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Resource Interactions in Mobile Applications: Three Presentations for the SPL Testing Community

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Presentation Overview

- Characterizing Resource Interaction Failures in Mobile Applications (Doctoral Symposium)
- Resource Interaction Failures in Mobile Applications: A Challenge for the Software Product Line Testing Community (Challenges and Solutions Track)
- RIFDiscoverer: A Tool for Finding Resource Interaction Failures (Demonstrations and Tools Track)

SPLC 2024 – Doctoral Symposium

CHARACTERIZING RESOURCE INTERACTION FAILURES IN MOBILE APPLICATIONS

Summary

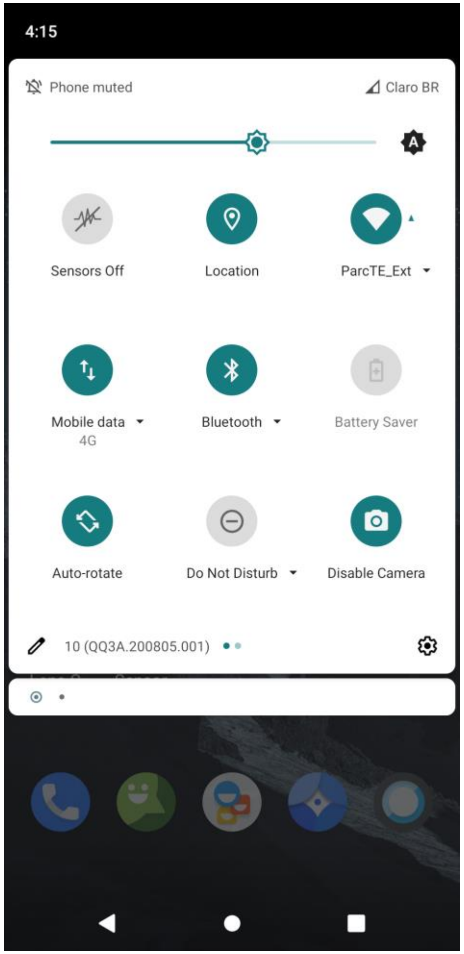
- Introduction
- Main Research Questions
- Research Method
- Preliminary Results
- Work Plan

Introduction

- Mobile devices have a rich set of resources
- “Resource” refers to sensors, radios, and user-controlled options
- User interaction with devices can enable or disable the resources
- Unexpected application behavior can occur in specific resource settings
- However, the testing of all input combinations is impracticable

Resources in mobile applications

- Platform configurations
  - Enabled/disabled resources
- Communication features
  - Wi-Fi, Bluetooth, etc
- Sensors
  - Accelerometer, Gyroscope, etc
- User-controlled options
  - Battery saver, Auto-rotate, etc



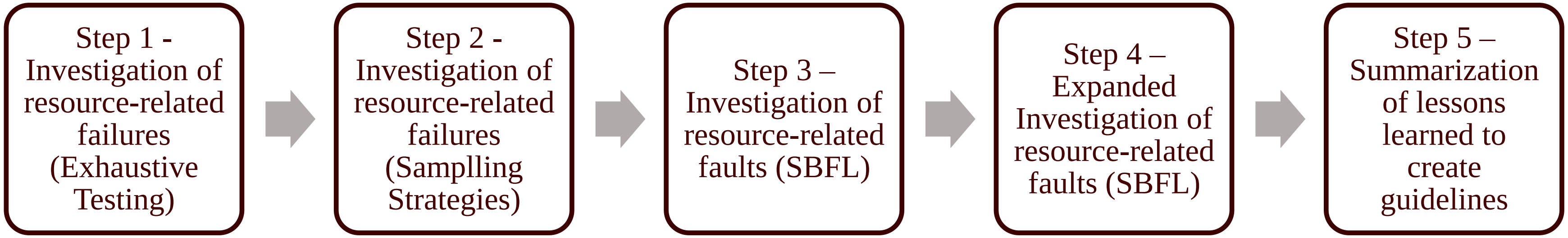
Sampling Strategies

- Resource interactions are like Feature interactions
- Resource settings are 14-tuple of resource and state pairs
- Sampling strategies are alternatives for decreasing the testing effort
- Random, One Enabled, One Disabled, Most Enabled Disabled, Pairwise

Main Research Questions

- RQ1: Which resource interactions more frequently cause failures?
- RQ2: Which sampling strategies are the most effective to find resource interaction failures in mobile applications?
- RQ3: To what extent the Spectrum-based Fault Localization technique can be used for locating faults in mobile applications?

Research Method



Step 1 - Investigation of resource-related failures (Exhaustive Testing)

Step 2 - Investigation of resource-related failures (Samplling Strategies)

Step 3 – Investigation of resource-related faults (SBFL)

Step 4 – Expanded Investigation of resource-related faults (SBFL)

Step 5 – Summarization of lessons learned to create guidelines

Dataset

- 20 Android applications
- 14 target resources
  - Auto Rotate, Battery Saver, Bluetooth, Camera, Do Not Disturb, Location, Mobile Data, Wi-Fi, Accelerometer, Gyroscope, Light, Magnetometer, Orientation, Proximity
- Extended test suites

Dataset Excerpt

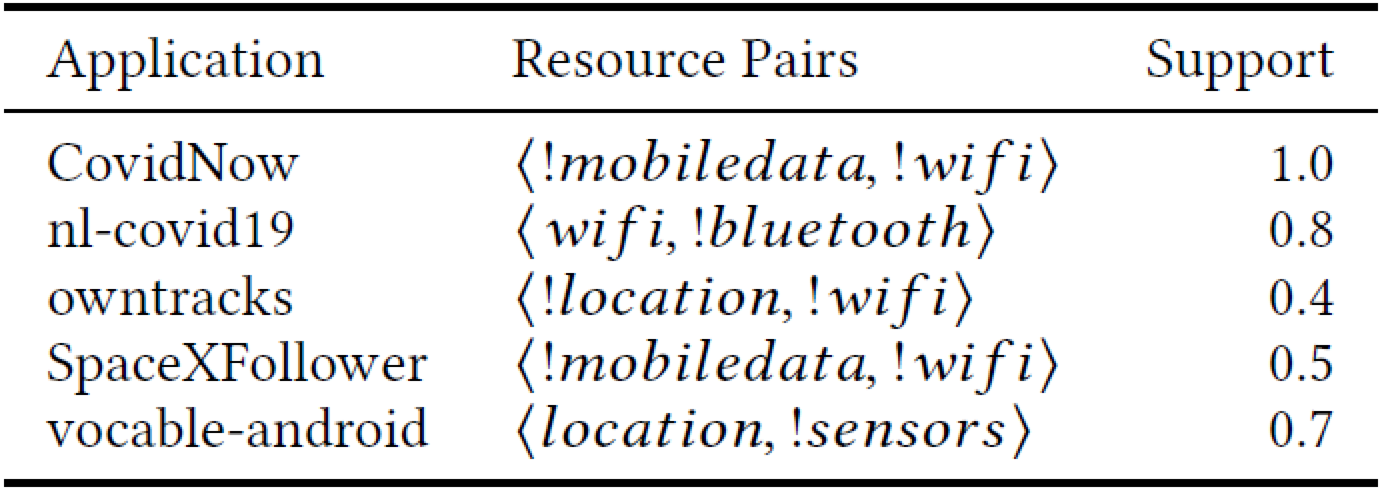
NAME	LOC	#Test Cases	Test LOC	RESOURCES
AnkiDroid	158 K	164	2,770	Cam, MD, Wi-Fi
CovidNow	2 K	21	540	MD, Wi-Fi
Iosched	27 K	9	473	Loc, MD, Wi-Fi
Mixin-Messenger	168 K	160	3,732	BT, Cam, Loc, MD, Wi-Fi
Moonshot	**0,455 K**	28	**464**	MD, Wi-Fi
Radio-Droid	22 K	23	1,735	BT, MD, Wi-Fi
WordPress	**347 K**	115	**3,674**	Cam, MD, Wi-Fi

BT - Bluetooth
Cam - Camera
Loc - Location
MD - Mobile Data

Test suite instrumentation

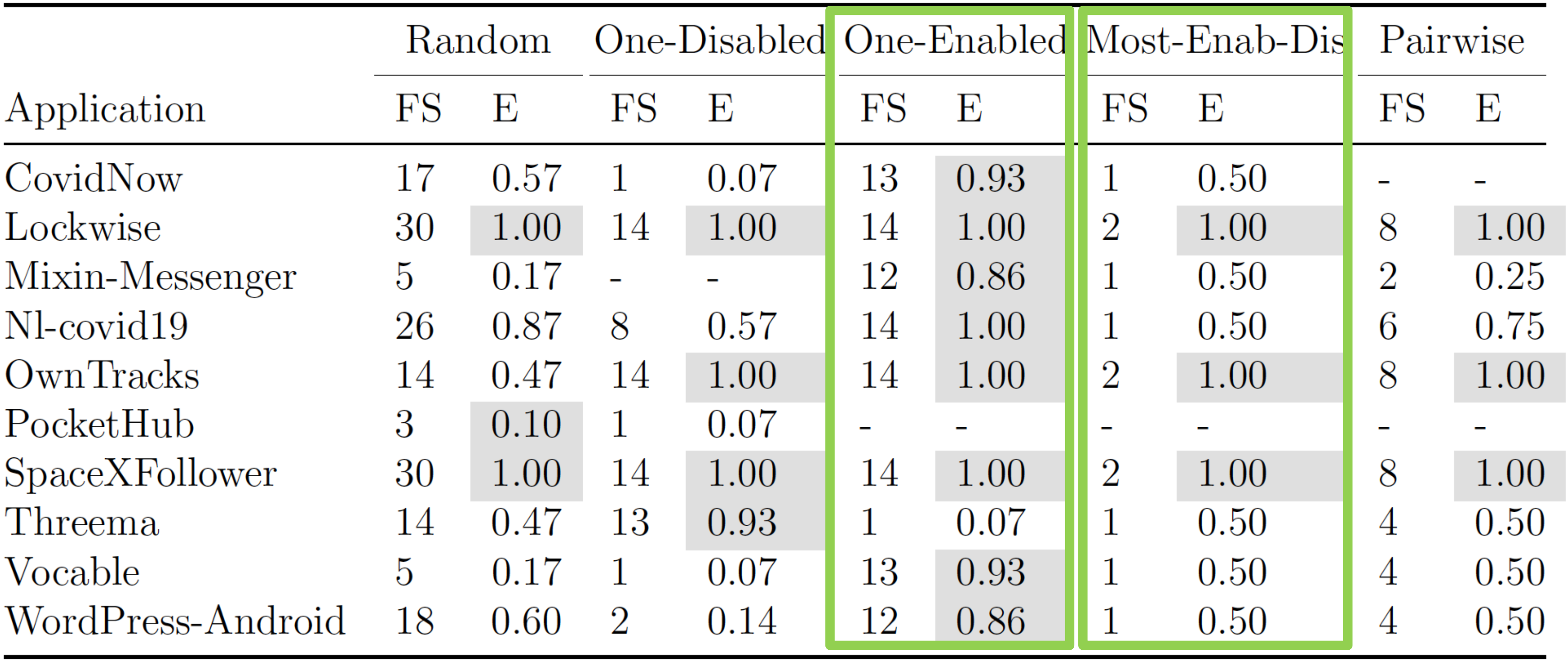
- Functional tests are the target
  - Android APIs for interacting with the device
- Extension by means of UI Automator
- Each test class is extended with instrumentation code
- Before each test case the instrumentation code is executed
- Test reports are processed

Resource Interactions Most Likely to Cause a Failure (RQ1)



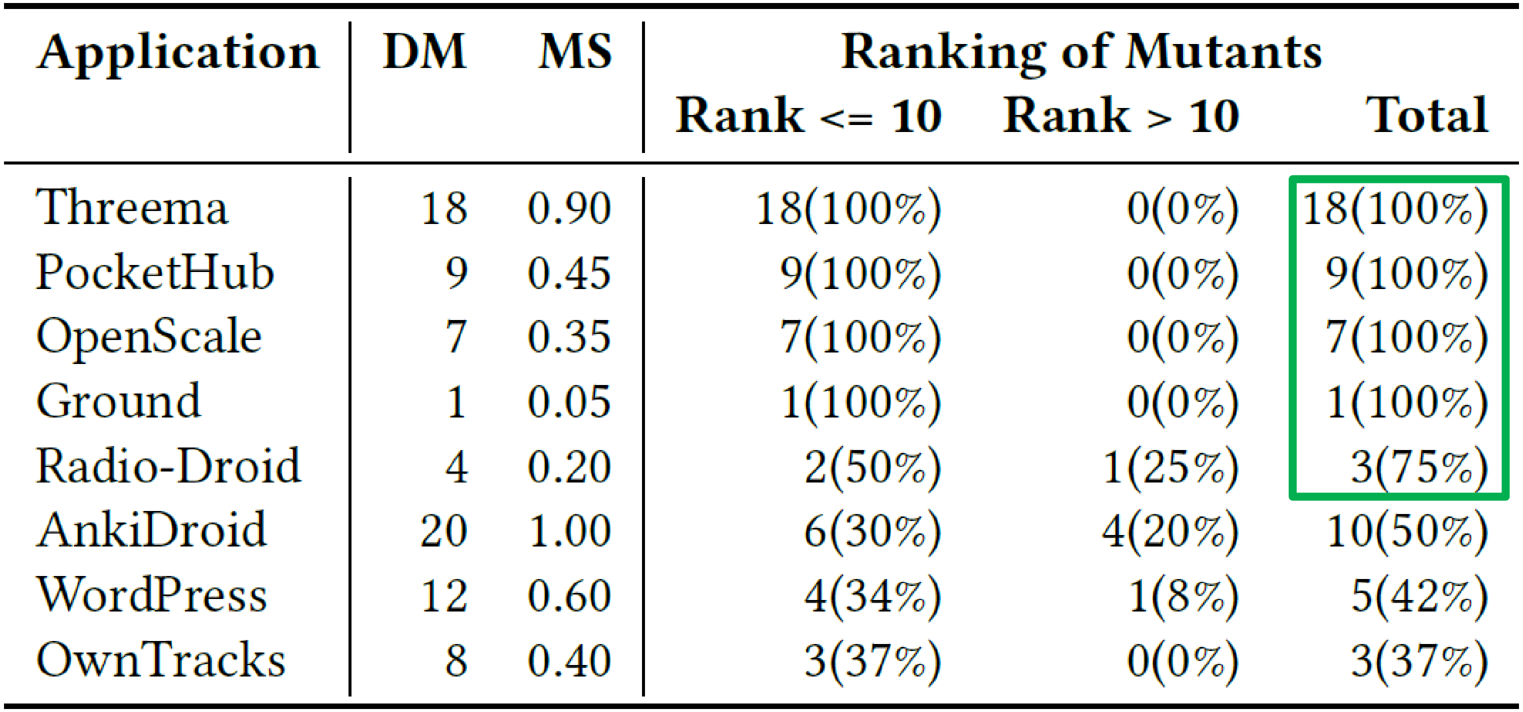
Application	Resource Pairs	Support
CovidNow	$\langle !mobiledata, !wifi \rangle$	1.0
nl-covid19	$\langle wifi, !bluetooth \rangle$	0.8
owntracks	$\langle !location, !wifi \rangle$	0.4
SpaceXFollower	$\langle !mobiledata, !wifi \rangle$	0.5
vocable-android	$\langle location, !sensors \rangle$	0.7

The Most Effective Testing (RQ2)



	Random		One-Disabled		One-Enabled		Most-Enab-Dis		Pairwise	
Application	FS	E	FS	E	FS	E	FS	E	FS	E
CovidNow	17	0.57	1	0.07	13	0.93	1	0.50	-	-
Lockwise	30	1.00	14	1.00	14	1.00	2	1.00	8	1.00
Mixin-Messenger	5	0.17	-	-	12	0.86	1	0.50	2	0.25
Nl-covid19	26	0.87	8	0.57	14	1.00	1	0.50	6	0.75
OwnTracks	14	0.47	14	1.00	14	1.00	2	1.00	8	1.00
PocketHub	3	0.10	1	0.07	-	-	-	-	-	-
SpaceXFollower	30	1.00	14	1.00	14	1.00	2	1.00	8	1.00
Threema	14	0.47	13	0.93	1	0.07	1	0.50	4	0.50
Vocable	5	0.17	1	0.07	13	0.93	1	0.50	4	0.50
WordPress-Android	18	0.60	2	0.14	12	0.86	1	0.50	4	0.50

Use of SBFL for Mobile Applications (RQ3)



Application	DM	MS	Ranking of Mutants		
			Rank <= 10	Rank > 10	Total
Threema	18	0.90	18(100%)	0(0%)	18(100%)
PocketHub	9	0.45	9(100%)	0(0%)	9(100%)
OpenScale	7	0.35	7(100%)	0(0%)	7(100%)
Ground	1	0.05	1(100%)	0(0%)	1(100%)
Radio-Droid	4	0.20	2(50%)	1(25%)	3(75%)
AnkiDroid	20	1.00	6(30%)	4(20%)	10(50%)
WordPress	12	0.60	4(34%)	1(8%)	5(42%)
OwnTracks	8	0.40	3(37%)	0(0%)	3(37%)

* DM = Dead mutants

* MS = Mutation score

Work Plan

- Characterize faults behind the failures
  - How to identify faulty classes?
    - Failures are related to the test framework scope
    - Android event-driven nature is a challenge for debugging activities
- Expanded investigation of Spectrum based Fault Localization
  - Bug fix patterns

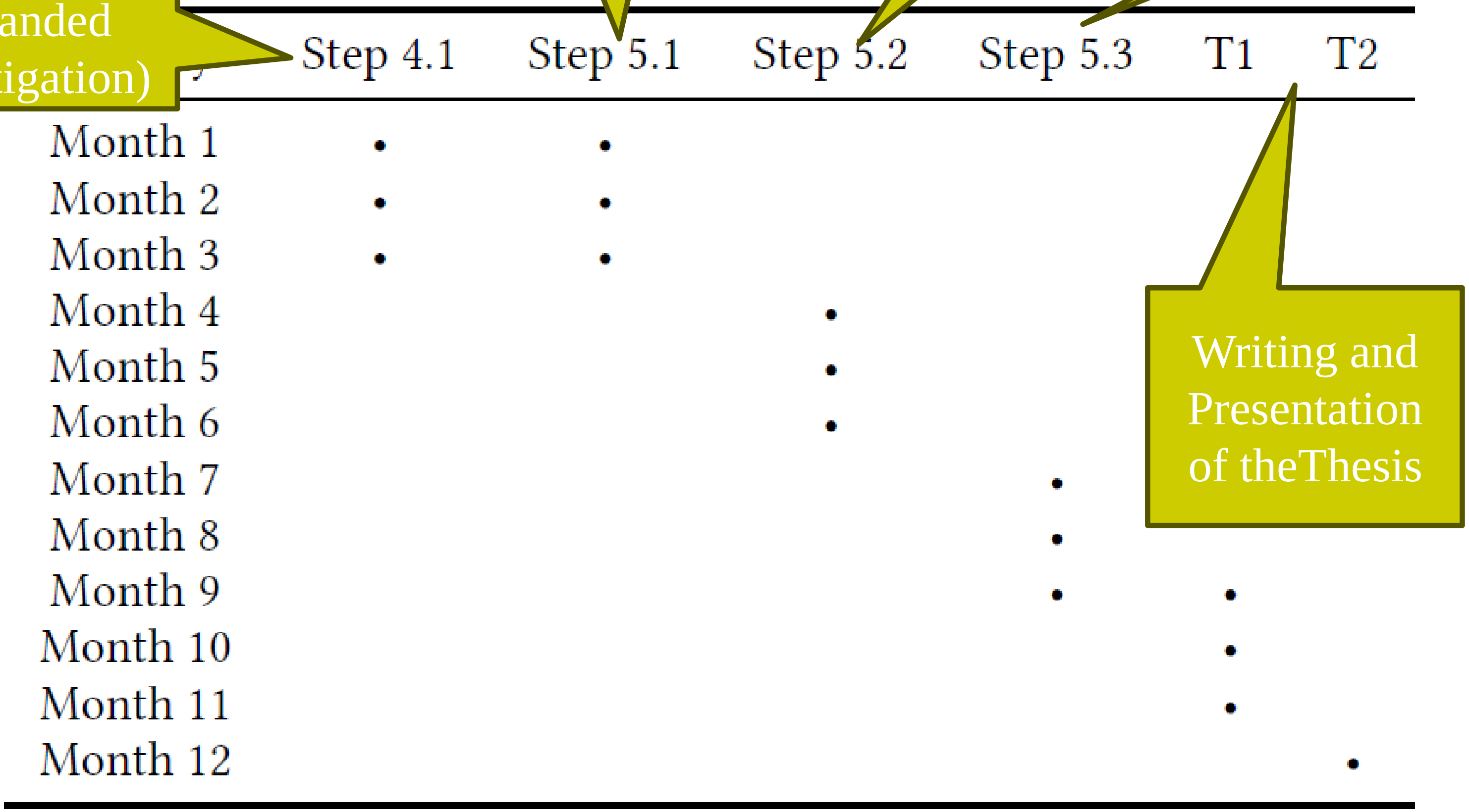
Remaining A s

Writing a Paper (SBFL expanded investigation)

Documentation of Guidelines

Validation of Guidelines

Writing Papers about Guidelines



	Step 4.1	Step 5.1	Step 5.2	Step 5.3	T1	T2
Month 1	●	●				
Month 2	●	●				
Month 3	●	●				
Month 4			●			
Month 5			●			
Month 6			●			
Month 7				●		
Month 8				●		
Month 9				●	●	
Month 10					●	
Month 11					●	
Month 12						●

Writing and Presentation of theThesis

Questions?

SPLC 2024 – Challenges and Solutions Track

CHARACTERIZING RESOURCE INTERACTION FAILURES IN MOBILE APPLICATIONS

Summary

- Introduction
- Dataset Overview
  - Artifacts
  - Test suite instrumentation
  - Failure Reports
  - Example of Use

Introduction

- Mobile devices have a rich set of resources
- “Resource” refers to sensors, radios, and user-controlled options
- User interaction with devices can enable or disable the resources
- Unexpected application behavior can occur in specific resource settings
- However, the testing of all input combinations is impracticable

Sampling Strategies

- Resource interactions are like Feature interactions
- Resource settings are 14-tuple of resource and state pairs
- Sampling strategies are alternatives for decreasing the testing effort
- Random (30), One Enabled (14), One Disabled (14), Most Enabled Disabled (2), Pairwise (8)

Proposed Challenge

- SPLC participants must propose testing strategies for mobile applications
  - Taking resource interactions into account
- The failure detection capability and the effectiveness must be higher than our baseline
  - Increase the number of unique detected failures and minimize the number of tested settings
- Solution efficiency (SE)

$$SE = \frac{FailingSettings}{TotalSettings}$$

Dataset Overview

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Cam - Camera
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Dataset Artifacts

- Application source code and test suites
- Found Failures (CSV)
- Analyzed Settings (CSV)

Test suite instrumentation

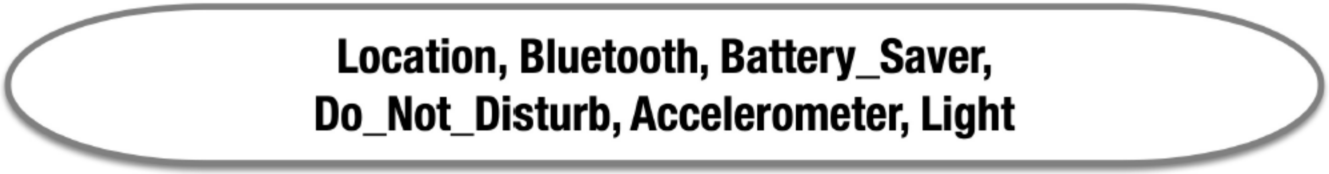
- Functional tests are the target
  - Android APIs for interacting with the device
- Extension by means of UI Automator
- Each test class is extended with instrumentation code
- Before each test case the instrumentation code is executed
- Test reports are processed

Failure Reports

NAME	FAILING SETTINGS	SOLUTION EFFICIENCY	#FAILURES
CovidNow	32	0.47	2
Lockwise	68	1.00	4
Mixin-Messenger	20	0.29	2
Nl-covid19	55	0.81	6
OwnTracks	68	1.00	3
PocketHub	4	0.06	1
SpaceXFollower	68	1.00	4
Threema	33	0.48	1
Vocable	24	0.35	7
WordPress	37	0.54	11

Example of Use

- Settings are provided in CSV files with only enabled resources



Location, Bluetooth, Battery_Saver,
Do_Not_Disturb, Accelerometer, Light

Example of Output

- Vocable is a communication tool for individuals who are speech impaired
- It uses the ARCore SDK to track the user's head movements
  - To understand where the user is looking on the screen
- When both Mobile Data and Wi-Fi are disabled (*verifyDefaultTextAppears* test)
  - ARCore fatal exception

Questions?

SPLC 2024 – Demonstrations and Tools Track

RIFDISCOVERER: A TOOL FOR FINDING RESOURCE INTERACTION FAILURES

Summary

- Introduction
- The RIFDiscoverer tool
  - Architecture
  - Design and Implementation
  - Test Instrumentation
- Preliminary Results

Introduction

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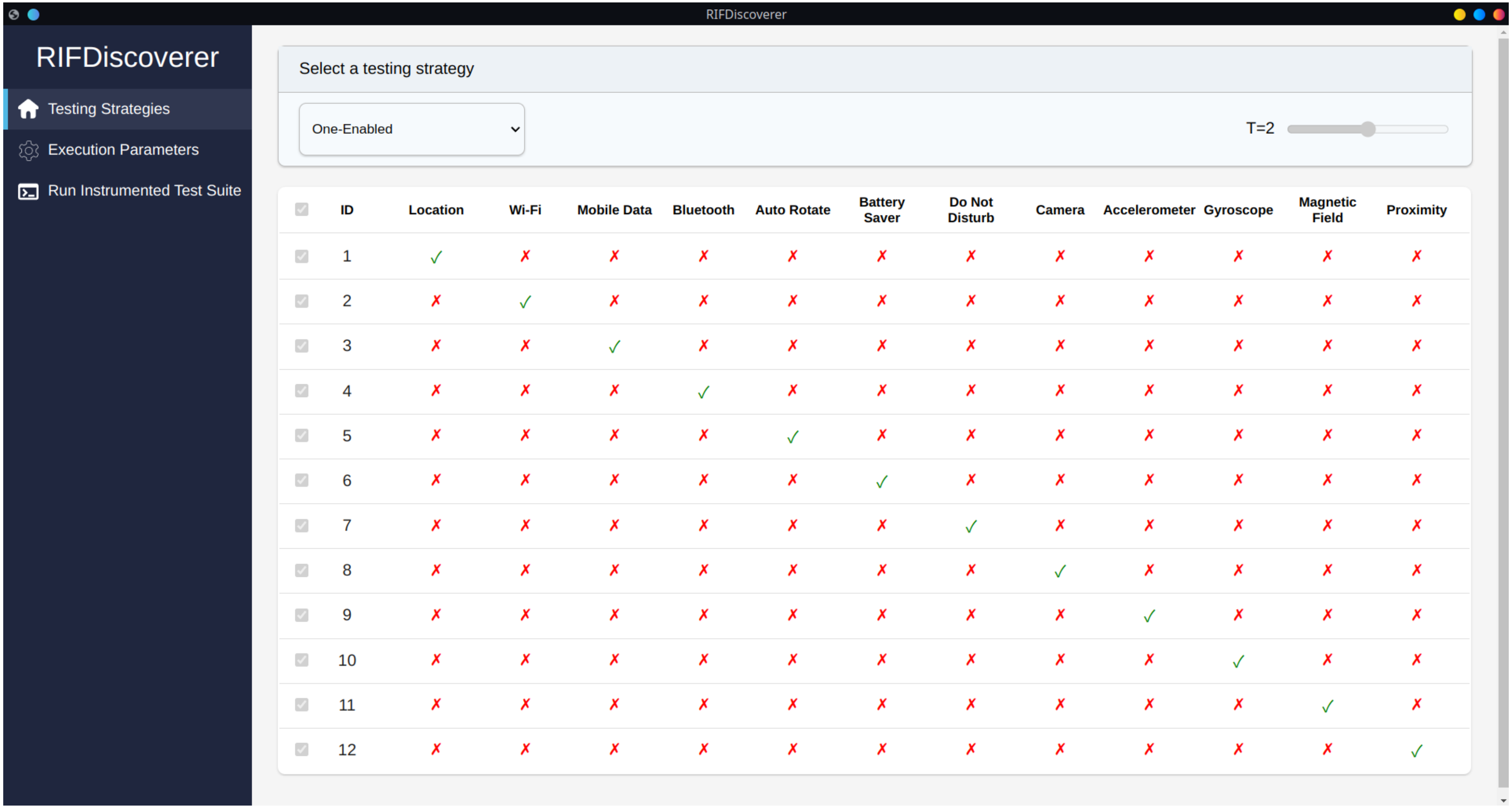
Resource Interactions

- Resource interactions are like feature interactions
- Sampling strategies are used for decreasing the testing effort
- RIFDiscoverer
  - Tool for helping developers and testers to deal with Resource Interaction Failures

The RIFDiscoverer Tool



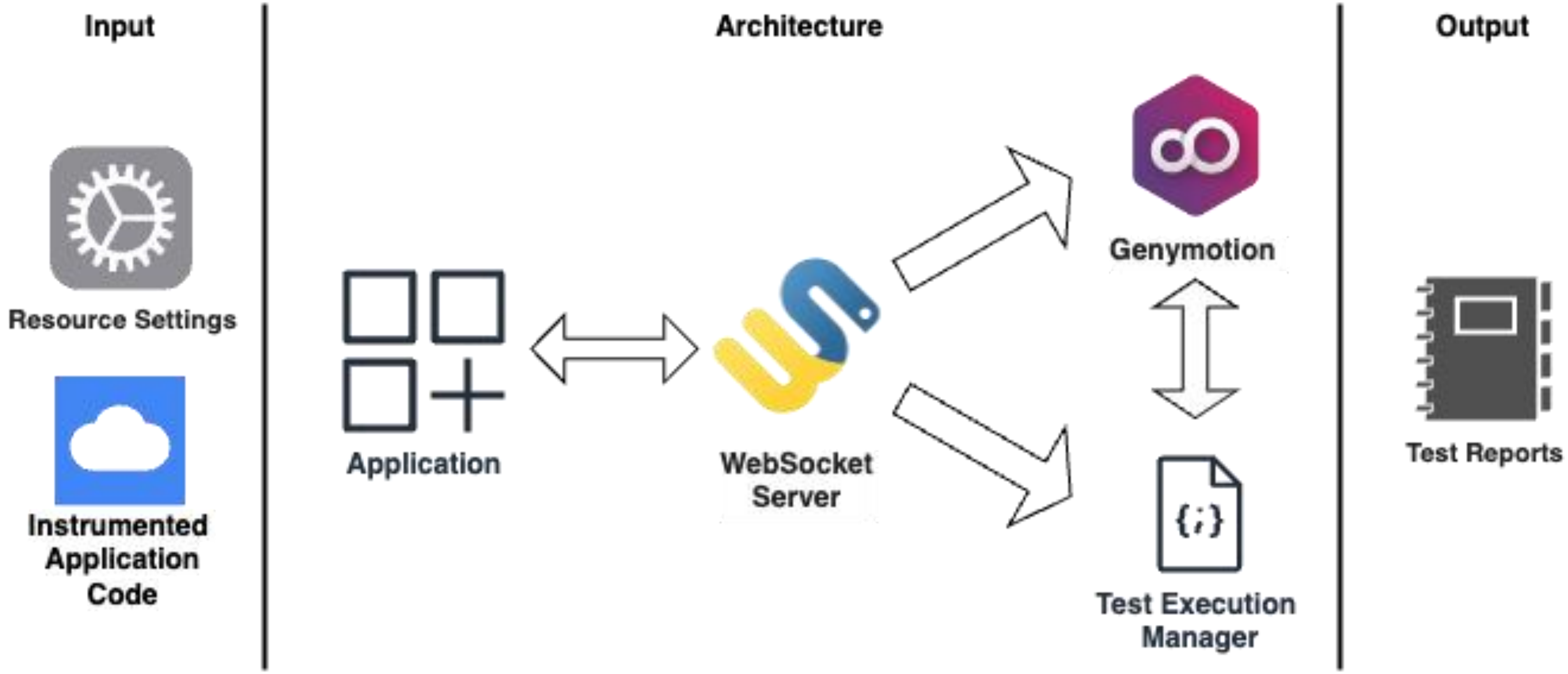
Select a testing strategy

One-Enabled

T=2

☑	ID	Location	Wi-Fi	Mobile Data	Bluetooth	Auto Rotate	Battery Saver	Do Not Disturb	Camera	Accelerometer	Gyroscope	Magnetic Field	Proximity
☑	1	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
☑	2	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
☑	3	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
☑	4	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗
☑	5	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗	✗
☑	6	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗	✗
☑	7	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗	✗
☑	8	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	✗
☑	9	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗
☑	10	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗
☑	11	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✗
☑	12	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓

Archicteture



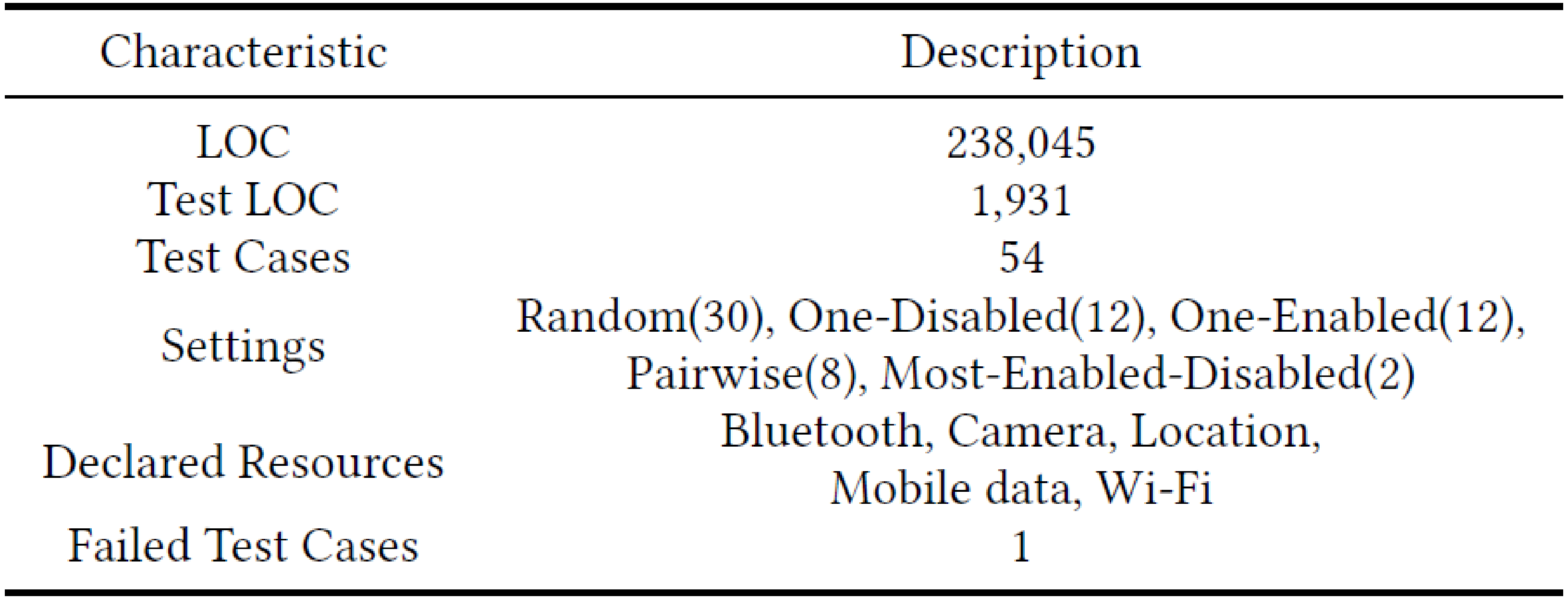
Design and Implementation

- Front-end implemented in Python EEL
  - Direct call to Python code
- WebSocket server
  - Run in a separate thread
  - Tool responsiveness

Test Instrumentation

- Functional tests are the target
  - Android APIs for interacting with the device
- Extension by means of UI Automator
- Each test class is extended with instrumentation code
- Before each test case the instrumentation code is executed
- Test reports are processed

Preliminary Results – Threema app



Characteristic	Description
LOC	238,045
Test LOC	1,931
Test Cases	54
Settings	Random(30), One-Disabled(12), One-Enabled(12), Pairwise(8), Most-Enabled-Disabled(2)
Declared Resources	Bluetooth, Camera, Location, Mobile data, Wi-Fi
Failed Test Cases	1

Questions?