Toward Black-box Detection of Logic Flaws in Web Applications

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Agenda

- Problem
- Approach
  - Model Inference
  - Behavioral Patterns Extraction
  - Attack Pattern-based Test Case Generation
  - Test Execution and Oracle
- Evaluation
- Conclusion

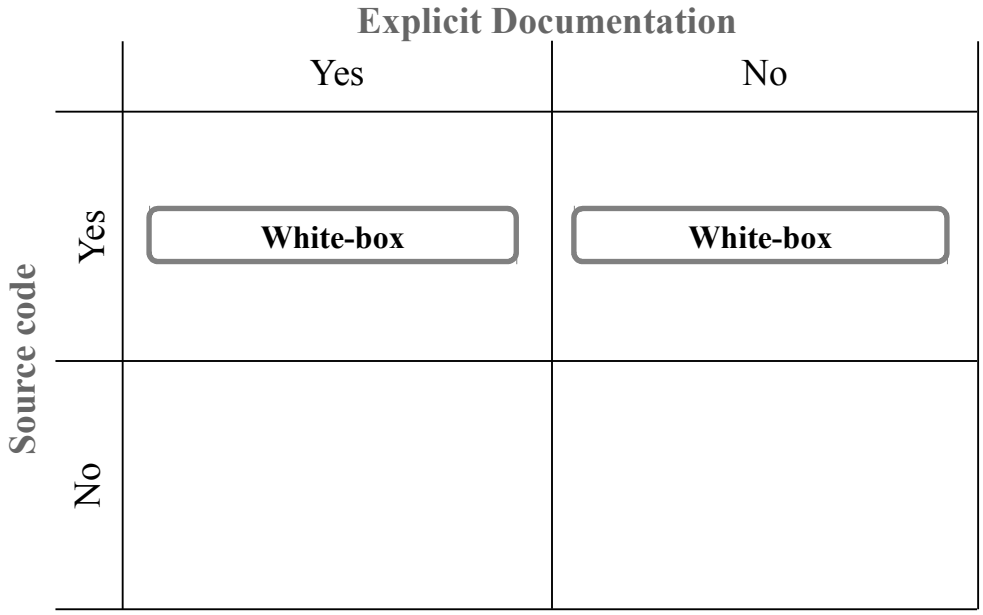
Logic Flaws

- Also known as design flaws/errors, business/application logic errors/flaws
- Lack a formal definition
  - CWE-ID 840: Business logic errors are "w*eaknesses […] that commonly allow attackers to manipulate the business logic of an application*"
- Mainly caused by insufficient validation of the application workflow and data flow
- Can exhibit patterns, e.g.
  - Improper authentication/authorization

Problem

Source code \ Explicit Documentation	Yes	No
Yes		
No		

Problem



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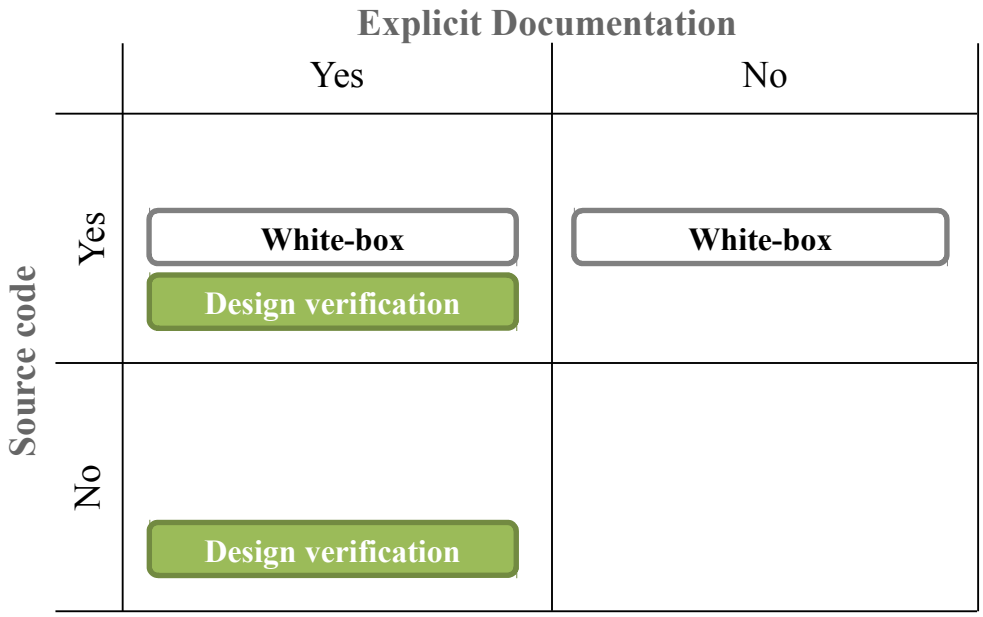

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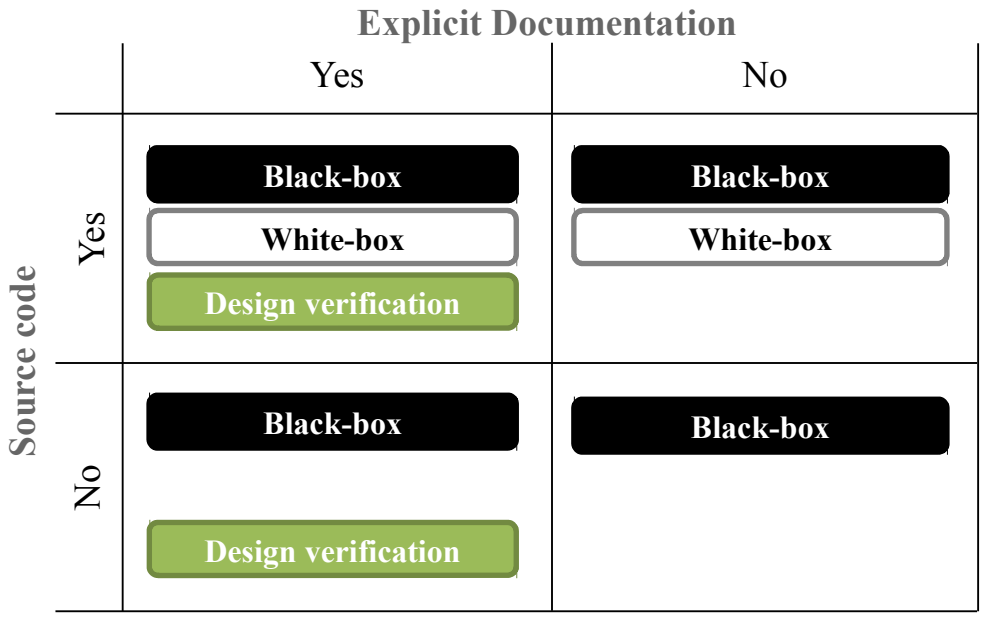

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- Black-box testing, e.g., web scanners [DoupèDIMVA10, WangS&P11, WangS&P12]
  - Cannot automatically detect logic flaws

➔ ***Testing for logic flaws is done manually***

Our Approach

Overview

1) Model Inference

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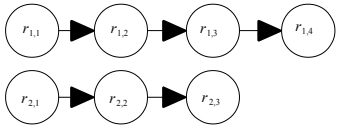
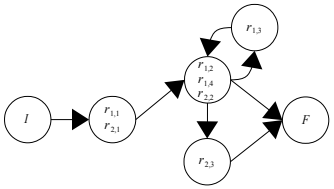
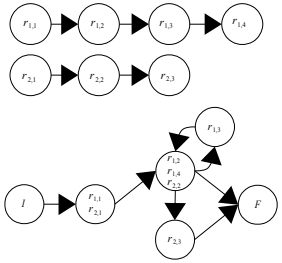
Resource Abstraction



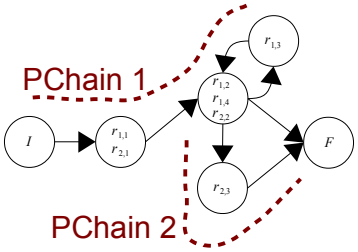
Resource Clustering



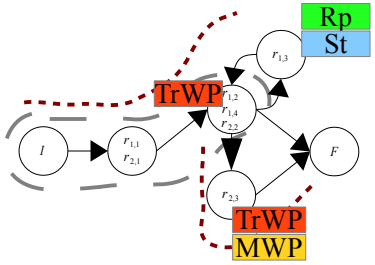
2) Behavioral Patterns



Data flow Patterns



Workflow Patterns



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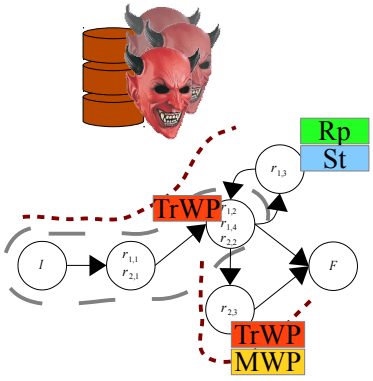

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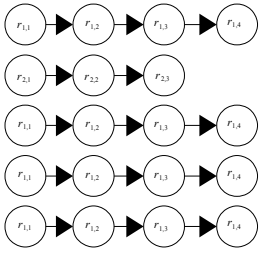

4) Test Cases Execution

Execution

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Oracle

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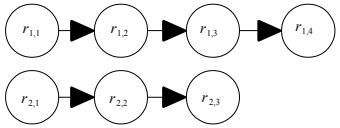

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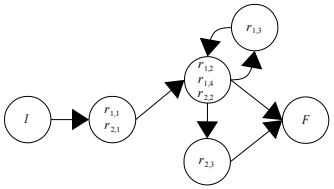

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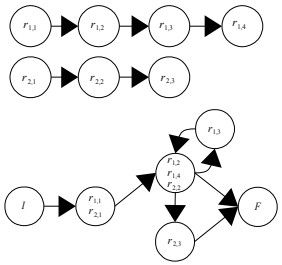

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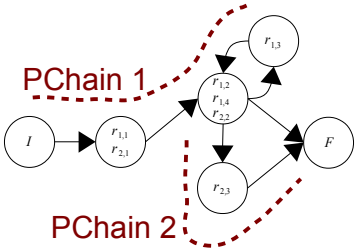

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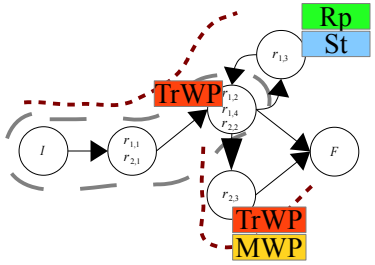

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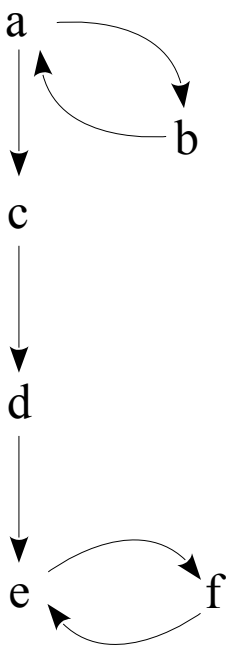

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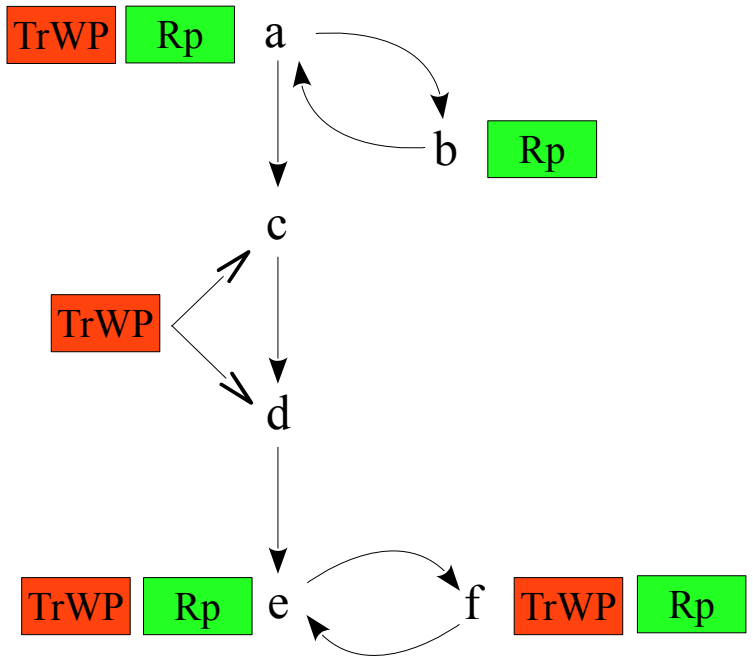

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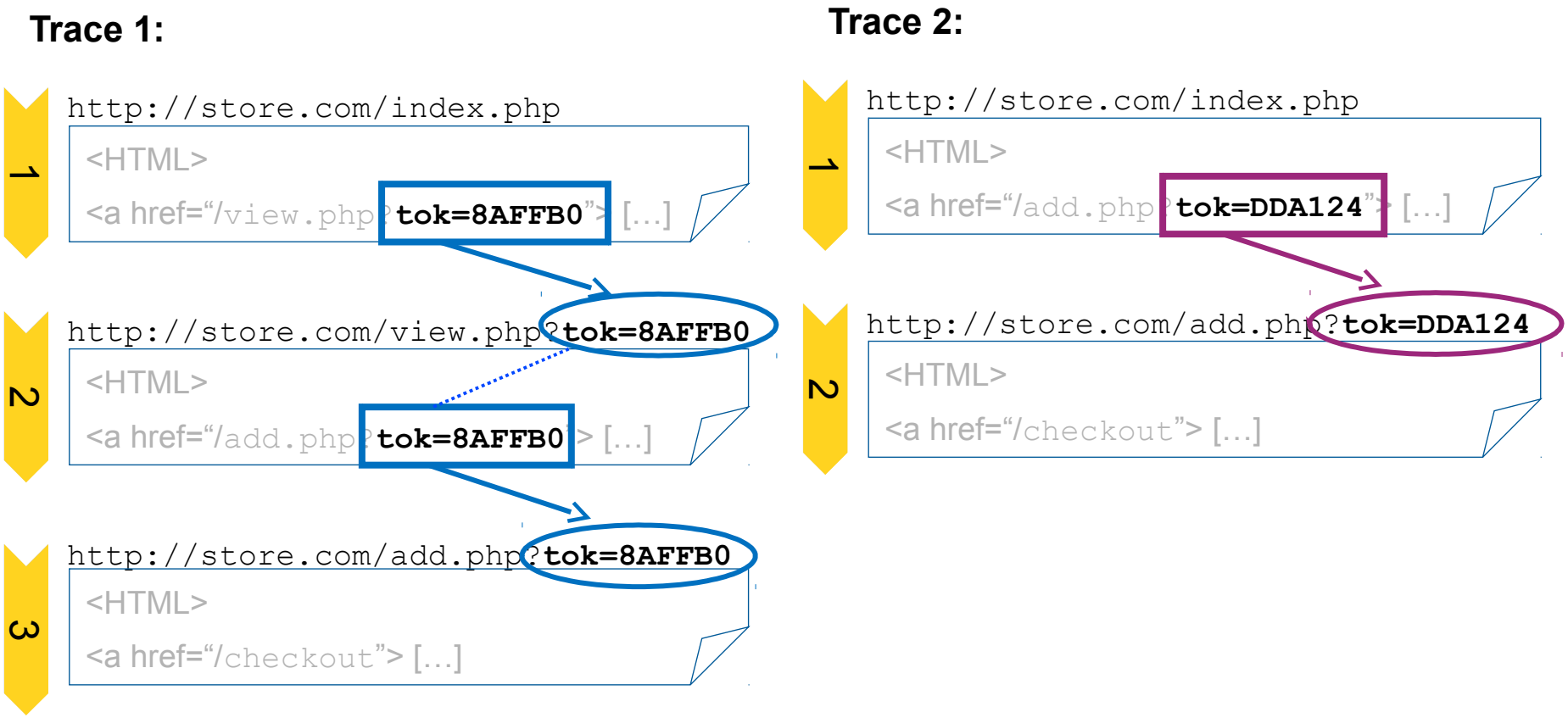

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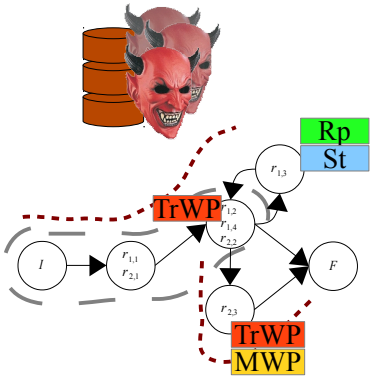

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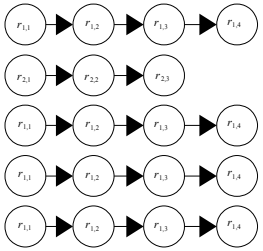

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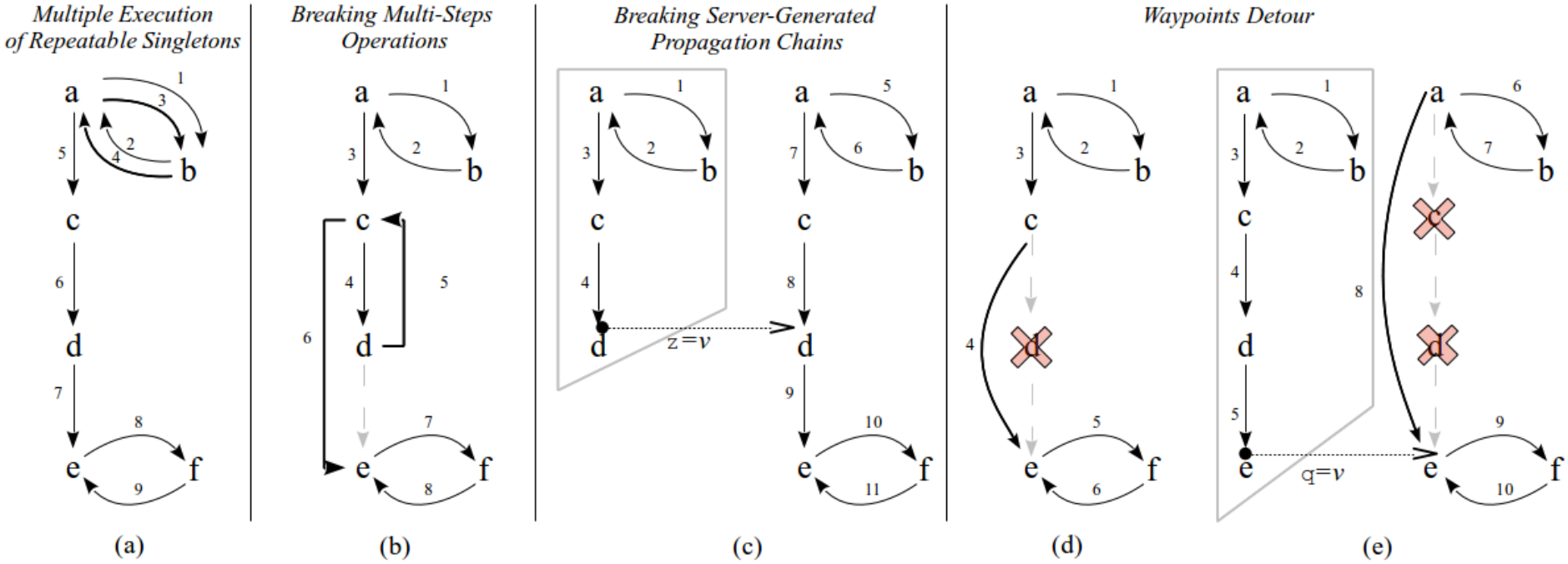

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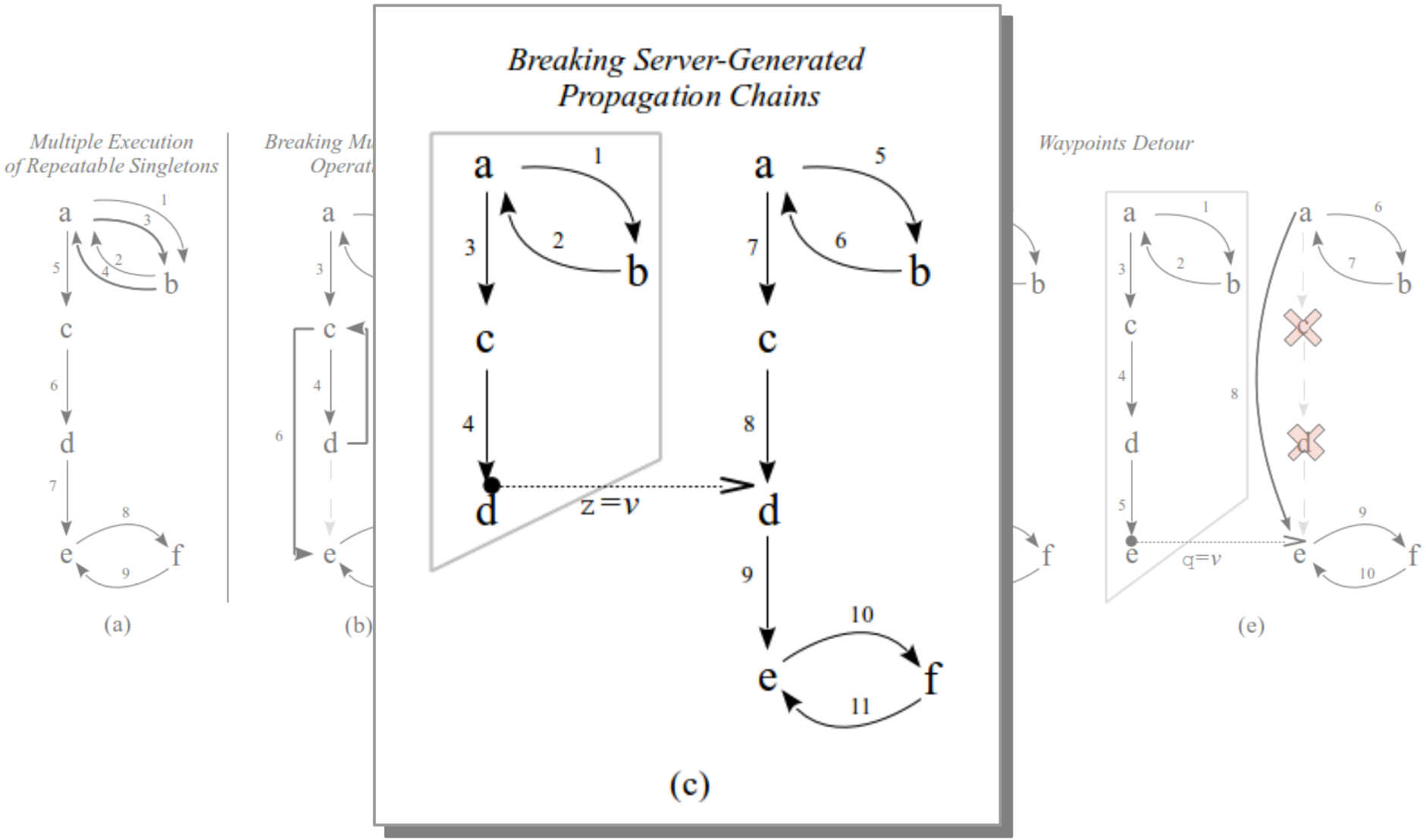

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Security Property:

$$ord_{placed} \wedge onStore(S) \implies$$
$$\blacksquare(paid(U,I) \wedge toStore(S) \ \wedge$$
$$\blacksquare(ack(U,I) \wedge onStore(S)))$$

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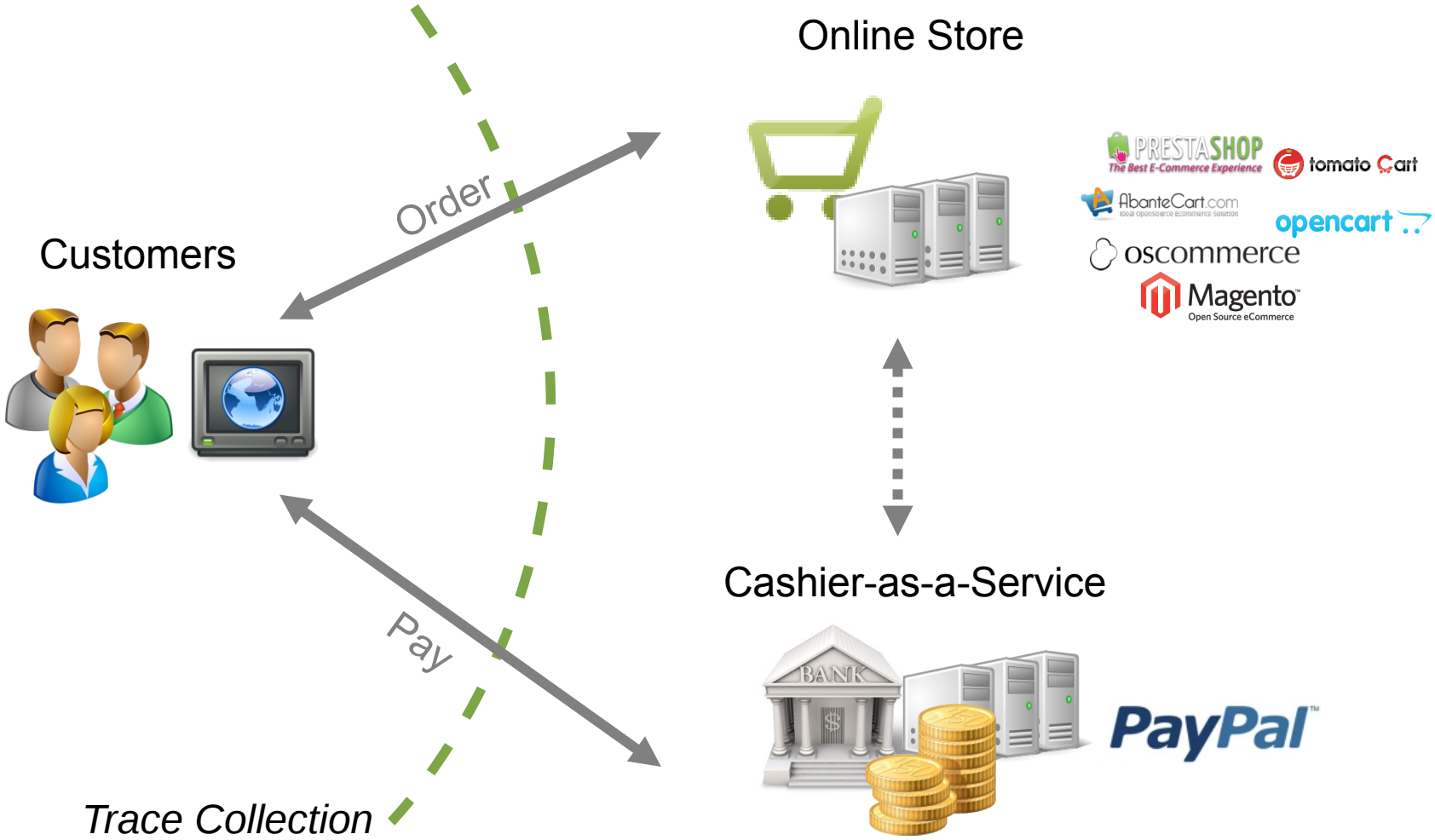
Evaluation

Case Study: Shopping Cart Web Applications



Experiments and Results

- Target: 7 popular eCommerce Web Applications
  - Deployed by >13M online stores
- Testbed: created 12 Paypal sandbox configurations
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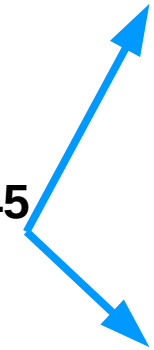

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    - 983 not violations
    - **909 violation**
      - 849 caused by bugs in the GUI
      - **90 caused by logic flaws**

Vulnerabilities

- 10 previously-unknown vulnerabilities
  - Allowing to shop for free or pay less

Application	Shop for free	Pay less	Session Fixation	
AbanteCart	x			Notified Devel.
Magento				
OpenCart		x x		Notified Devel.
osCommerce	x	x		CVE-2012-2991
PrestaShop				
TomatoCart	x	x x	x	CVE-2012-4934
CS-Cart	x			CVE-2013-0118

Conclusion

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- Proposed a black-box technique to detect logic flaws in web applications
- Combined passive model inference and attacker pattern-based test case generation
- Developed a prototype
  - assessed against 7 popular eCommerce web applications
- Discovered 10 previously-unknown logic flaws
  - allow an attacker to shop for free or pay less

References

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[WangS&P11] R. Wang, S. Chen, X. Wang, S. Qadeer
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[WangS&P12] R. Wang, S. Chen, X. Wang
Signing Me onto Your Accounts through Facebook and Google: a Traffic-Guided Security Study of Commercially Deployed Single-Sign-On Web Services. IEEE S&P 2012

EURECOM
Sophia Antipolis

Thank you

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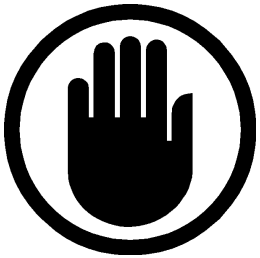
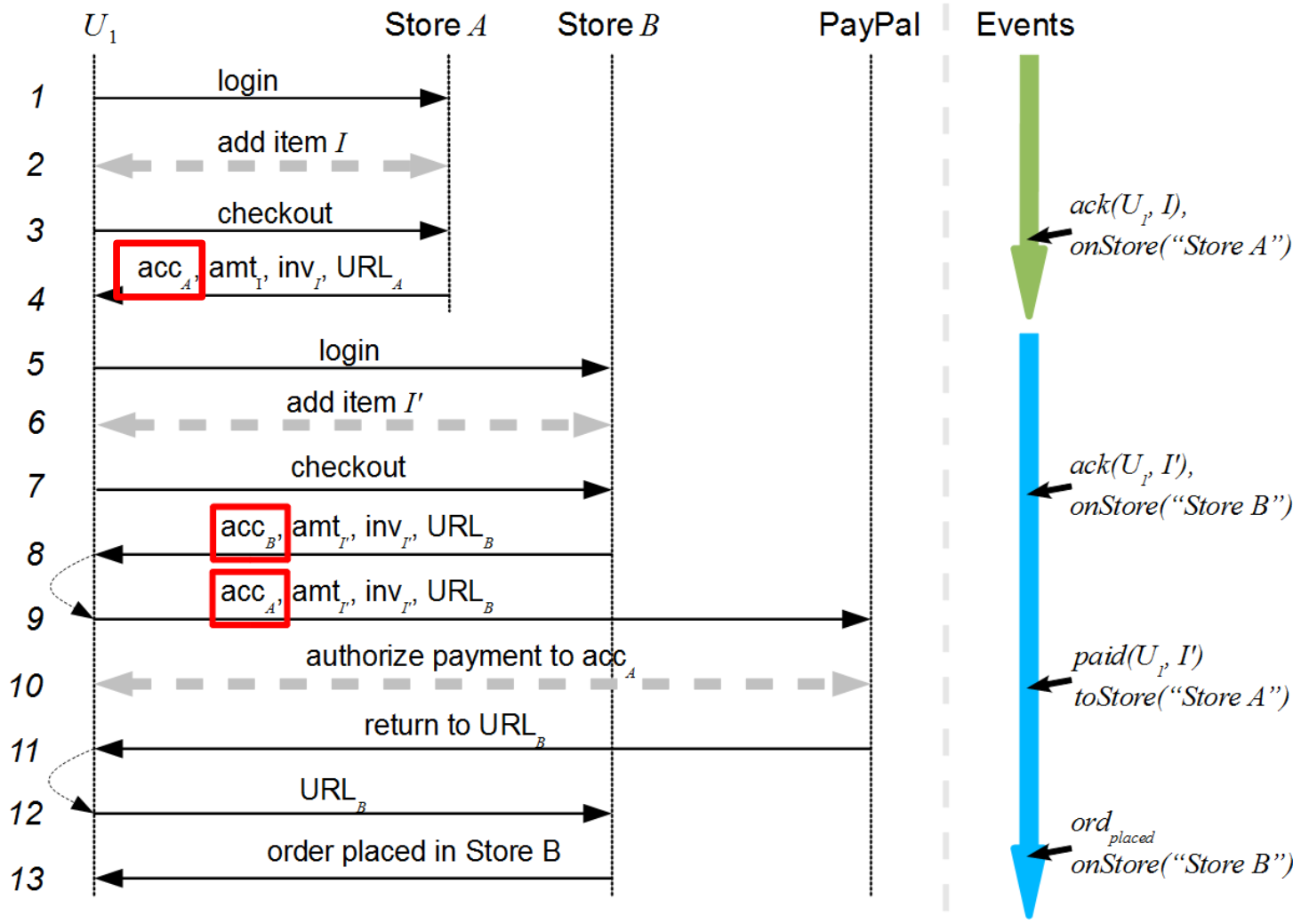
Backup slides



Results

Applications	CaaS	# Test Cases	# TC Exec.	Property Violations	
				due to Bugs	due to Vulns
AbanteCart	Std	233	74	16	1
Magento	Exp	343	240	65	-
	Std	386	210	126	-
OpenCart	Exp	173	140	46	12
	Std	135	71	30	-
osCommerce	Exp	165	117	22	20
	Std	225	128	34	1
PrestaShop	Exp	137	85	-	-
TomatoCart	Exp	302	238	65	25
	Std	224	115	24	-
CS-Cart	Exp	600	347	313	-
	Std	222	127	108	1
	Total	***3145***	***1892***	***849***	***60***

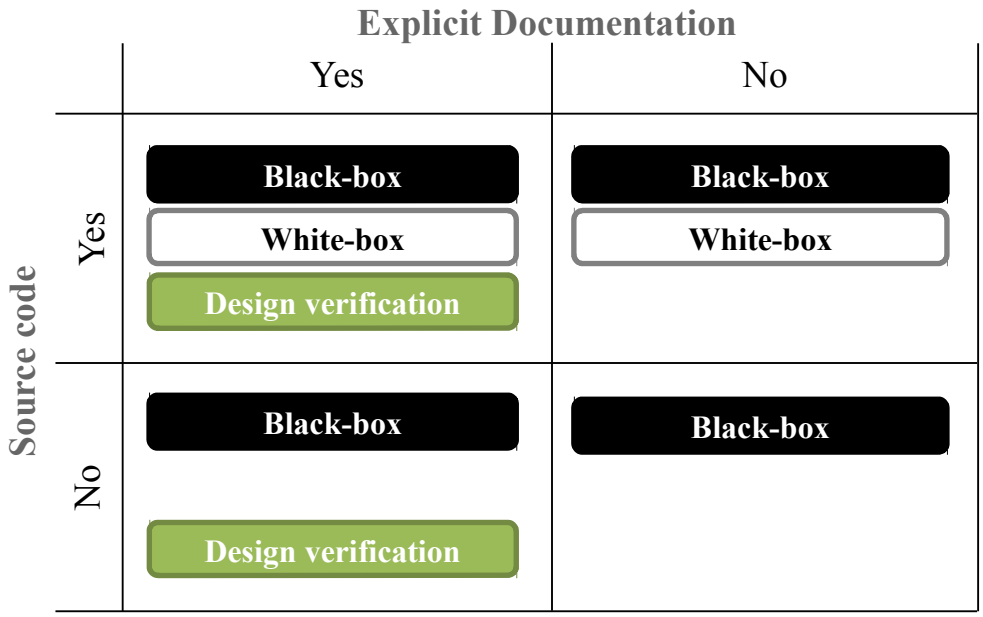
osCommerce and AbanteCart: Shopping for Free



OWASP Testing Guide v3: Manual Testing

- Understand the web application
  - Intended workflow and data flow
- Design tests to violate workflow and data flow
  - E.g., reorder steps, replay tokens, …
- Run tests and observe the results

Problem



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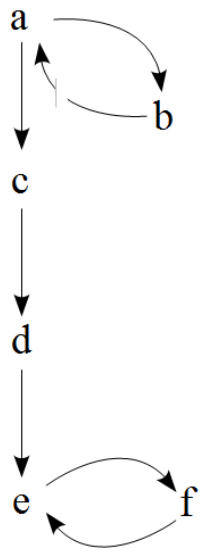

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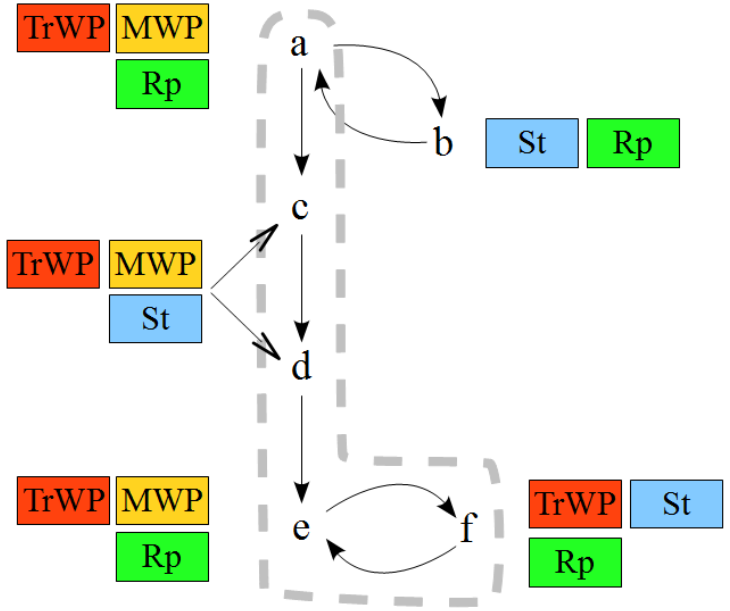

TrWP : Trace Waypoints

St : Singleton Nodes

: Multi-step Operations

Rp : Repeatable Operations

MWP : Model Waypoints