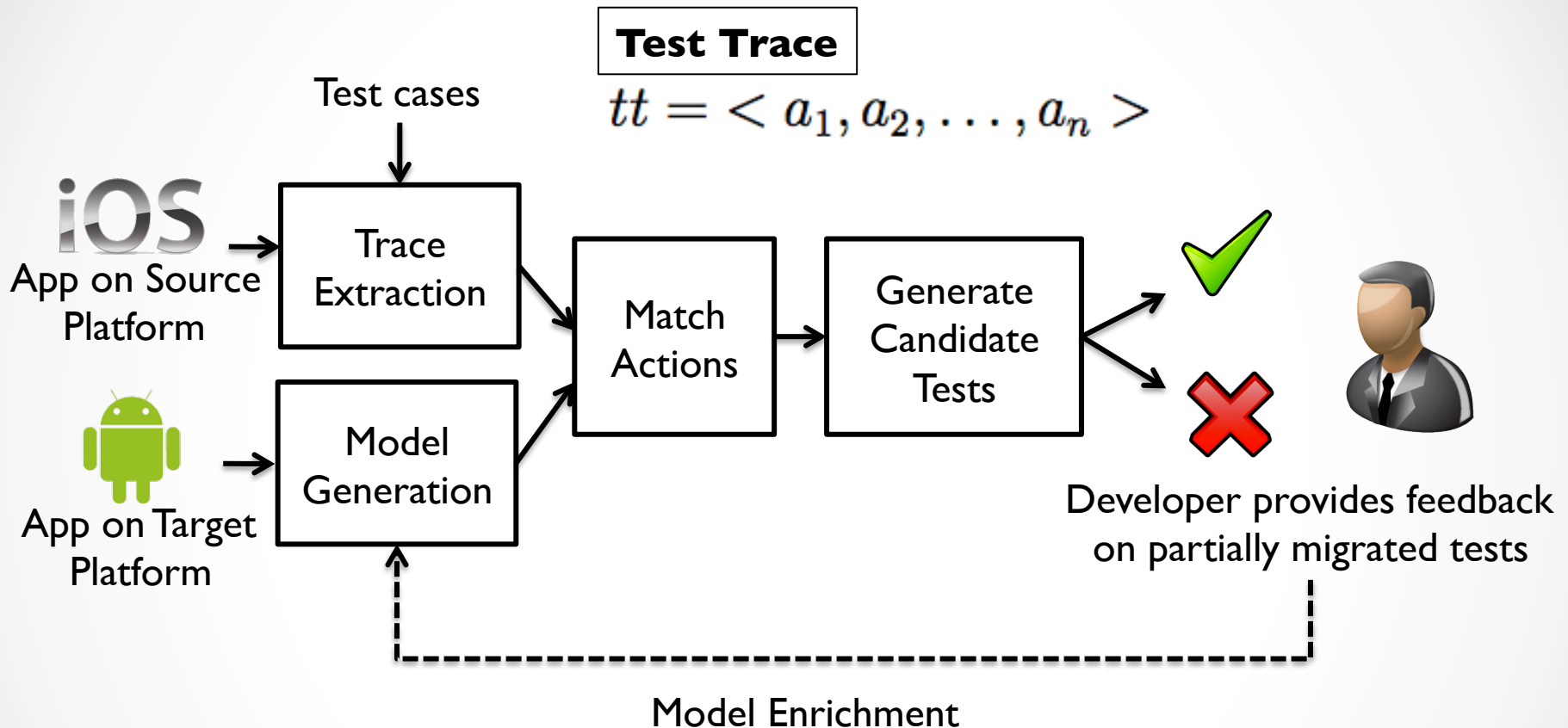


Same actions
Different Widgets

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



Model Trace

$$mt = \langle a_1, a_2, \dots, a_u \rangle$$

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:

$$\max \sum_{a_1 \in \Sigma tt_i} |Map(a_1)|$$

**Profit
function**

Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{\varepsilon \cup \Sigma\} \quad a_1 \text{ \& \& } a_2 \text{ from platforms } p_1 \text{ \& } p_2$
- $|Map(a)| = 0$ if a is mapped to ε and 1 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

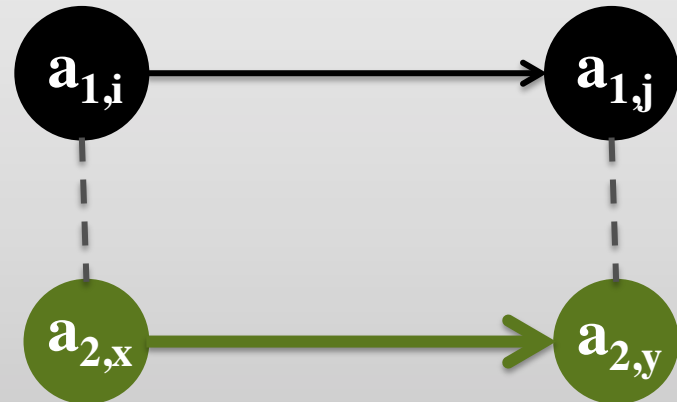
- Given: Test traces for Platform 1
Model for Platform 2
- Formulation:

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

Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{\varepsilon \cup \dots\}$
- $|Map(a)| = 0$ if a is mapped to ε
- $(Map(a_{1,i}) = a_{2,x}) \wedge (Map(a_{1,j}) = a_{2,y}) \wedge (a_{1,i} < a_{1,j}) \wedge (a_{2,x} \neq \varepsilon) \wedge (a_{2,y} \neq \varepsilon)$
 $\implies (a_{2,x} < a_{2,y}) \wedge (\{\forall a_{2,z} \mid (a_{2,x} < a_{2,z} < a_{2,y})\} \wedge \{\exists a_{1,k} \mid (Map(a_{1,k}) = a_{2,z})\}) \rightarrow$
 $(a_{1,i} < a_{1,k} < a_{1,j})$

Ordering Constraint
On matched actions



Action Matching as an Optimization Problem

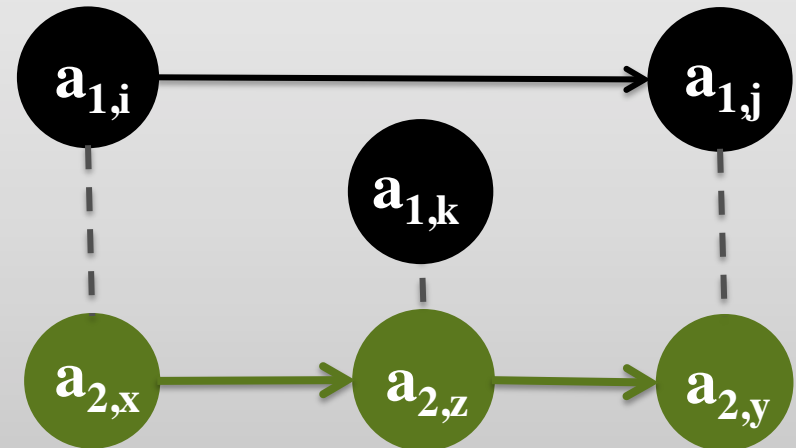
- Given: Test traces for iO
- Model for Android
- Formulation:

$$\max_{a_1, a_2} \text{score}(a_1, a_2)$$

Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{ \dots \}$
- $|Map(a)| = 0$ if a is mapped

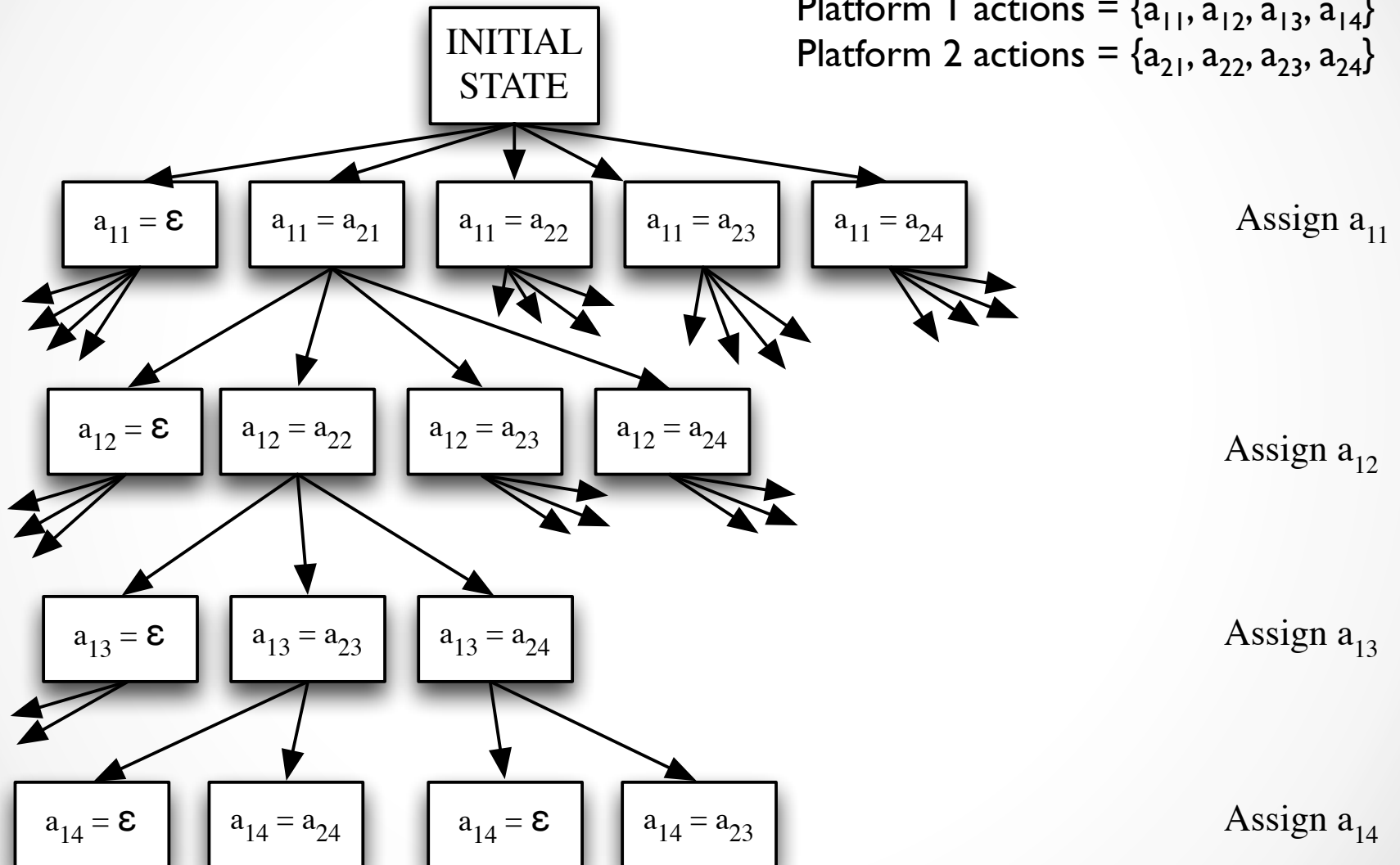
**No Invalid Ordering
b/w matched actions**



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

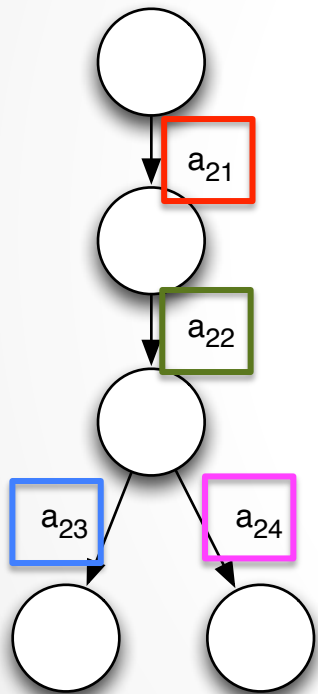
Branch & Bound Strategy

Platform 1 actions = $\{a_{11}, a_{12}, a_{13}, a_{14}\}$
Platform 2 actions = $\{a_{21}, a_{22}, a_{23}, a_{24}\}$

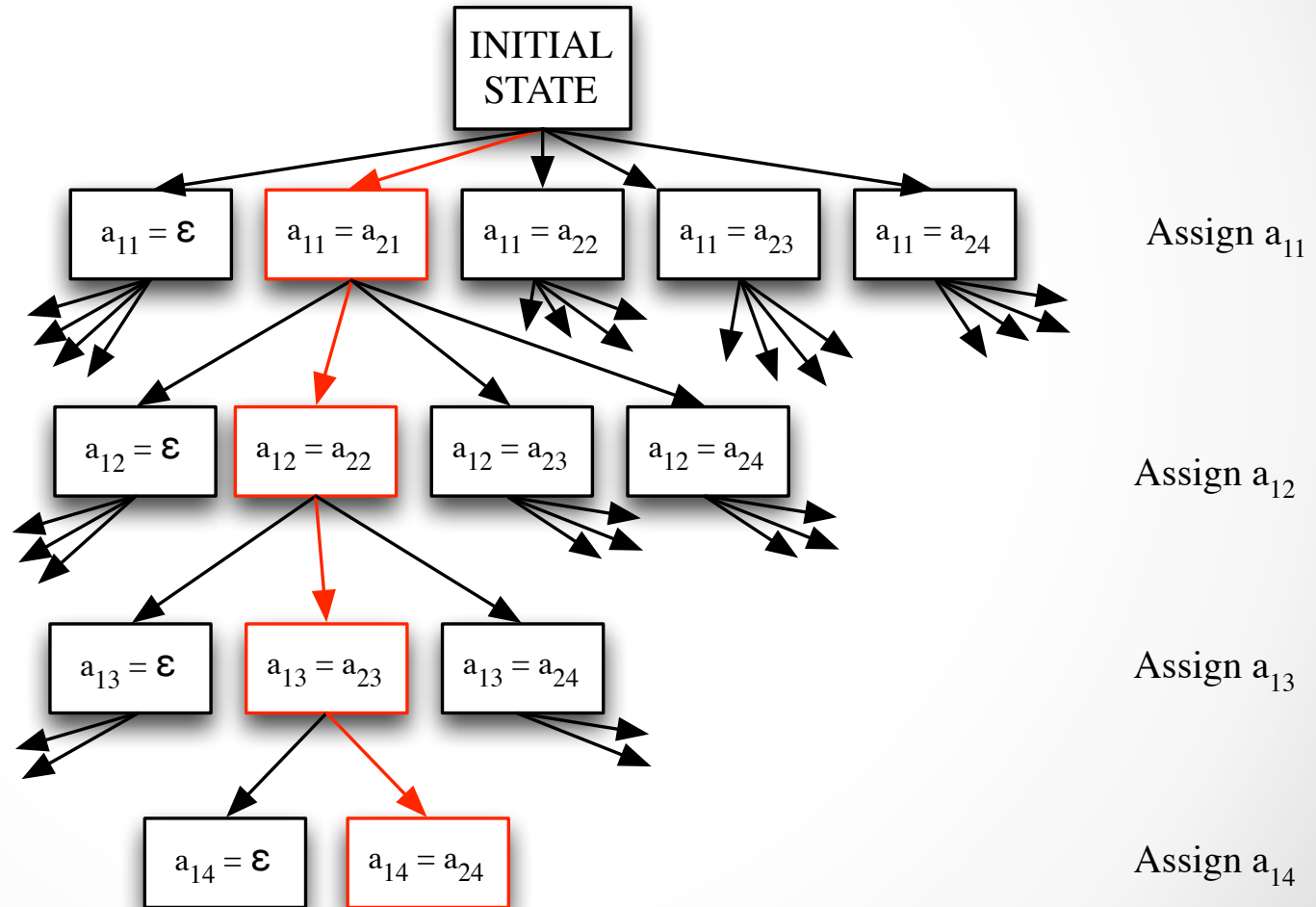


Branch & Bound Strategy

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

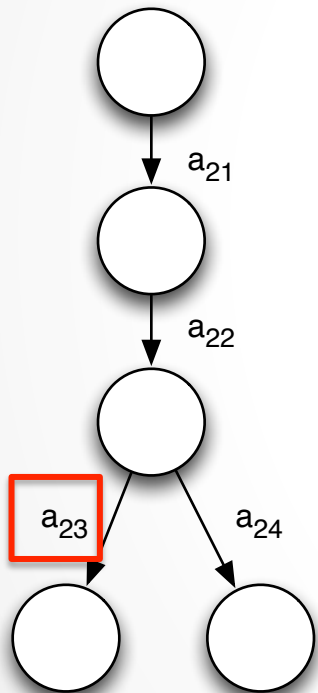


Profit = 4

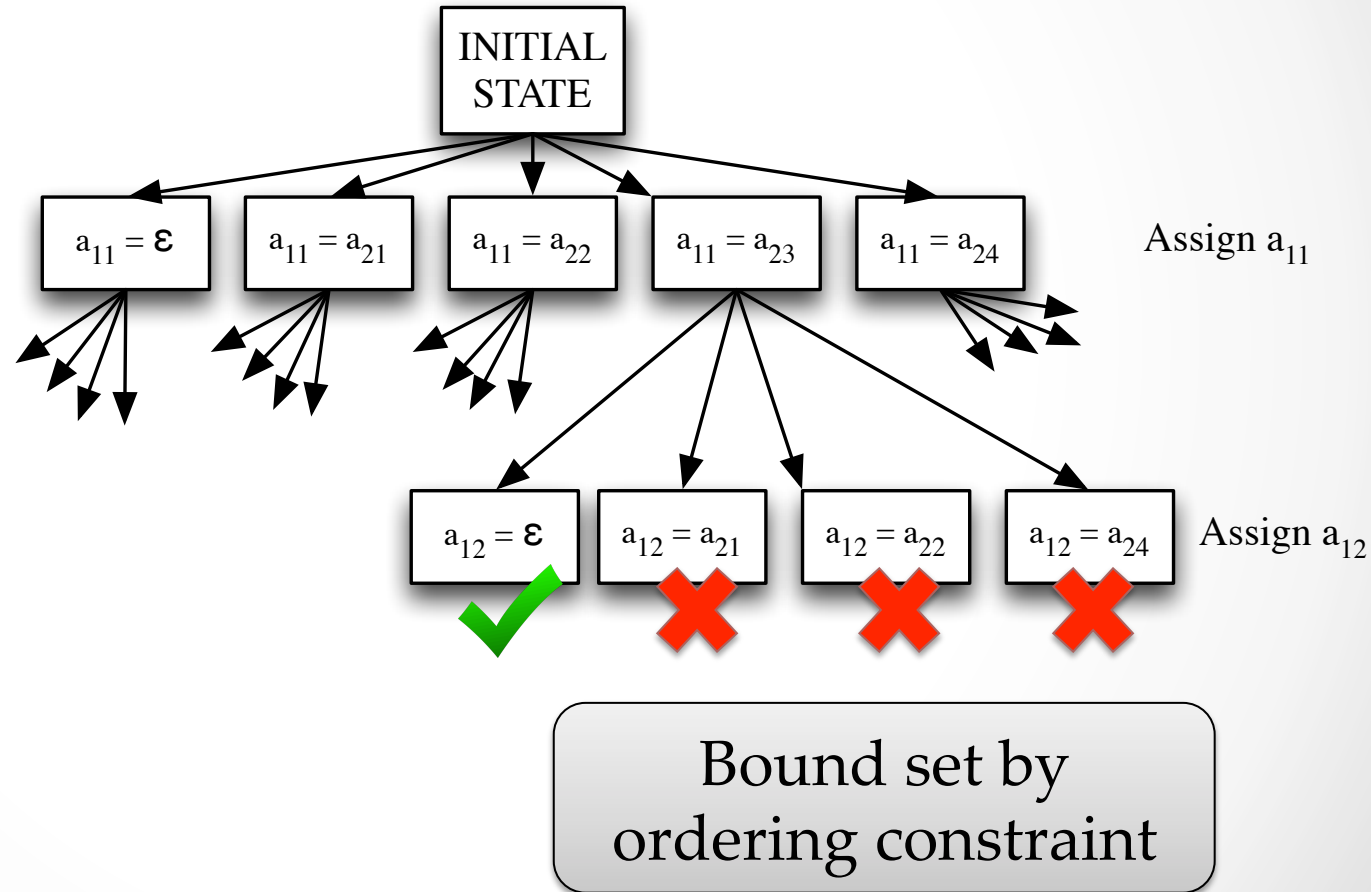


Branch & Bound Strategy

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

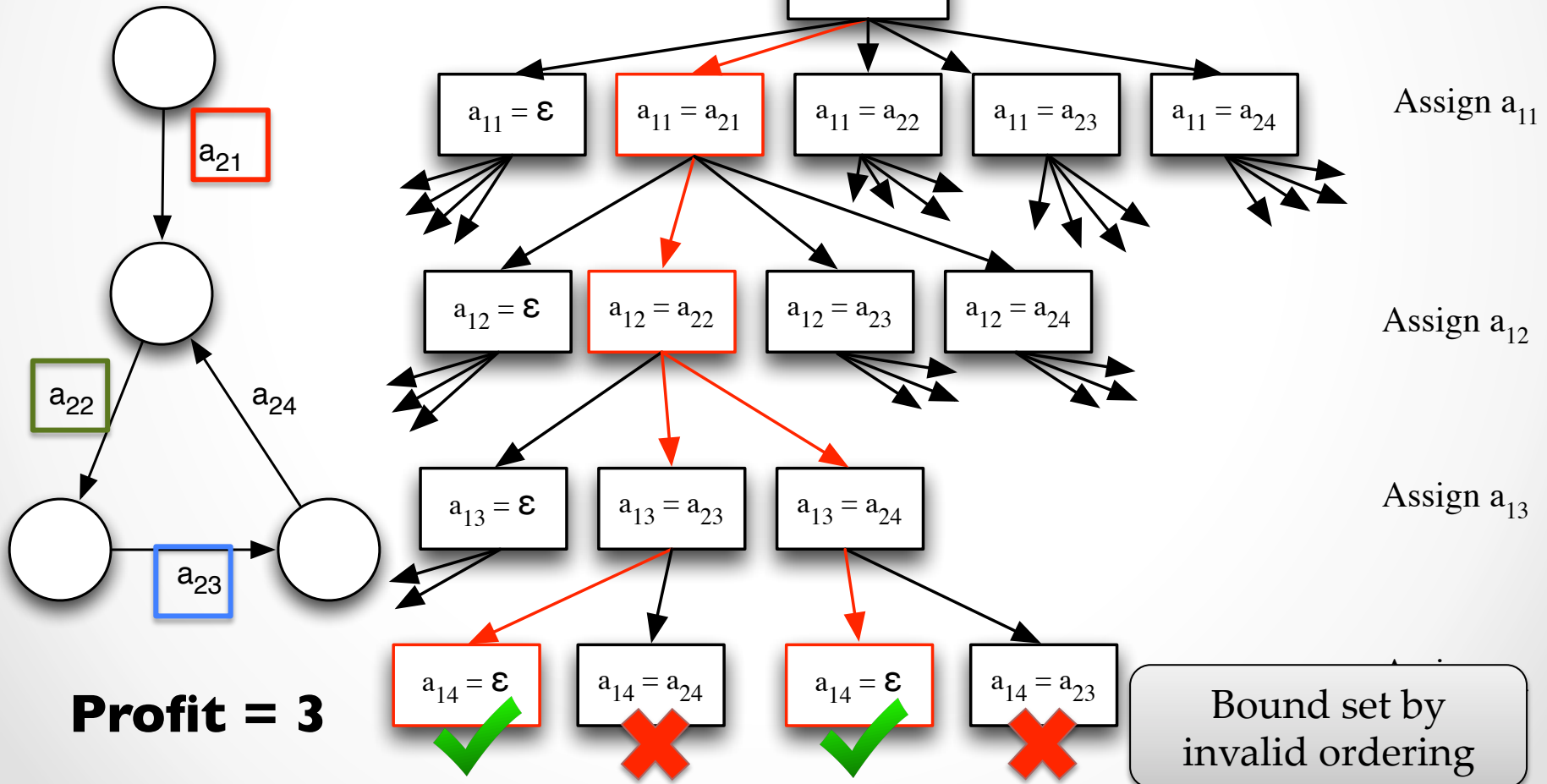


Profit = 1



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

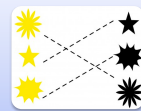
Web & Mobile Applications



Problem Space



Cross-Browser Testing

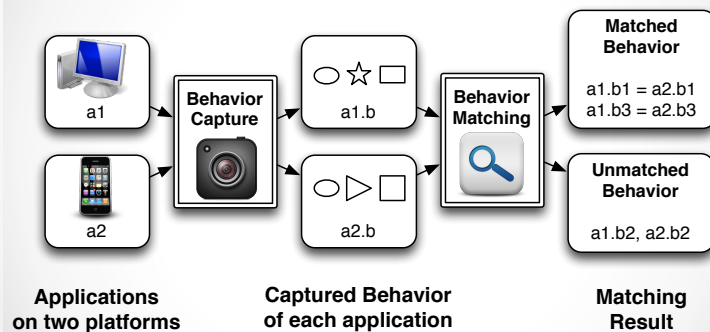


Feature Mapping



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