Cross-Platform Testing and Maintenance of Web and Mobile Applications

ICSE 2014 Doctoral Symposium

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School of Computer Science, Georgia Tech

Web & Mobile Applications

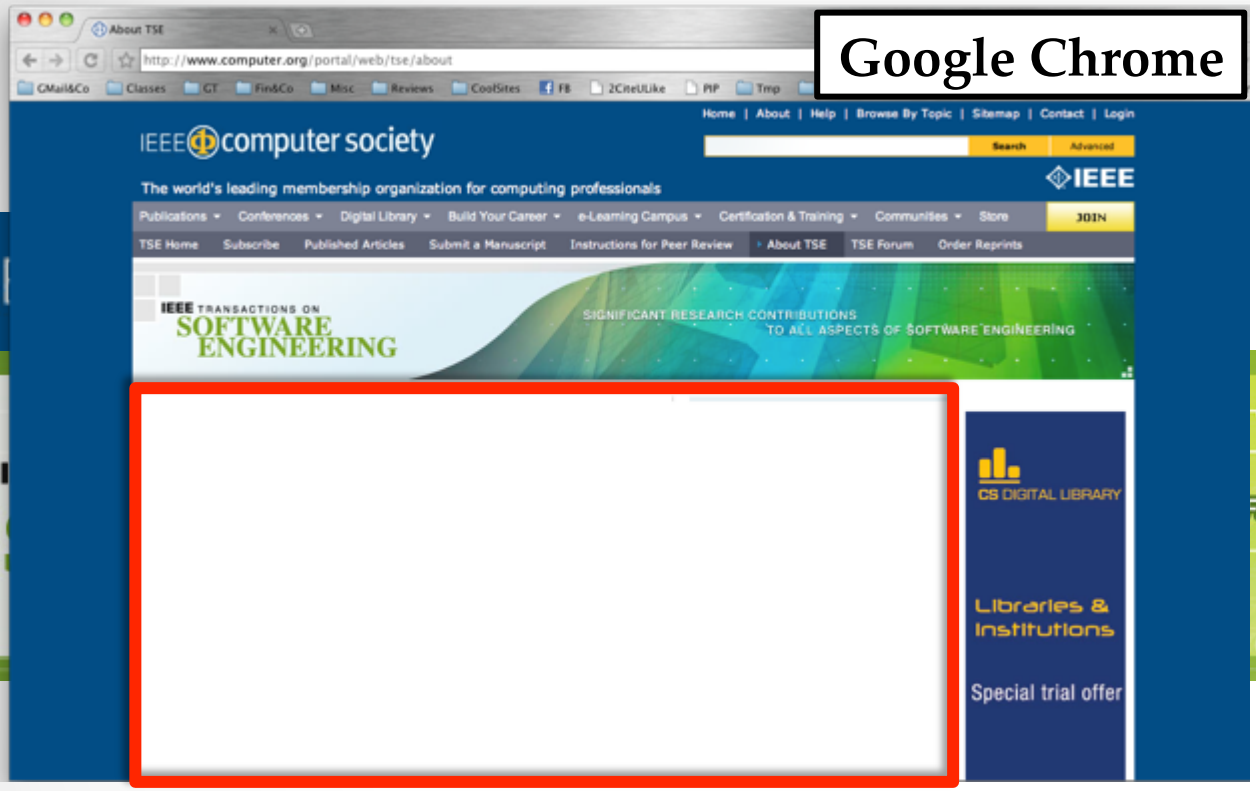
Web

MobileWeb

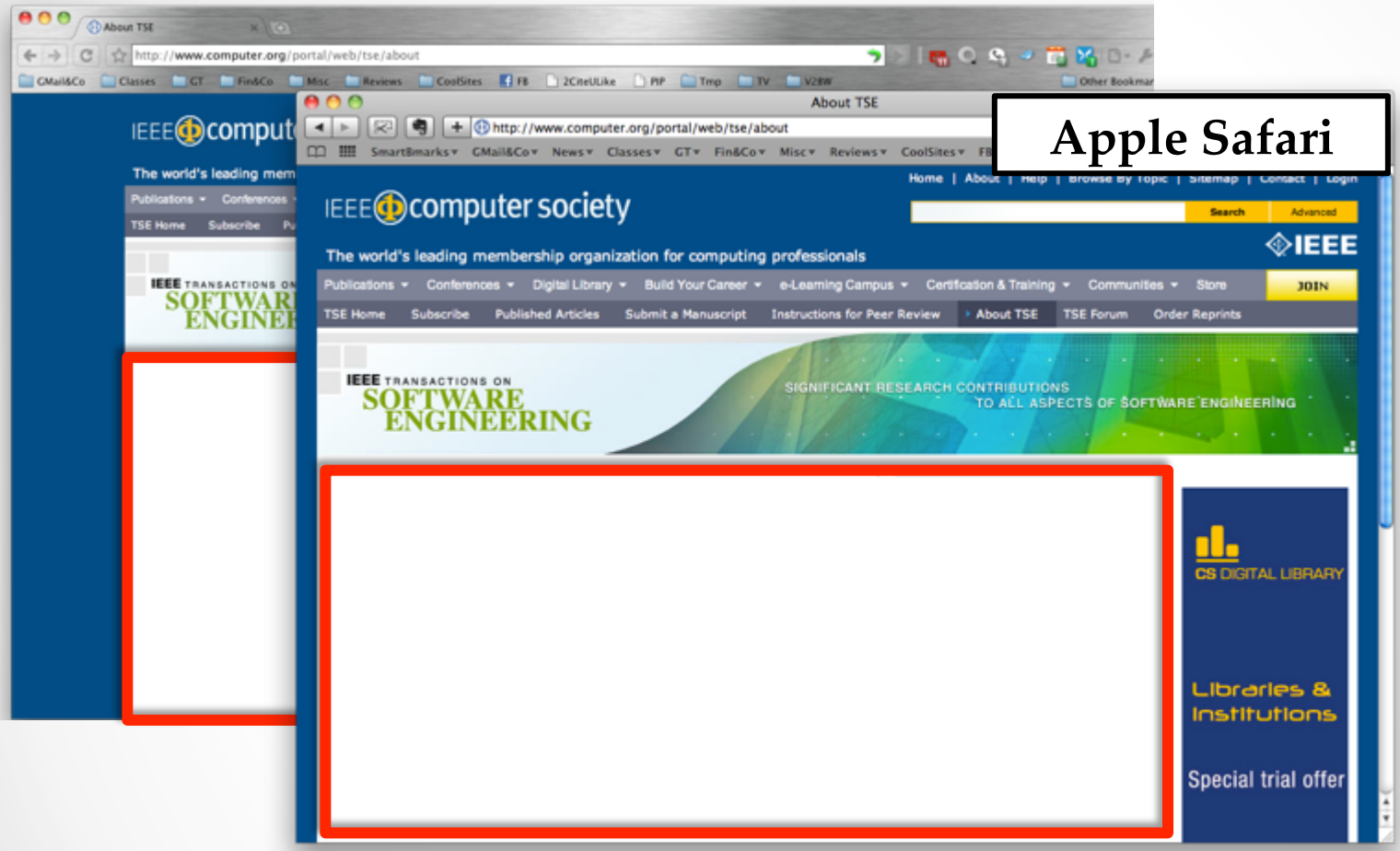
Mobile

Testing & Maintenance Issues for Multi-platform Applications

I. Inconsistencies



I. Inconsistencies



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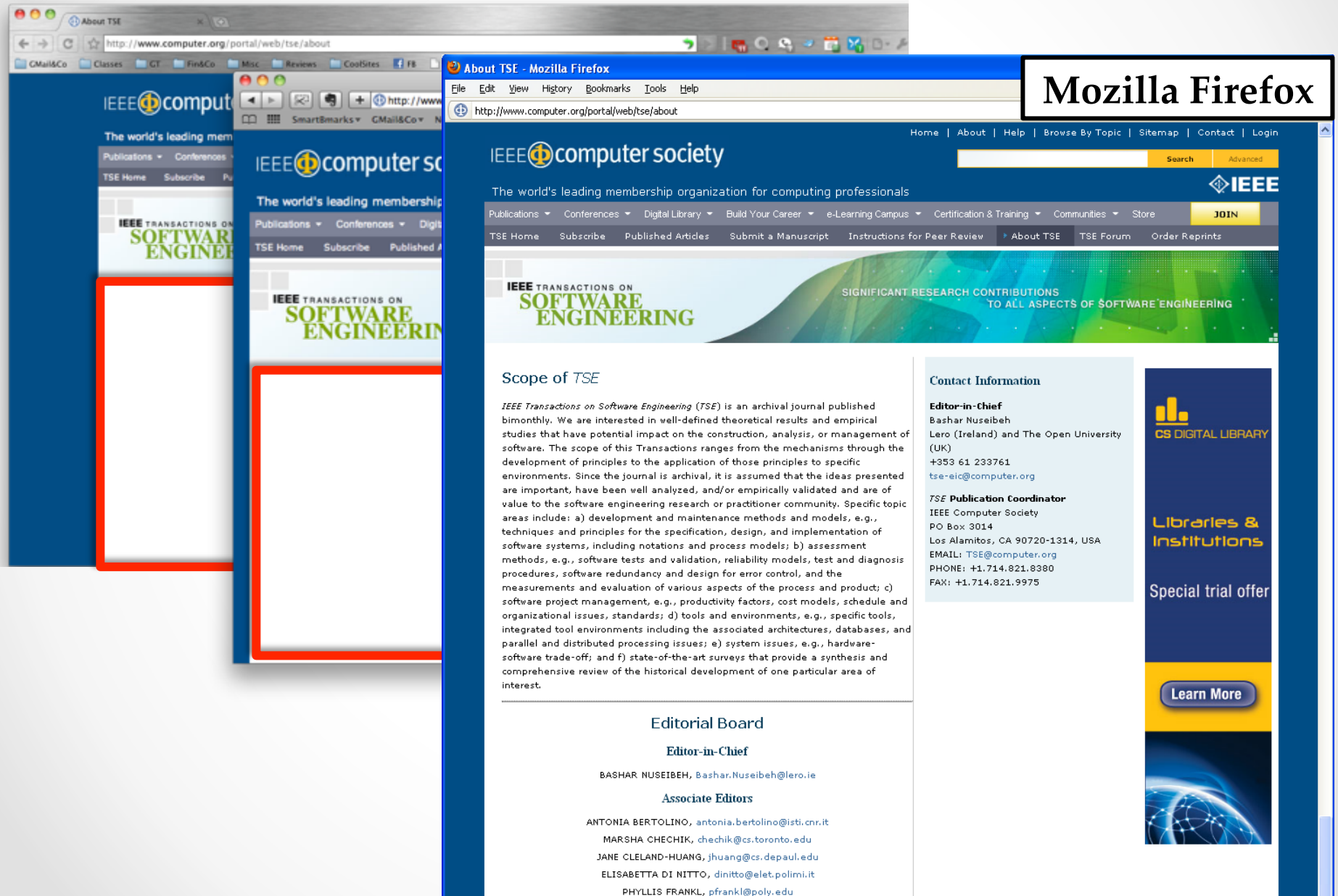

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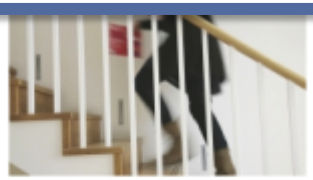

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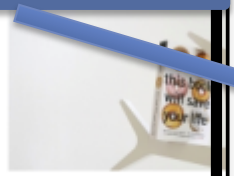

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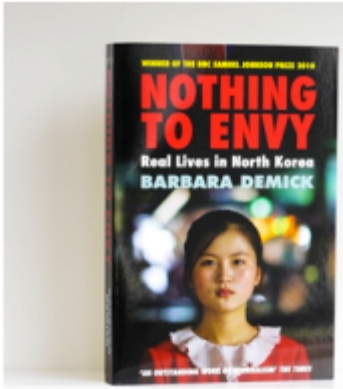

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The Times

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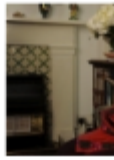

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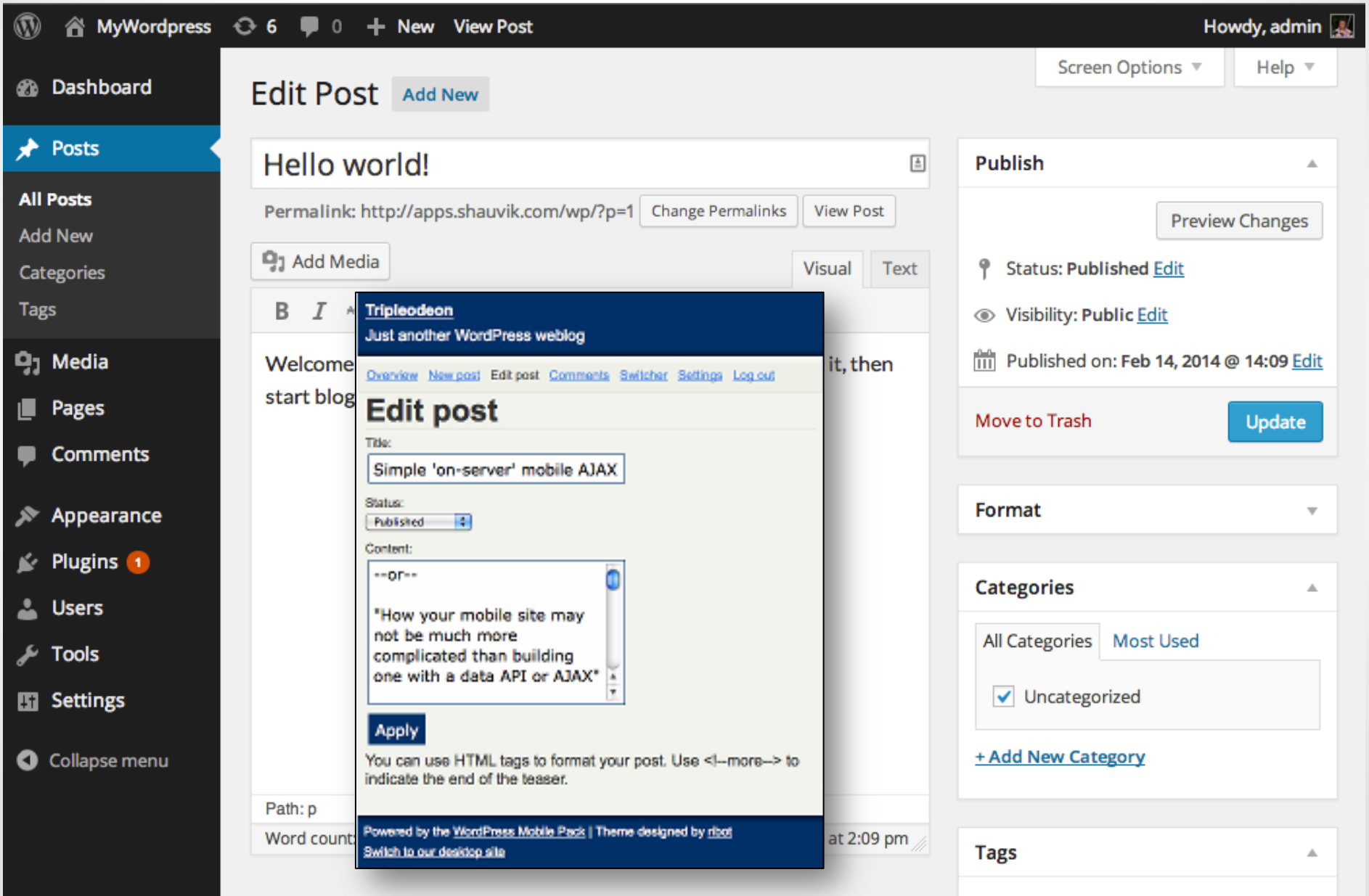
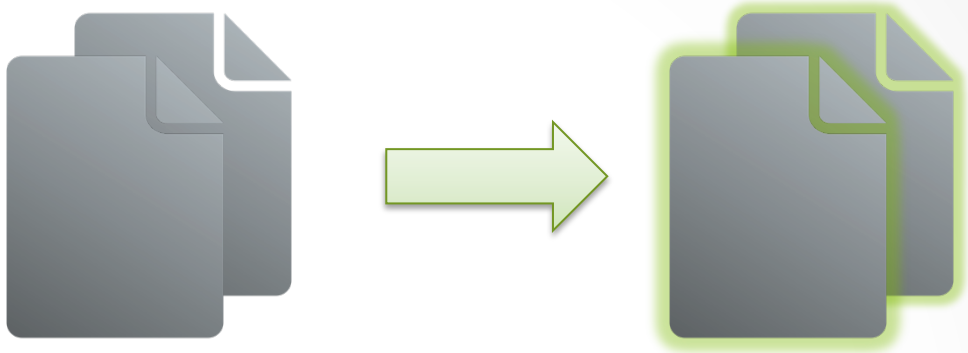
II. Missing Features

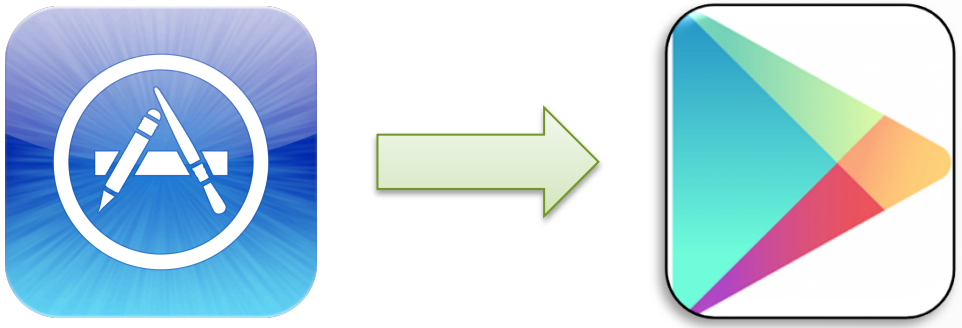


III. Costly Test Migration

Test Suite



Mobile App



Platform

How can we address these problems?

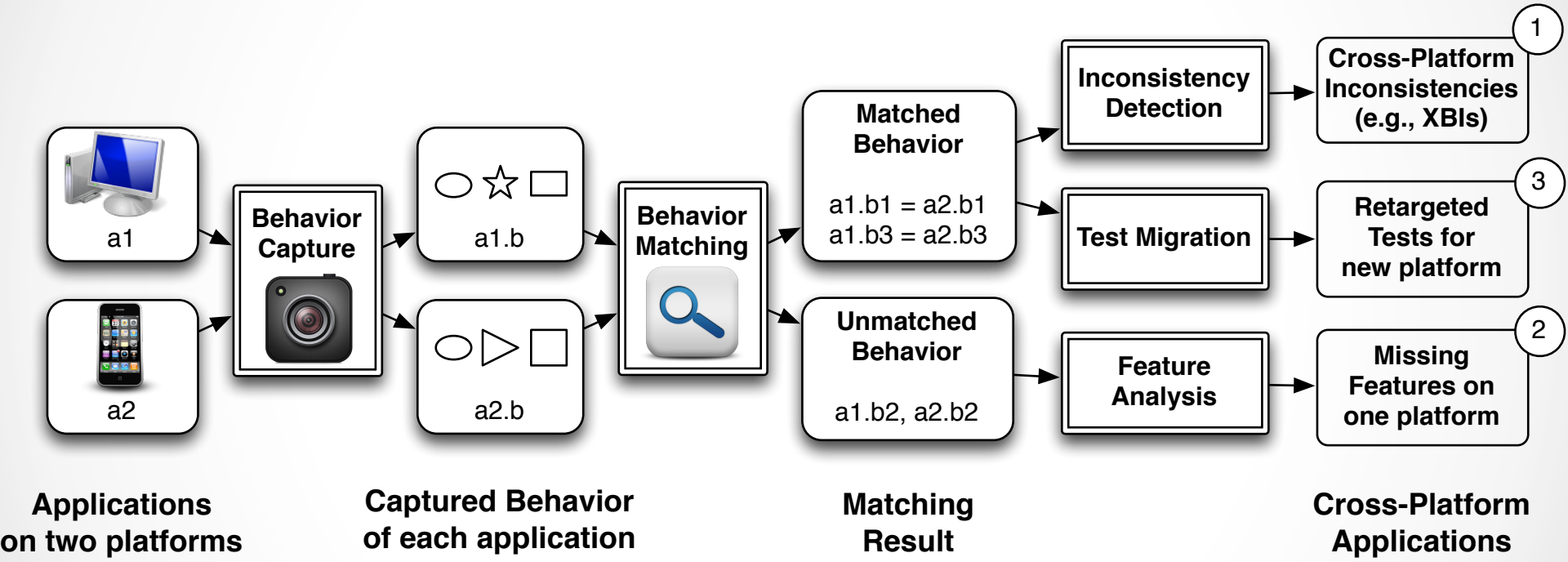
Proposed Thesis

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



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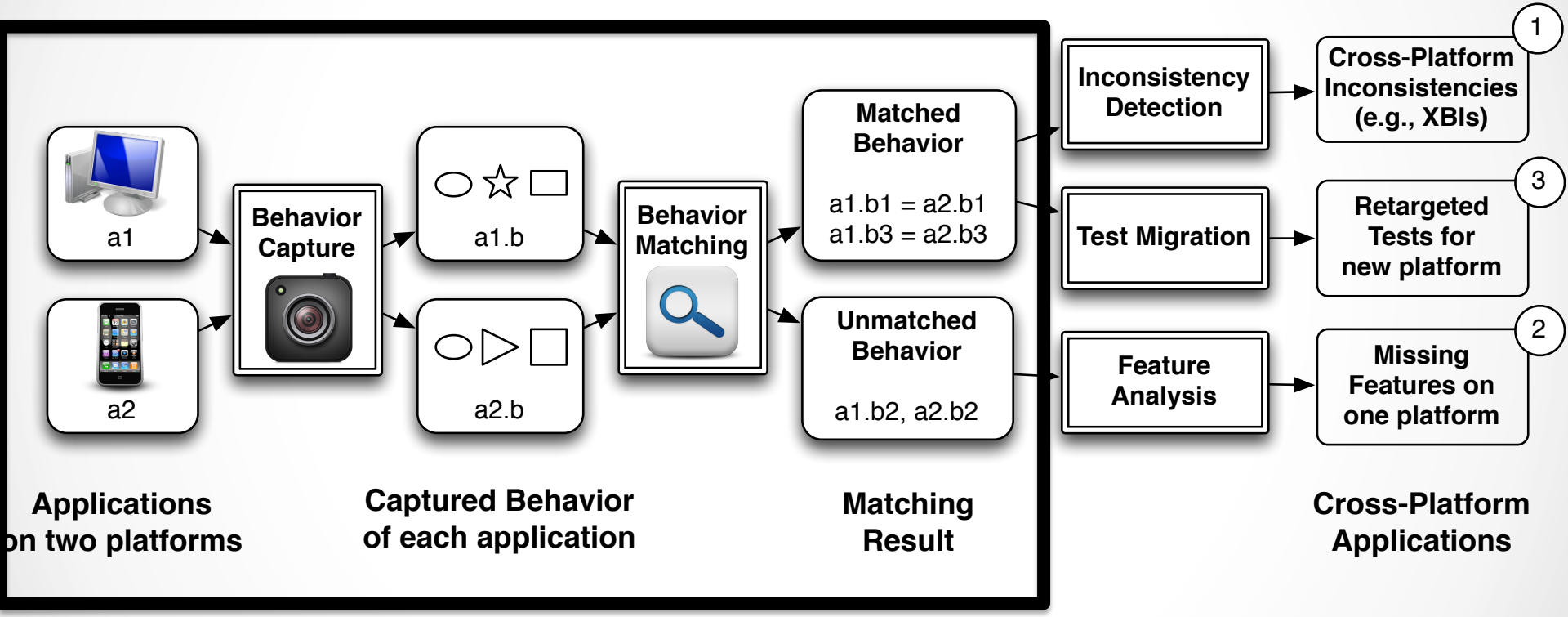

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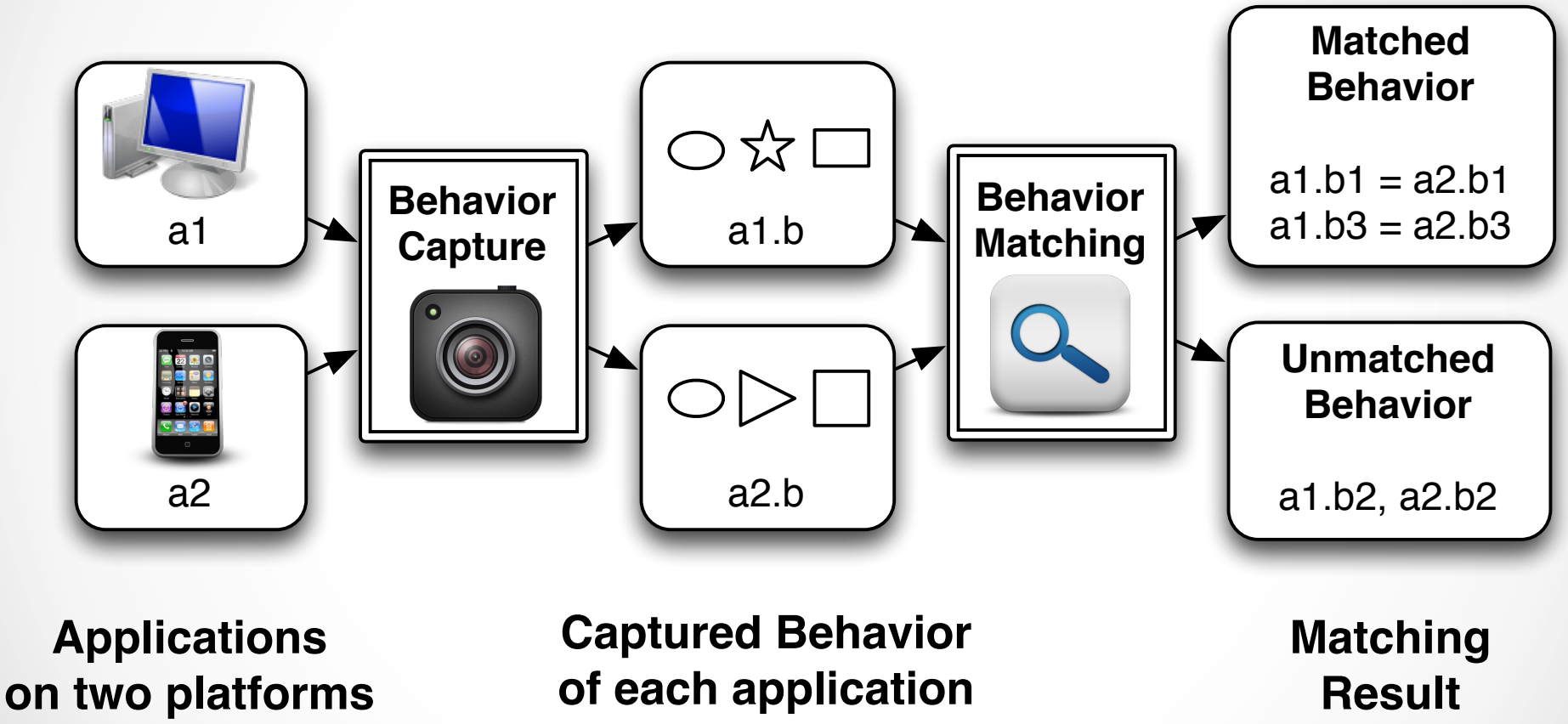

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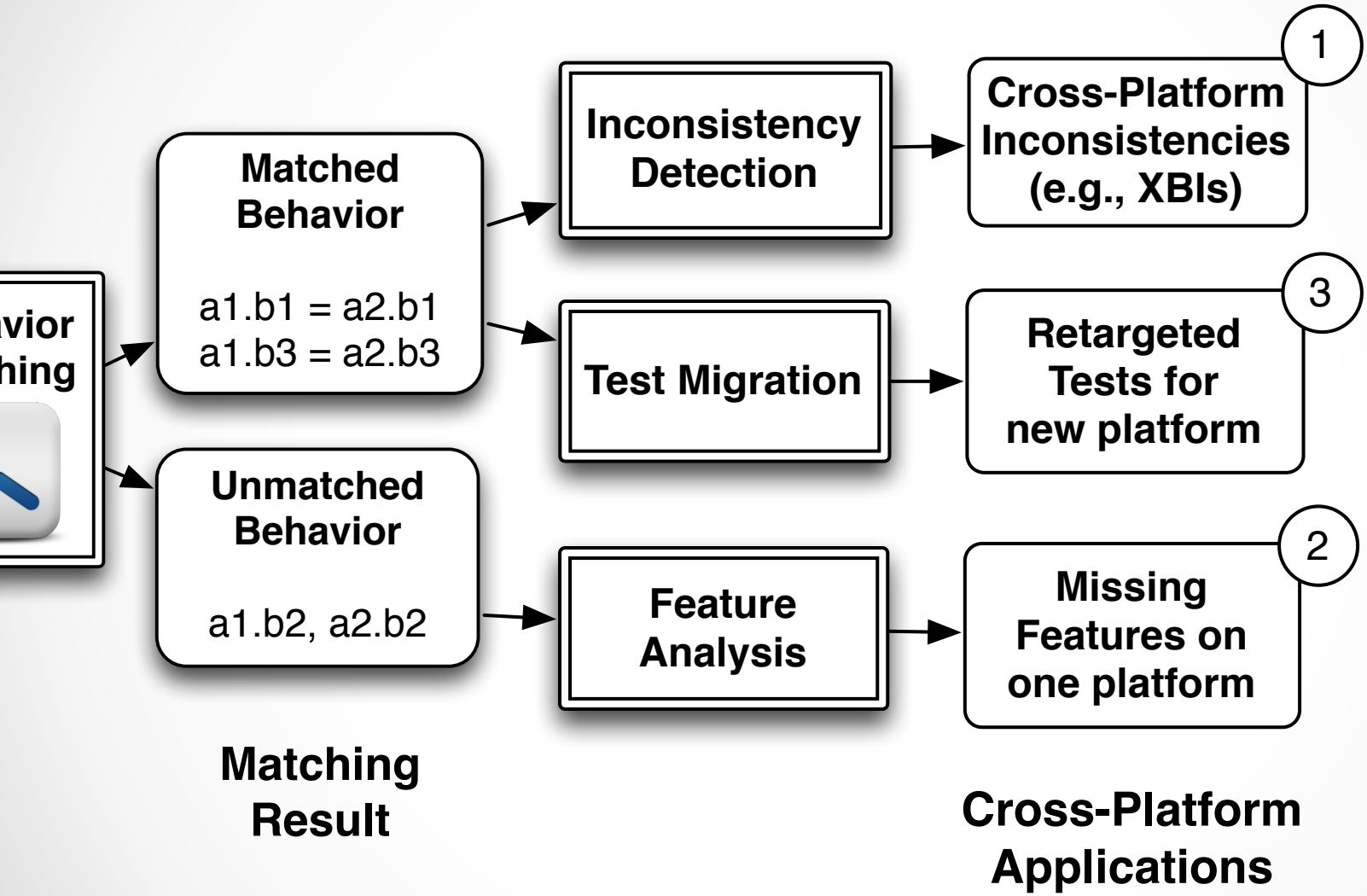
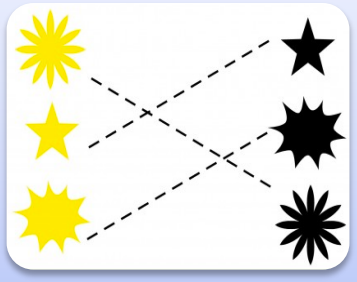


Research Outline

Cross-Browser Testing

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



Feature Mapping

- FMAP [ISSTA'14]

Test-suite Migration

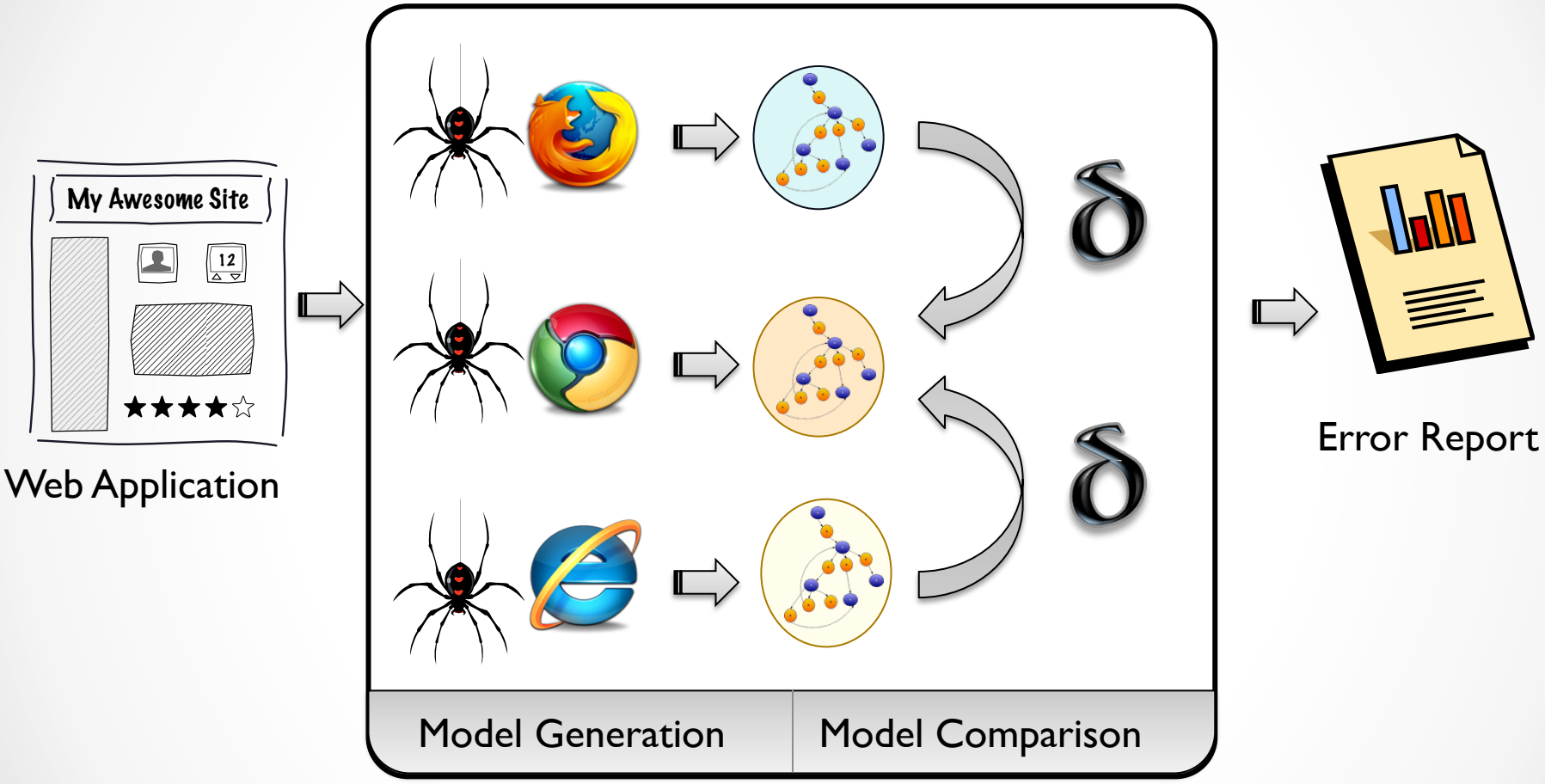
- Remaining work in progress

Cross-Browser Incompatibility Detection

(for web applications)

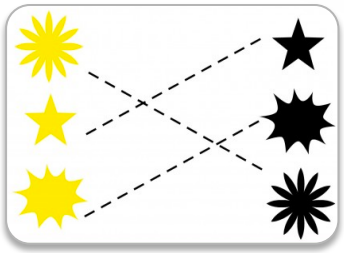
WebDiff [ICSM' 10], **CrossCheck** [ICST'12], **X-PERT** [ICSE'13]

Approach Overview



Effectiveness
77% Precision and **95%** Recall

Improvement over state-of-art
45%⇧ Precision & **14%⇧** Recall

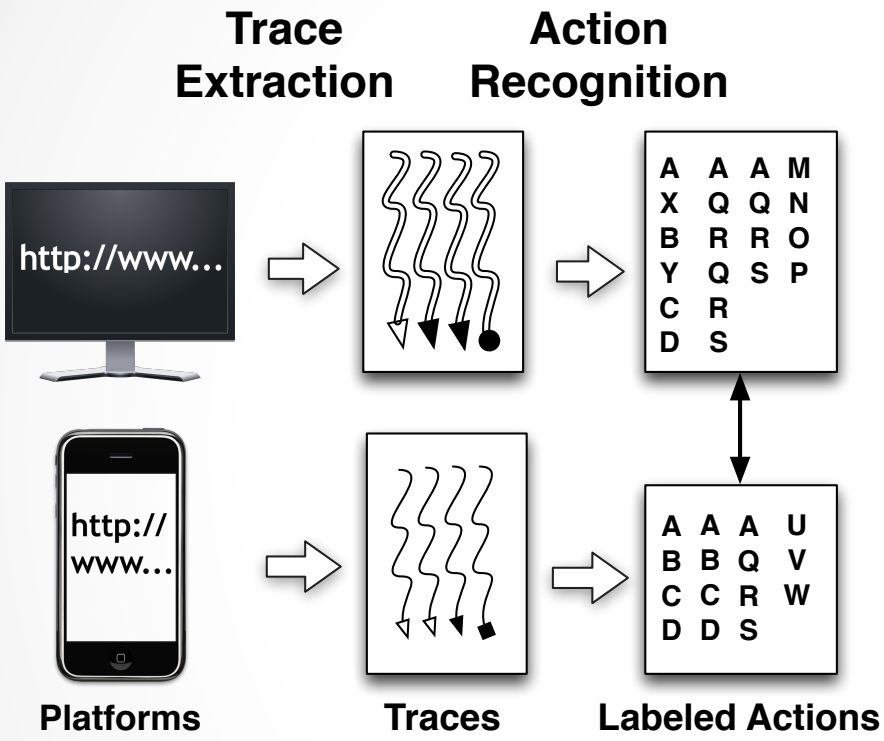


Feature Mapping Across Platforms

(for desktop & mobile web apps)

FMAP [ISSTA'14]

Approach Overview



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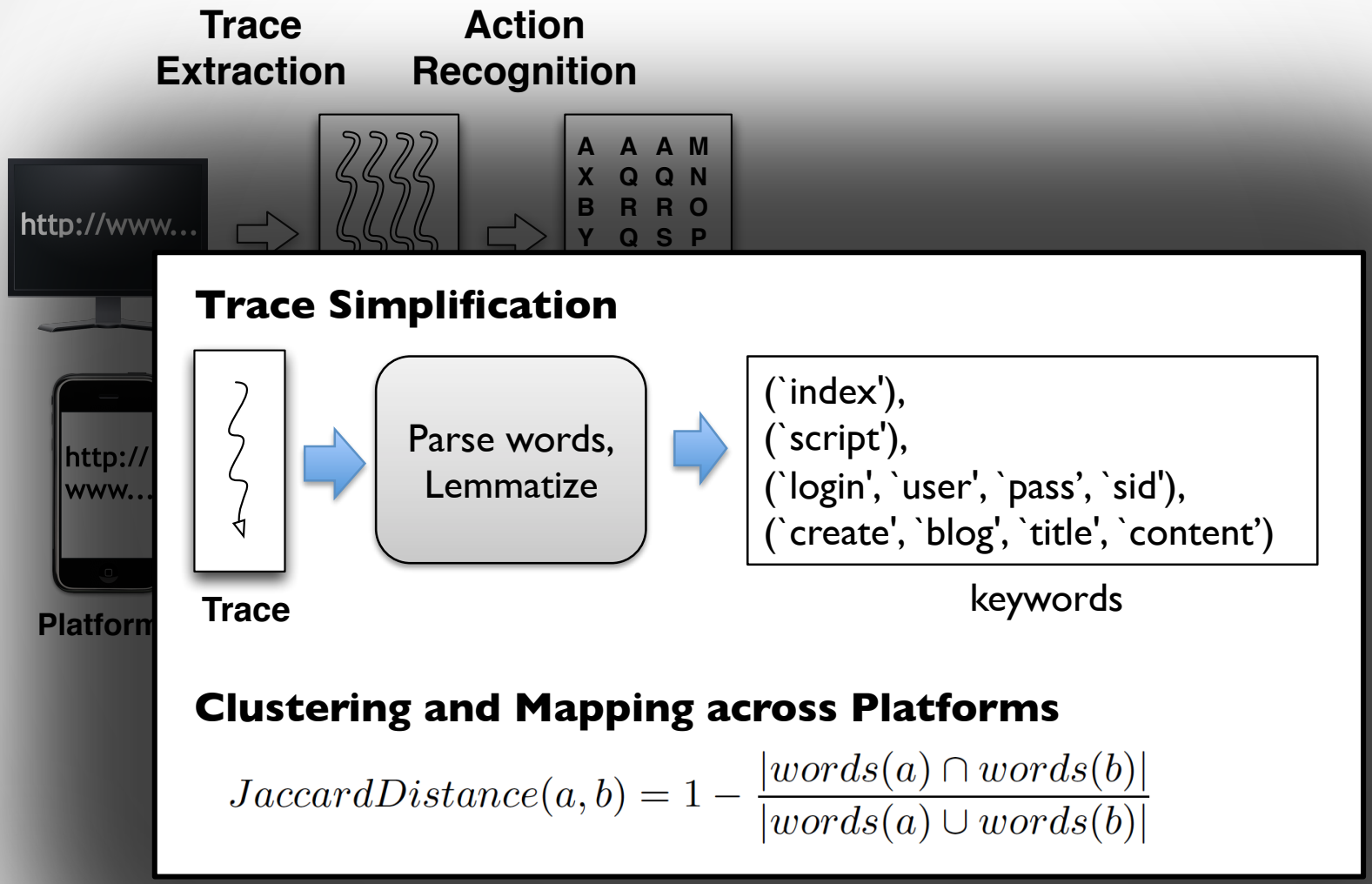

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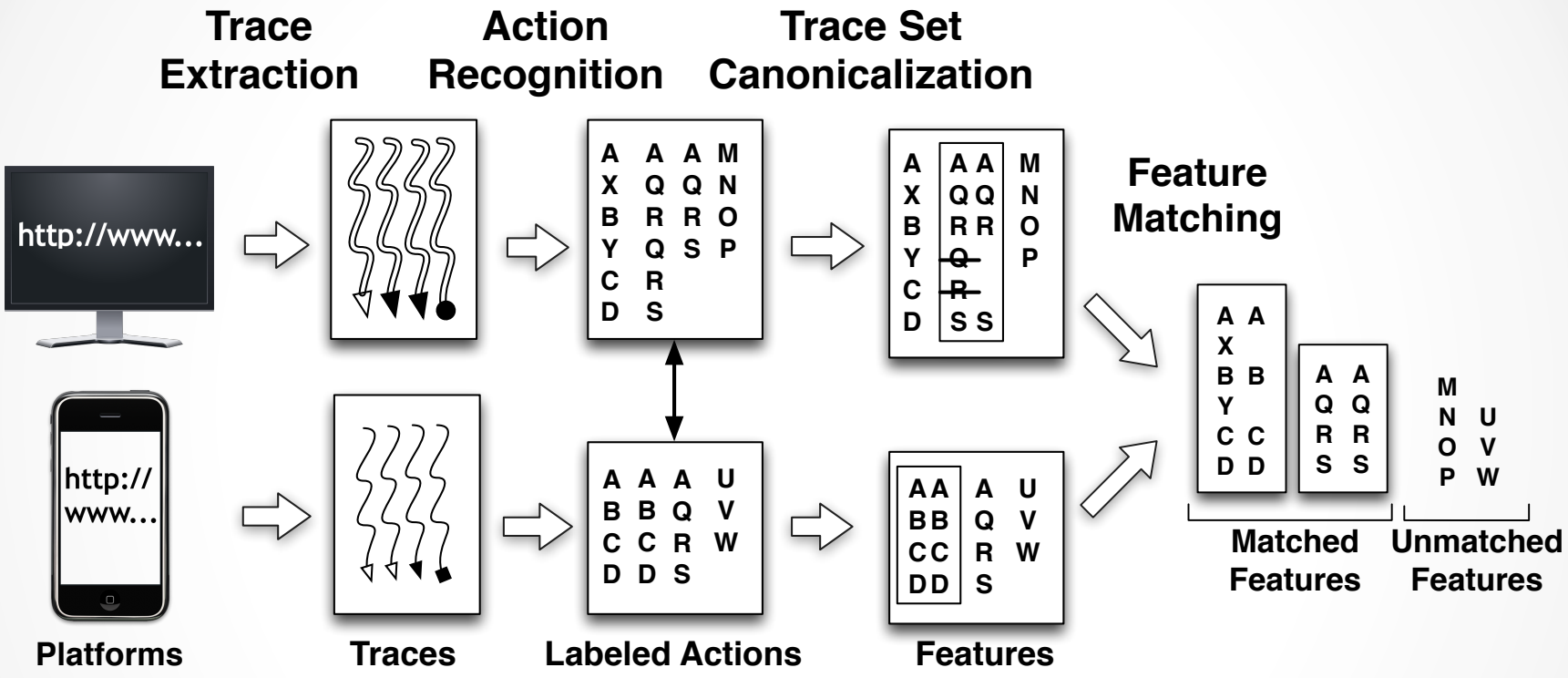


Action recognition F-Score:
97.8% (Desktop) vs 99.6% (Mobile)

Overall Effectiveness:
86.3% vs 51.5% (baseline)

Cross-platform Test Migration

(for mobile apps)

Remaining Work

Problem

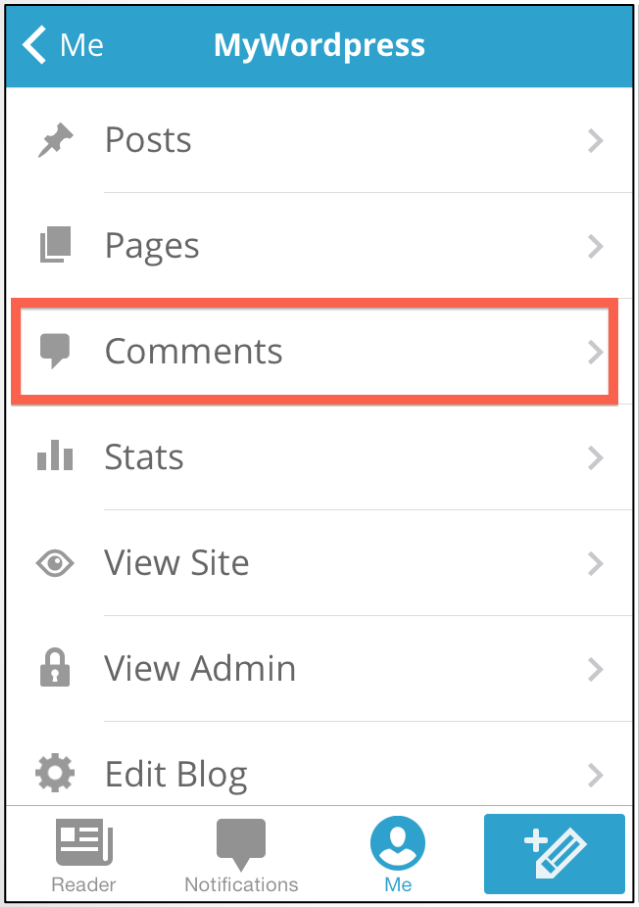
- **Given:** Test Suite (TS_i) for App on Platform 1
- **Task:** Generate corresponding Test Suite, (TS_a) for the same App on Platform 2

TS = Set of TC

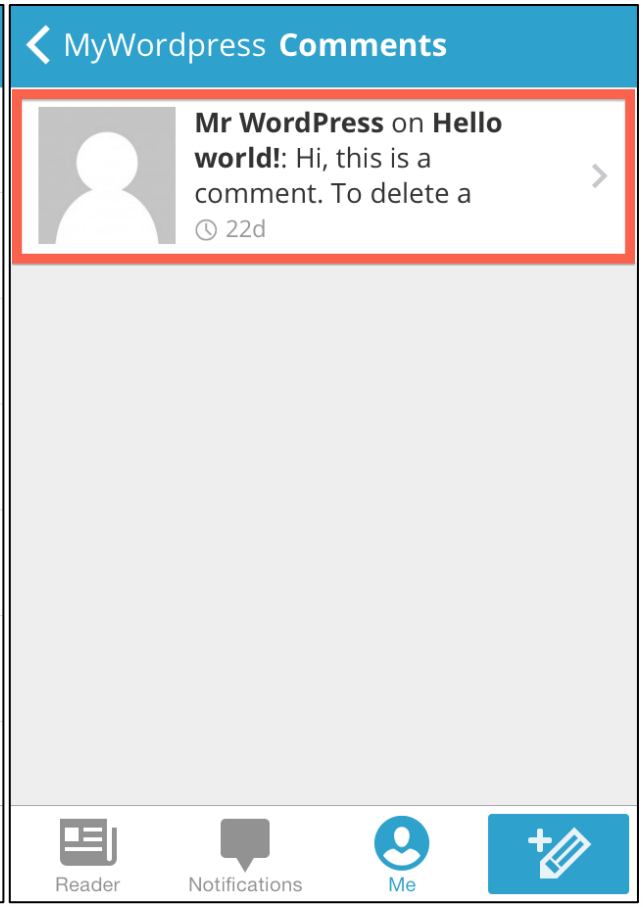
TC = [a_1, a_2, ... a_N, Oracle.assert()]

Action is [ActionType, Selector, Data]

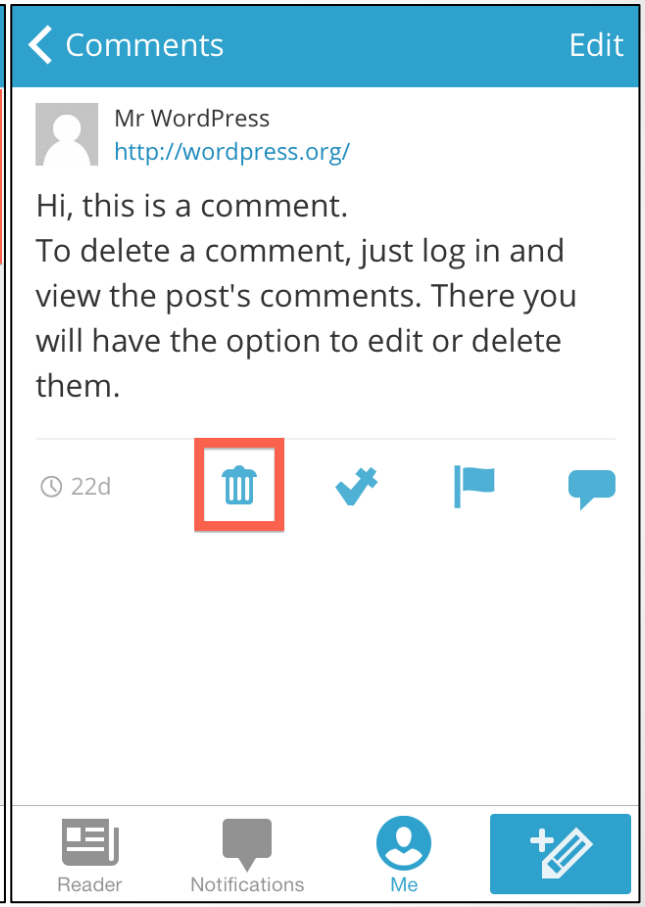
Example Test on iOS



tap “Comments”

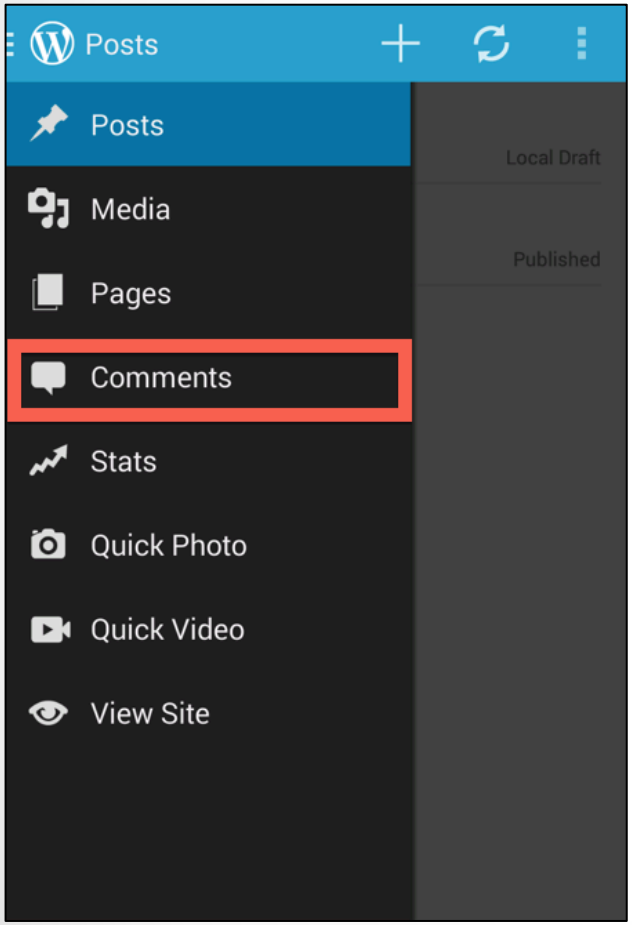


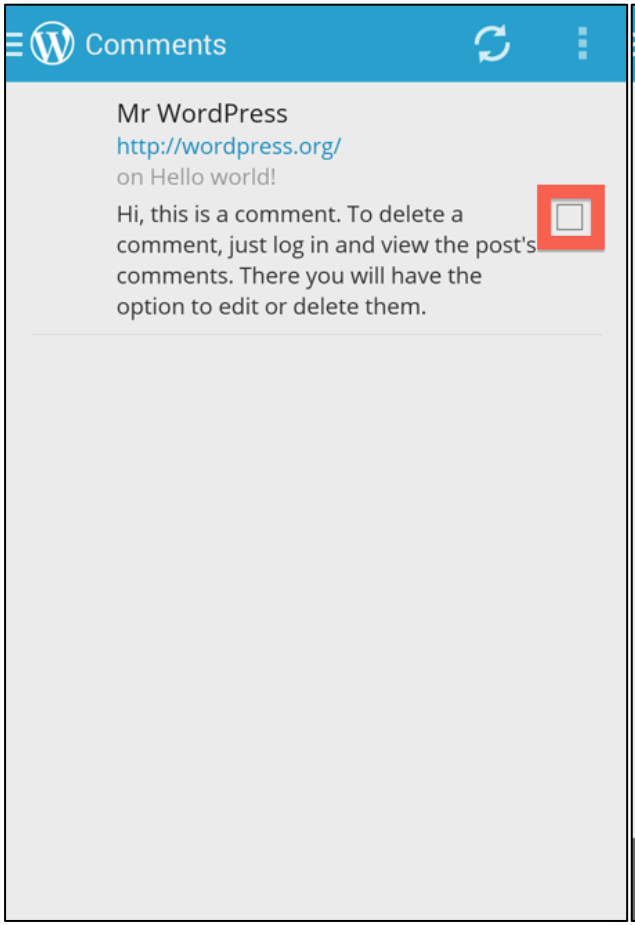
tap cell[0]

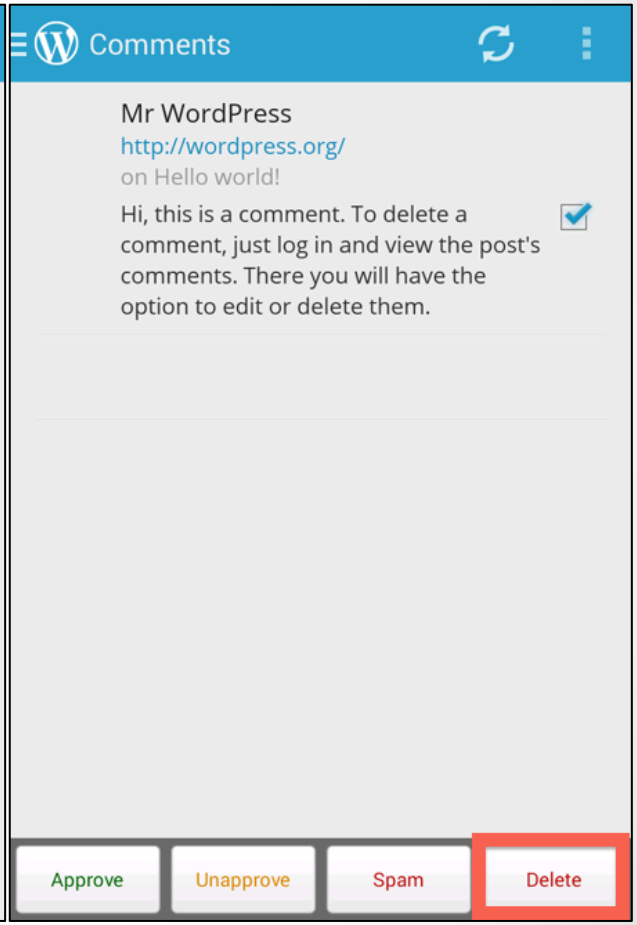


tap “icon delete”

Example Test on Android







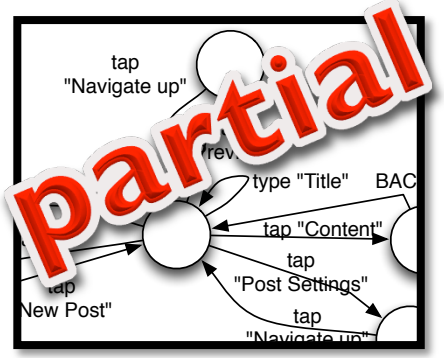
tap "Comments"

tap checkBox[0]

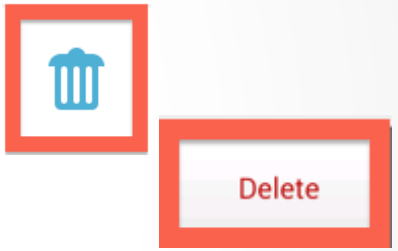
tap "Delete"

Challenges

Independently developed
(In different languages & frameworks)



Automated Behavior Exploration



Same actions
Different Widgets

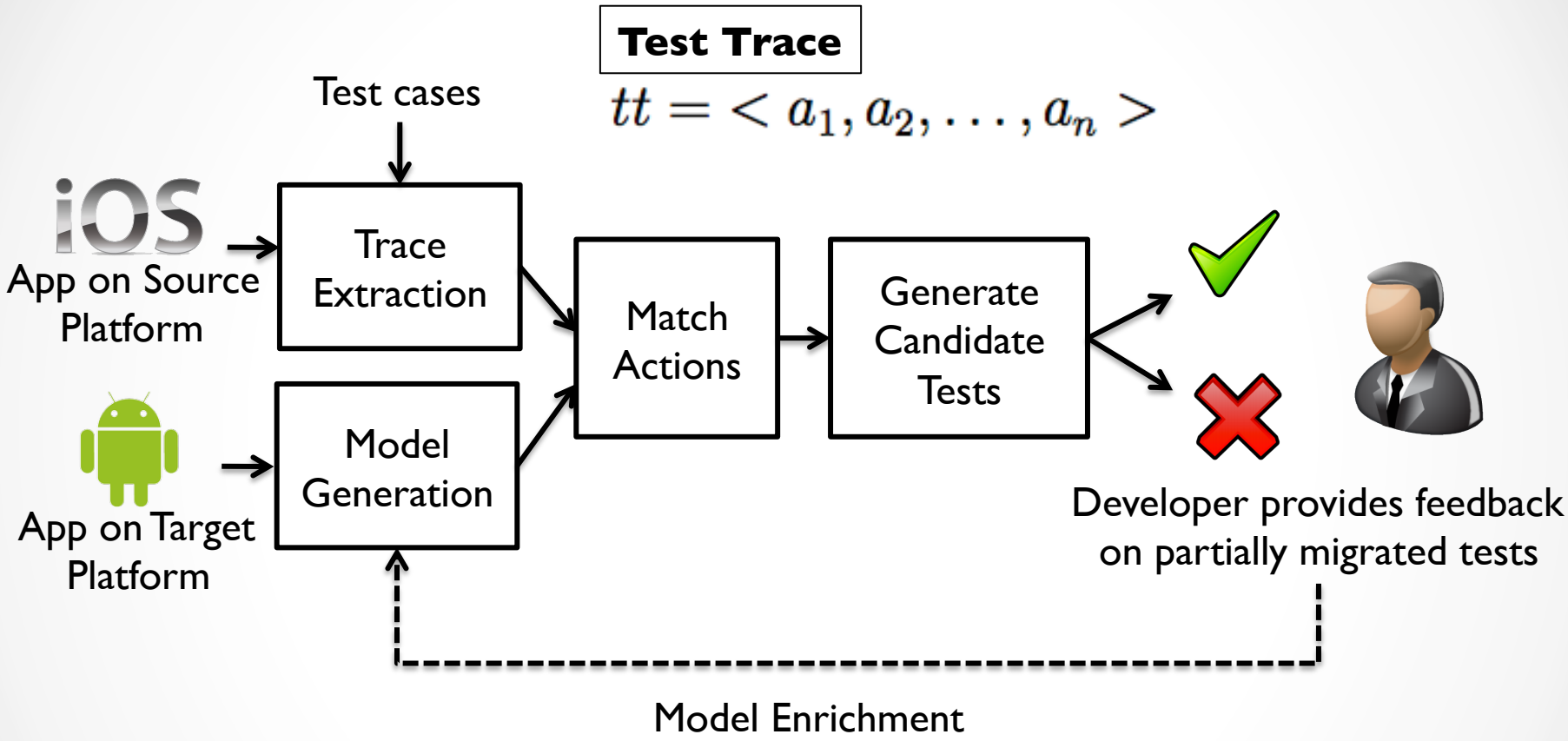
Assumptions

- **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

$mt = < a_1, a_2, \ldots, a_u >$

Action Matching as an Optimization Problem

- Given: Test traces for Platform1 $tt = a_{1,1},\ a_{1,2}, \ldots,\ a_{1,m}$

  Model for Platform 2 $mt = < a_1, a_2, \ldots, a_u >$

- Formulation:

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

Profit function

Such that

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

Action Matching as an Optimization Problem

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

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

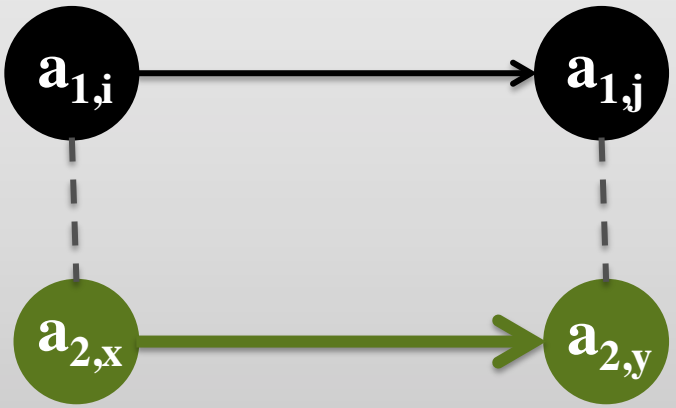
Such that

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

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

  $(a_{1,i} < a_{1,k} < a_{1,j})$

Ordering Constraint
On matched actions



Action Matching as an Optimization Problem

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

$$\max_{a_{1,i}} \quad a$$

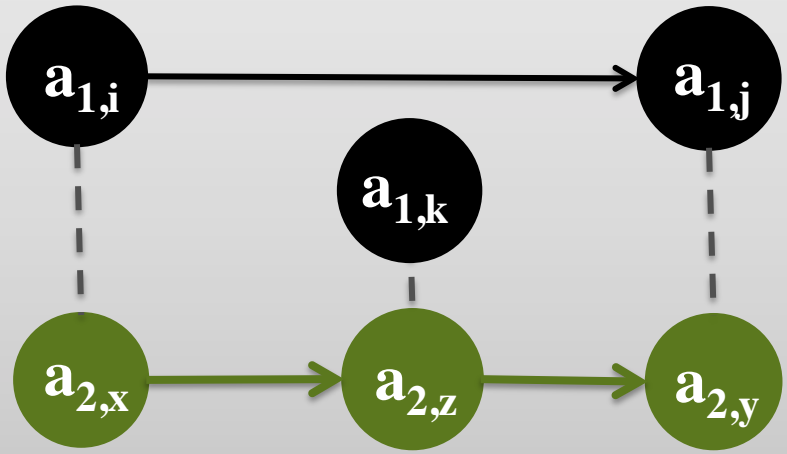
Such that

- $Map : a_1 \rightarrow a_2 \quad a_2 \in \{$
- $|Map(a)|$ = *0 if a is mapped*
- $(Map(a_{1,i}) = a_{2,x}) \wedge (Map(a_{1,j}) = a_{2,y}) \wedge (a_{1,i} < a_{1,j}) \wedge (a_{2,x} \neq \varepsilon) \wedge (a_{2,y} \neq \varepsilon)$

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

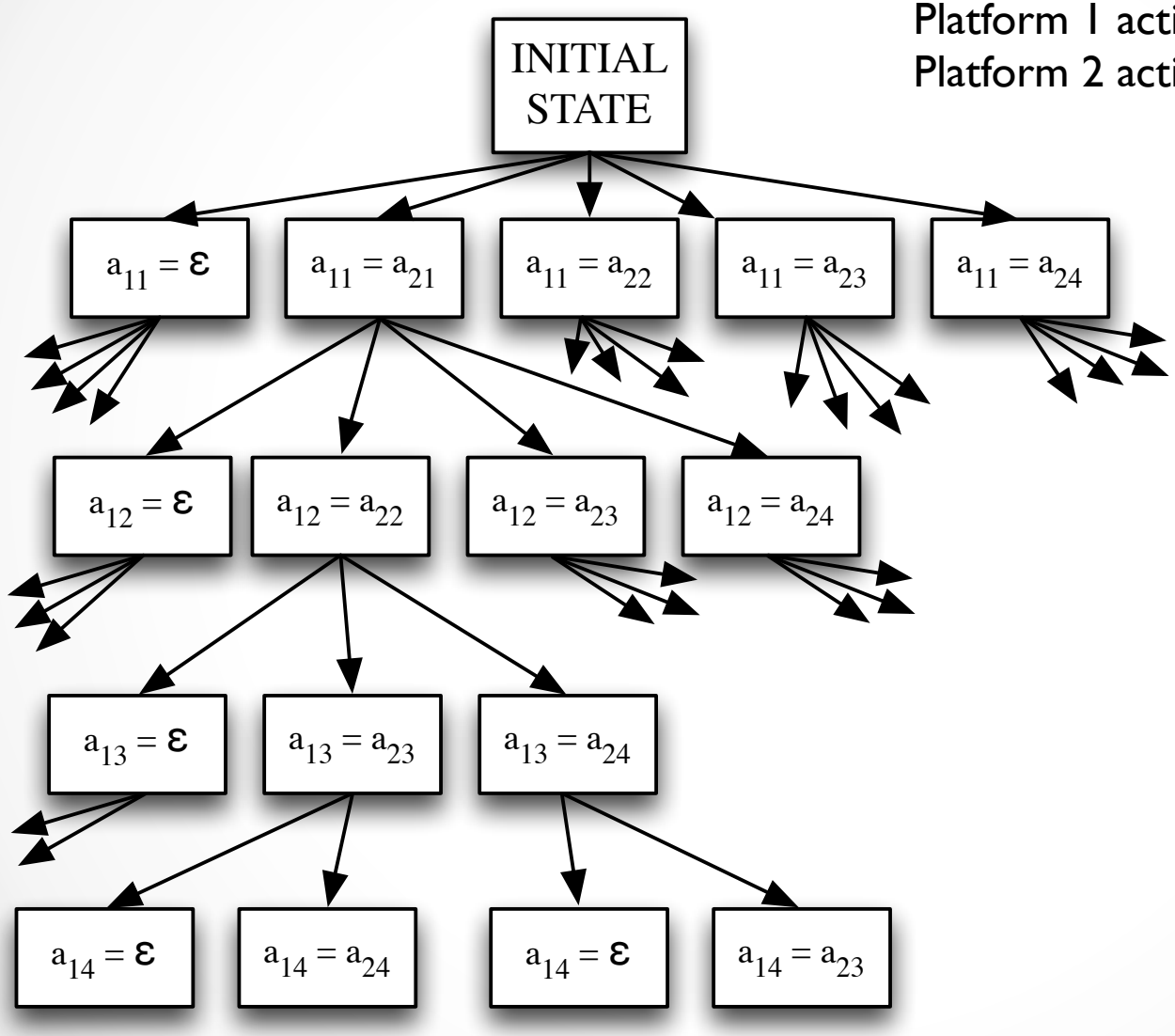
  $(a_{1,i} < a_{1,k} < a_{1,j})$

No Invalid Ordering
b/w matched actions



Branch & Bound Strategy

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



Assign a_{11}

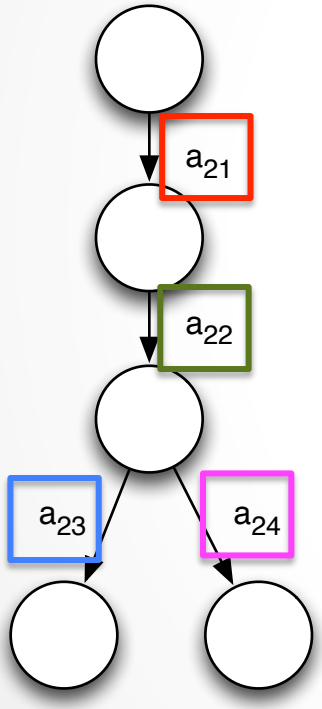
Assign a_{12}

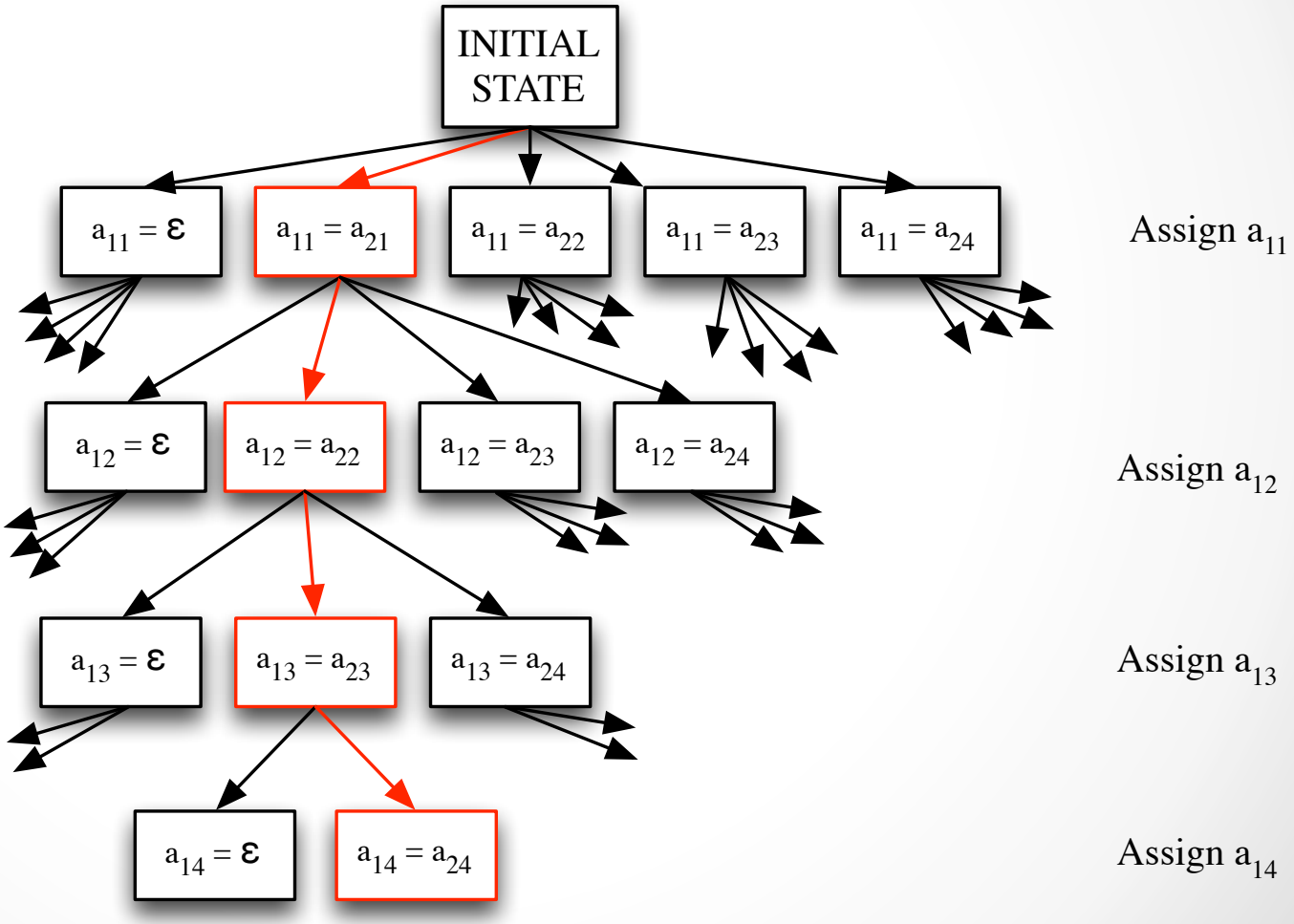
Assign a_{13}

Assign a_{14}

Branch & Bound Strategy

- Test traces: <a_{11}, a_{12}, a_{13}> <a_{11}, a_{12}, a_{14}>
- Model:

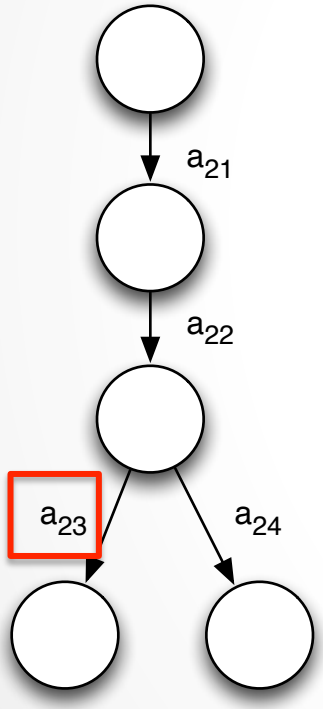


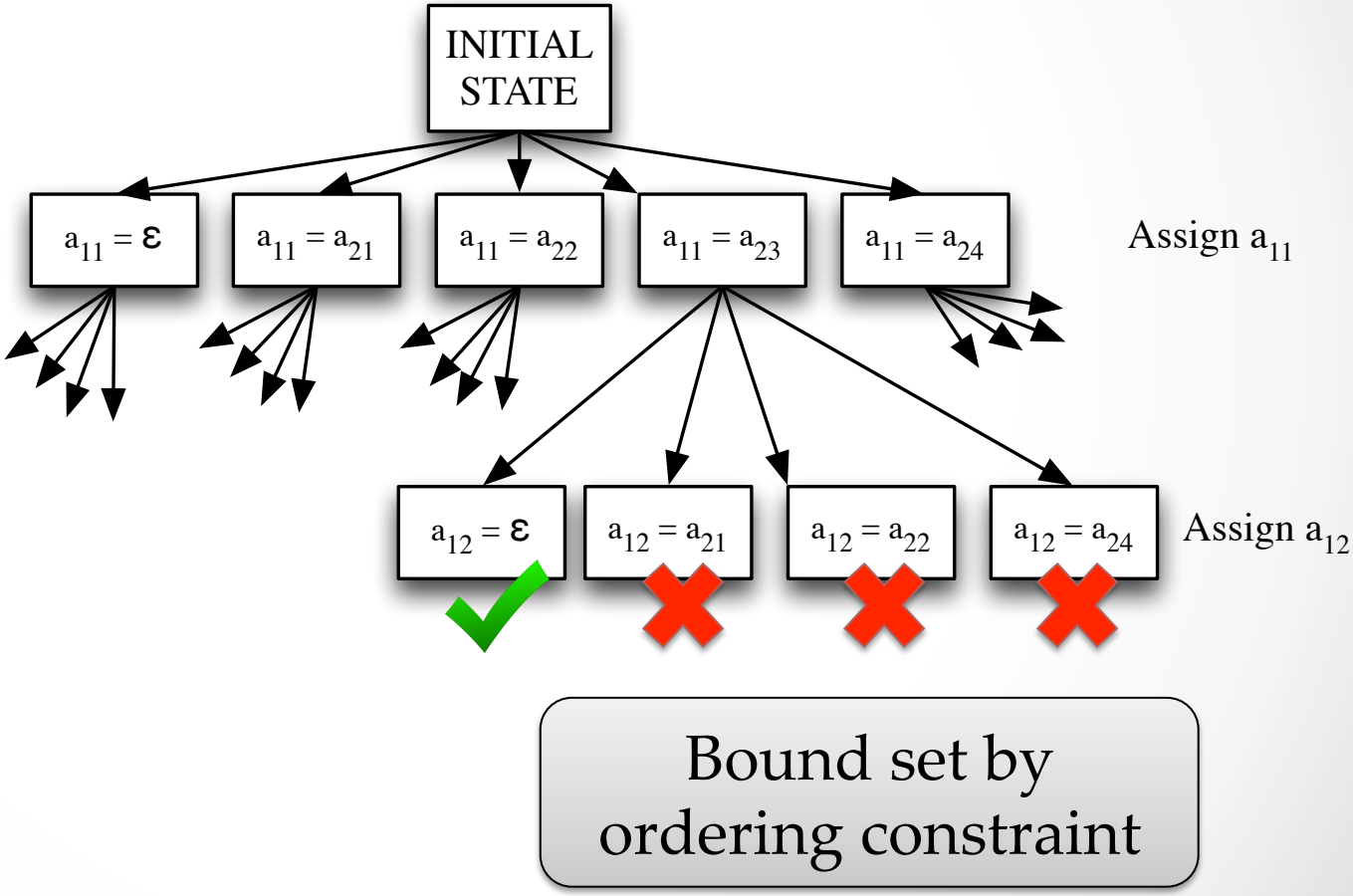


Profit = 4

Branch & Bound Strategy

- Test traces: <a_{11}, a_{12}, a_{13}> <a_{11}, a_{12}, a_{14}>
- Model:

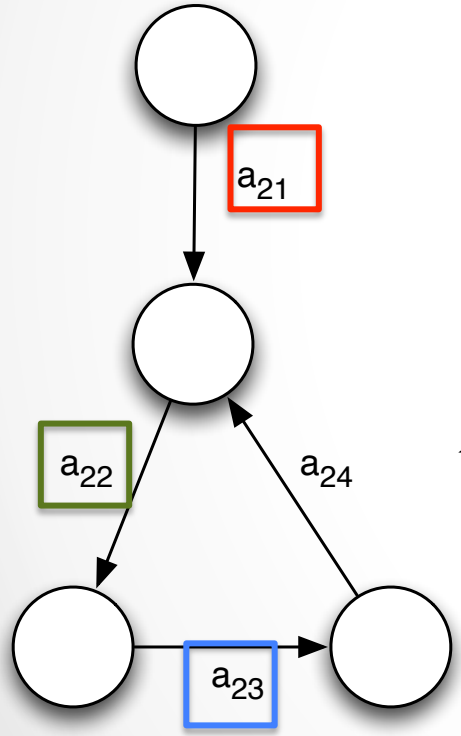


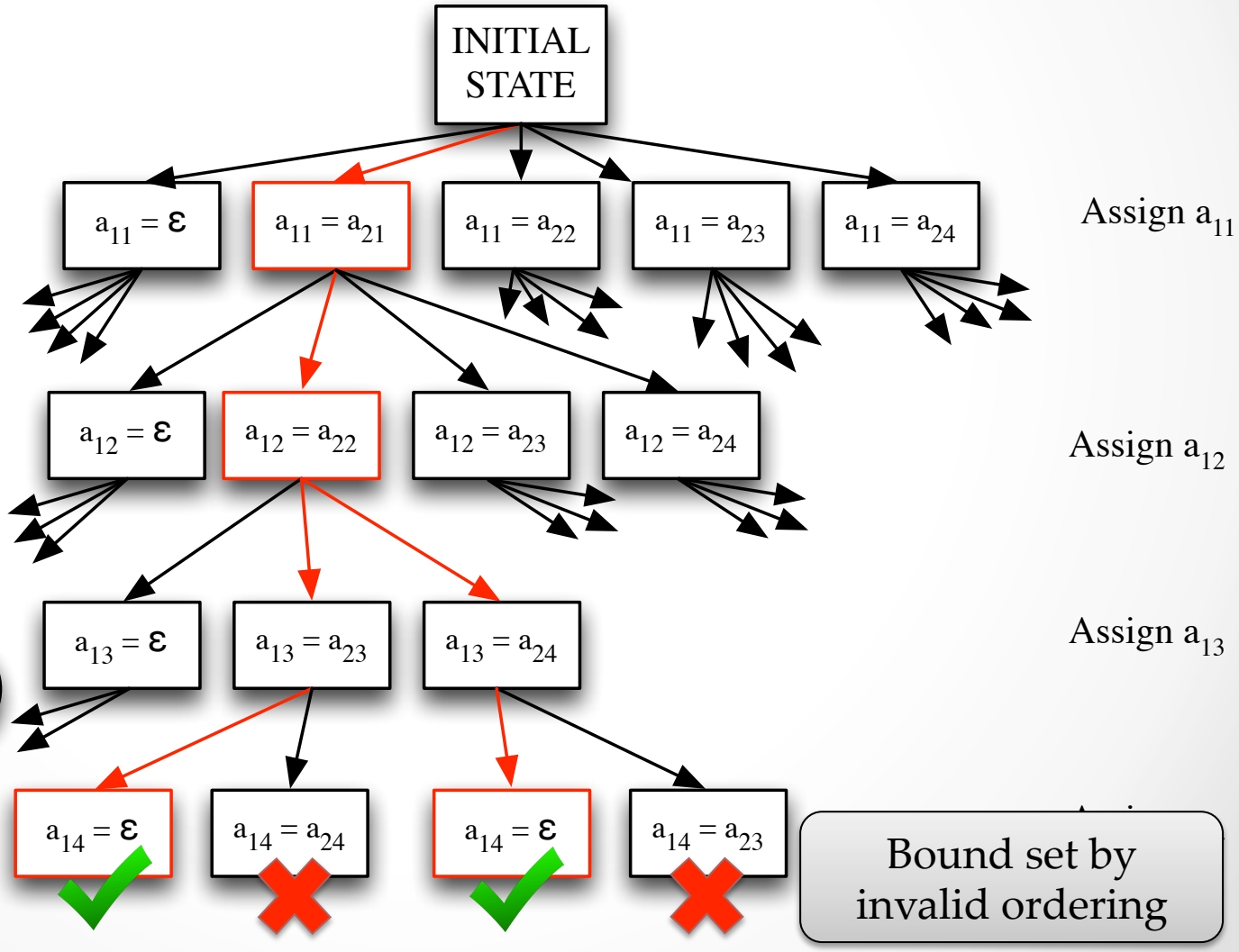


Profit = 1

Branch & Bound Strategy

- Test traces: <a_{11}, a_{12}, a_{13}> <a_{11}, a_{12}, a_{14}>
- Model:





Profit = 3

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 ?

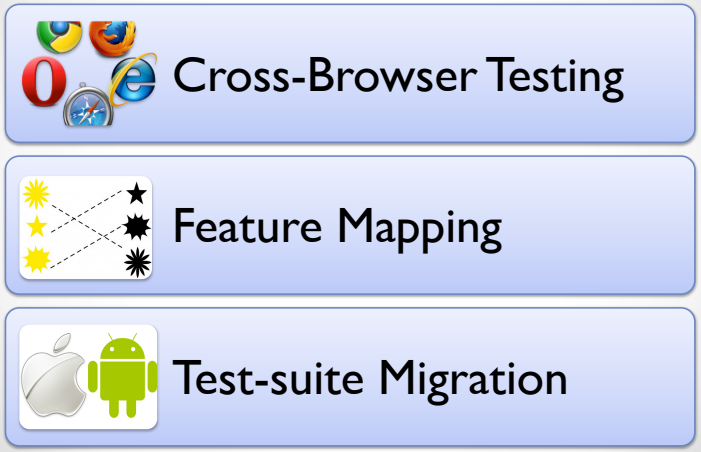
Plan

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

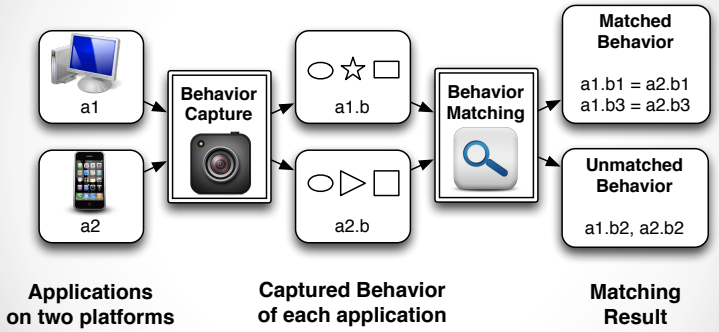
Summary

Web & Mobile Applications

Problem Space



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