A Qualitative Study on Framework Debugging

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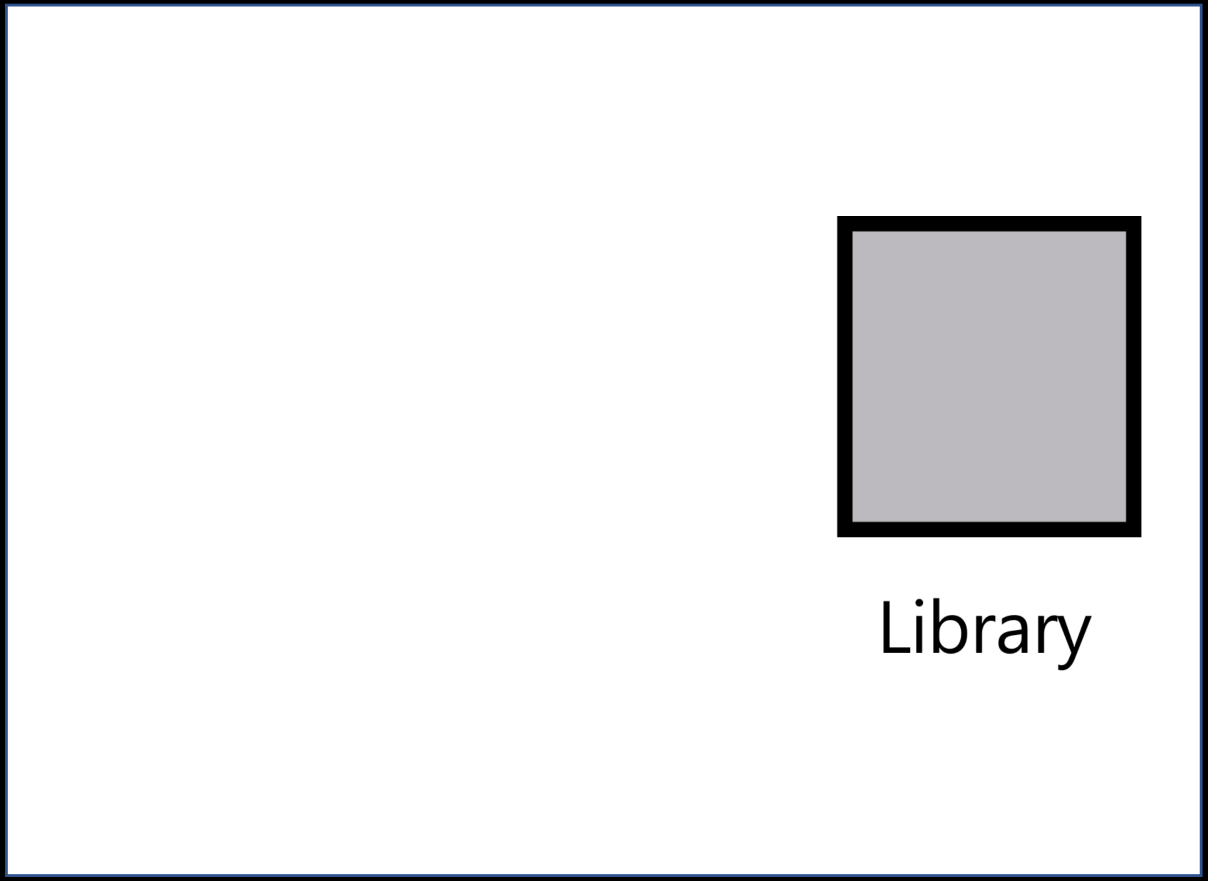
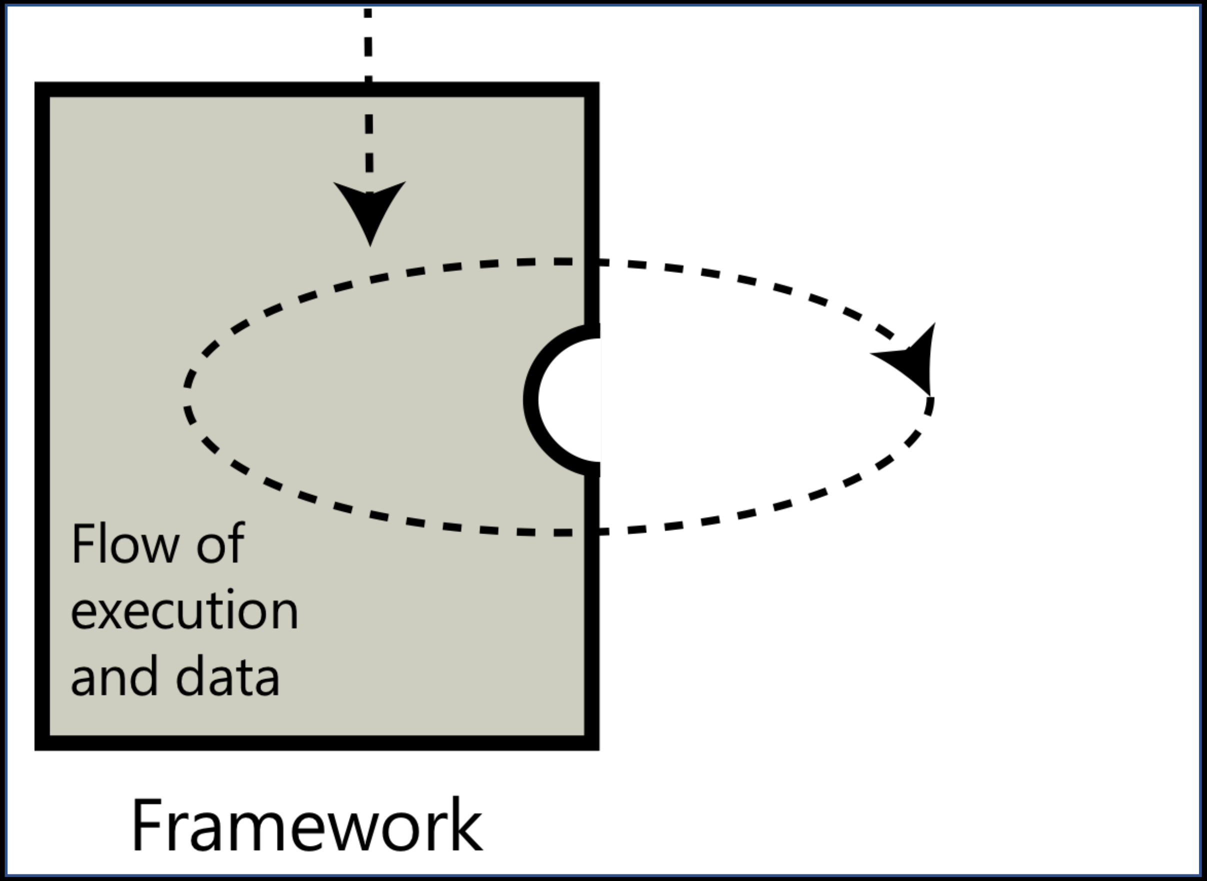
Frameworks are widely used in the software industry

Frameworks require a different development approach

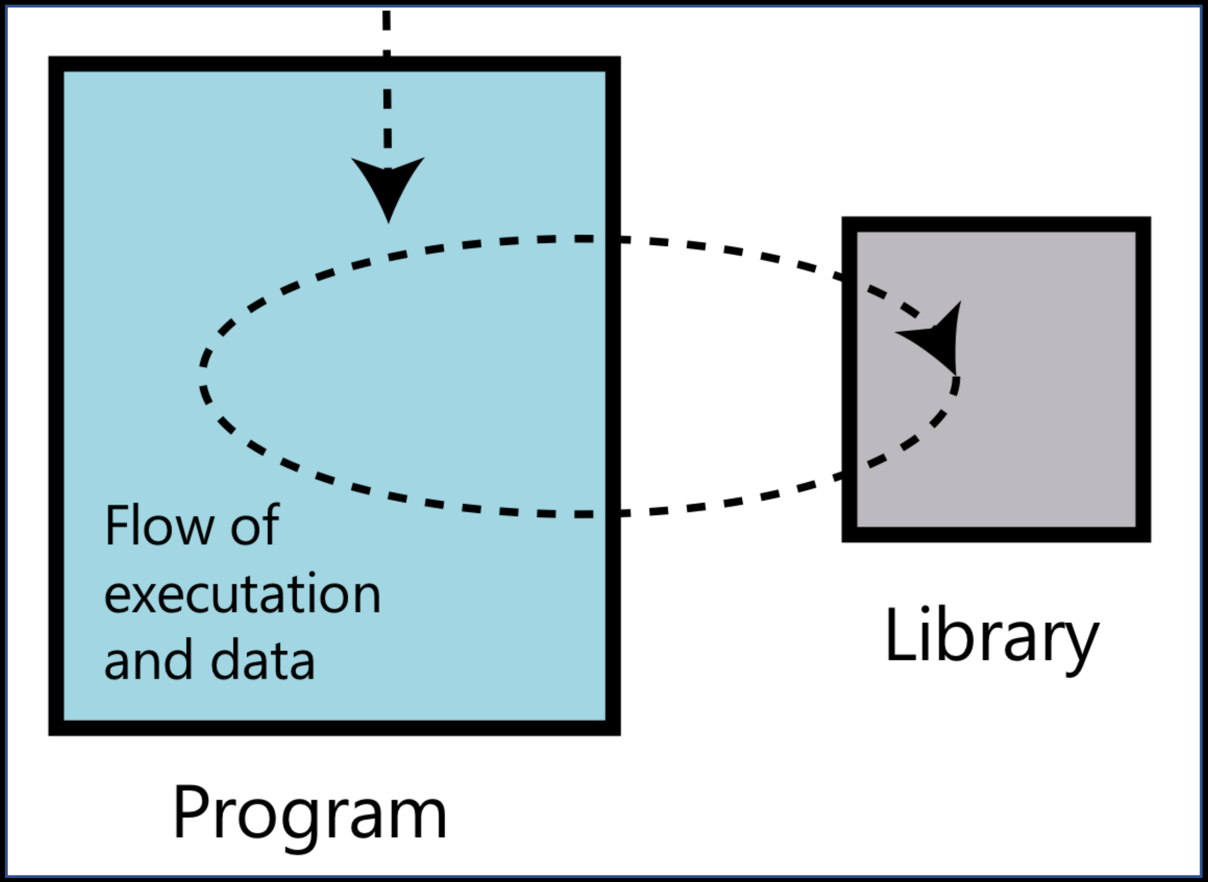




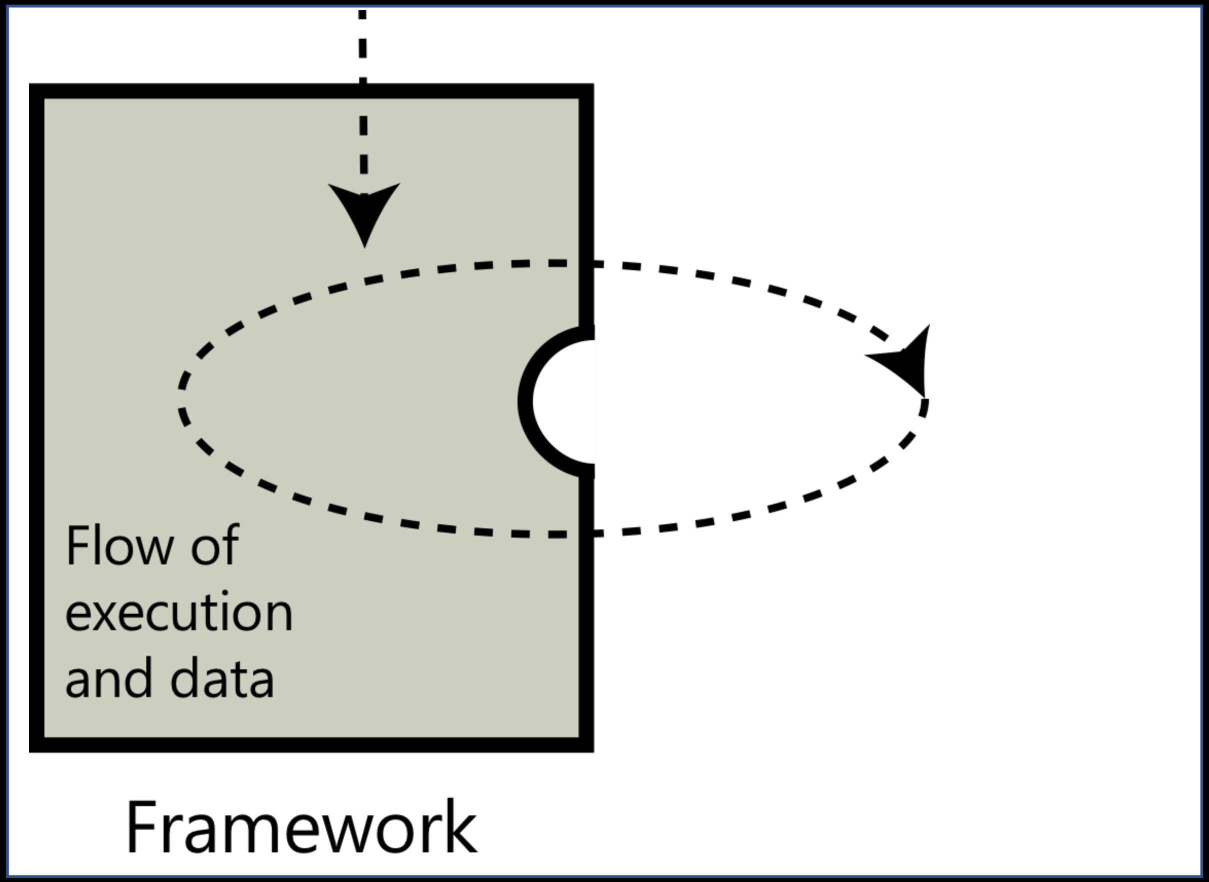
Library-based reuse

Framework-based reuse

Frameworks require a different development approach



Library-based reuse



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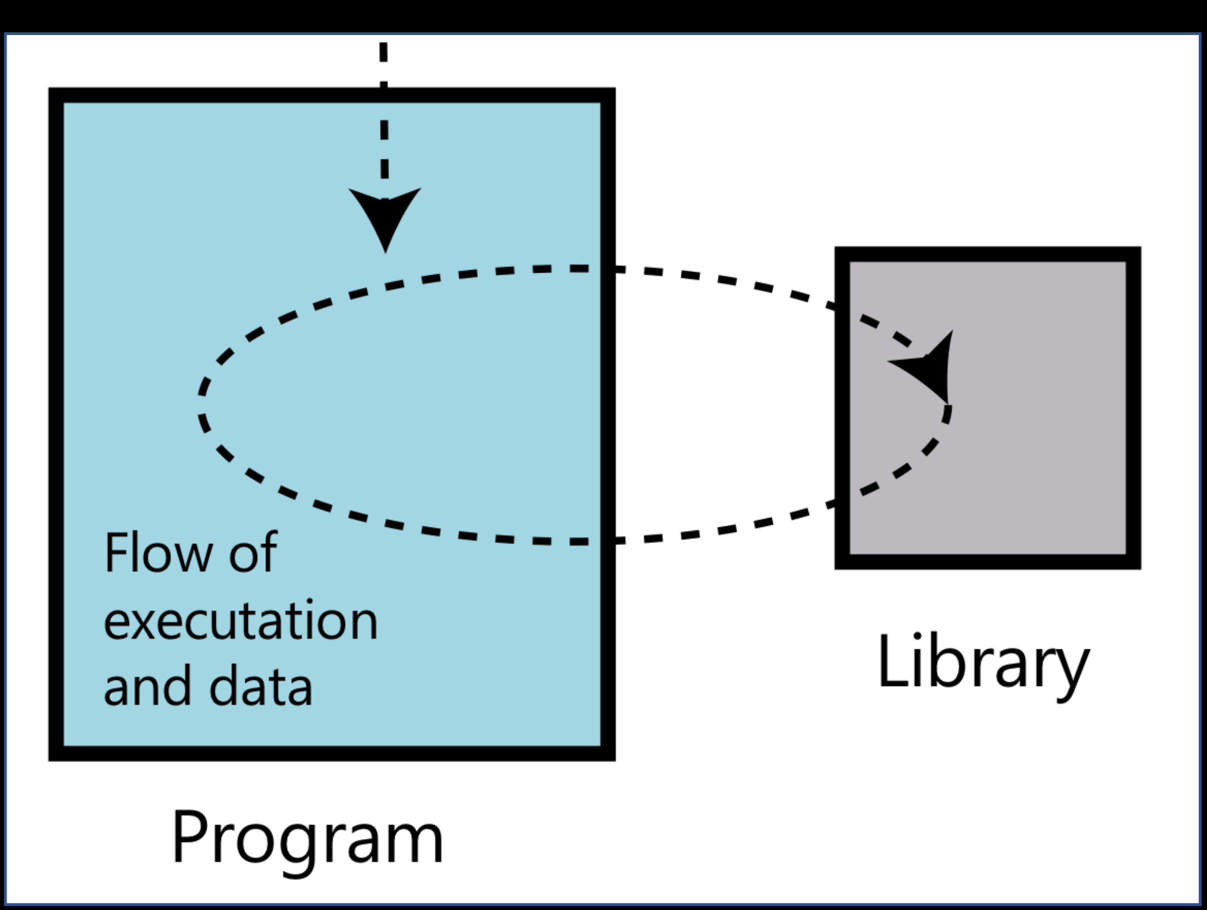

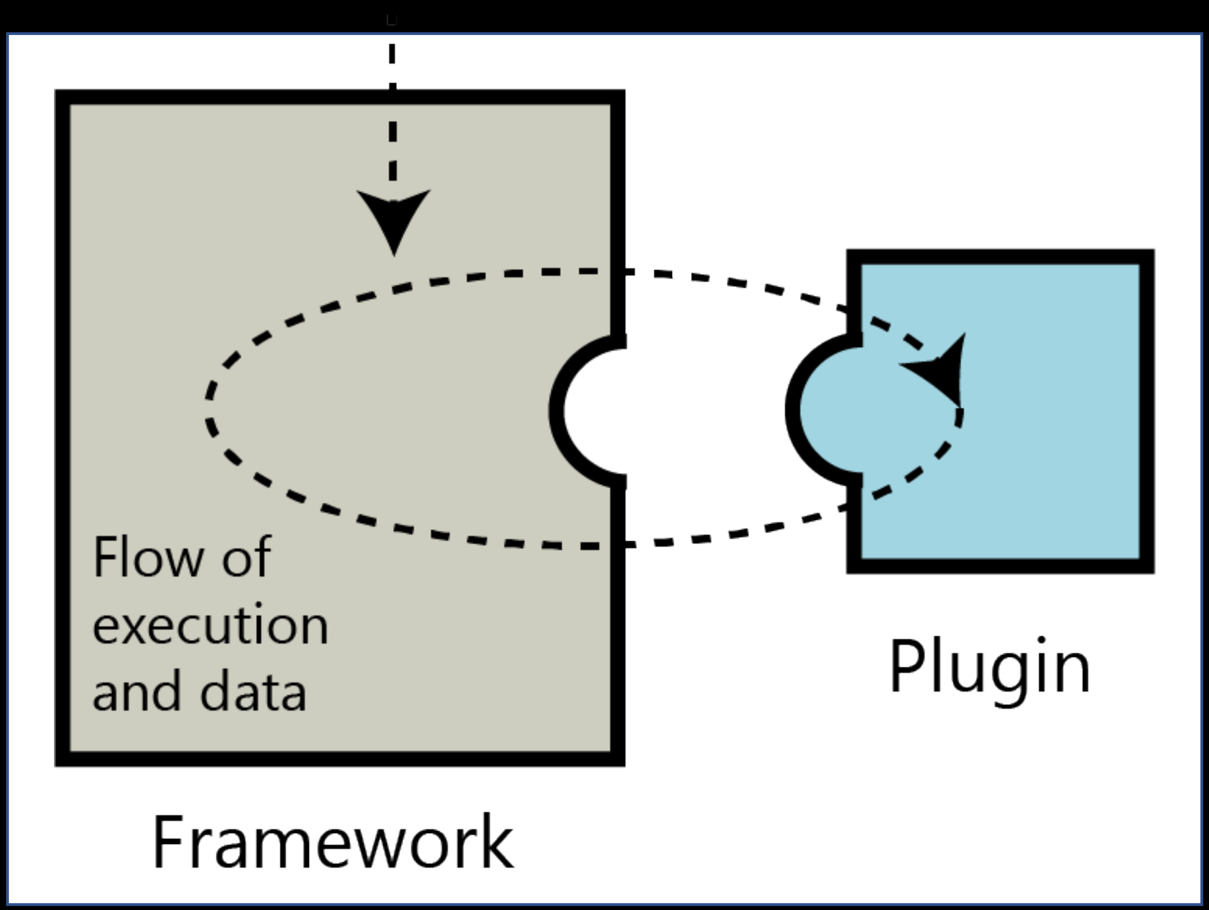

Library-based reuse

Framework-based reuse

Study motivation

Unique aspects of developing applications with frameworks lead to unique challenges in the application debugging process

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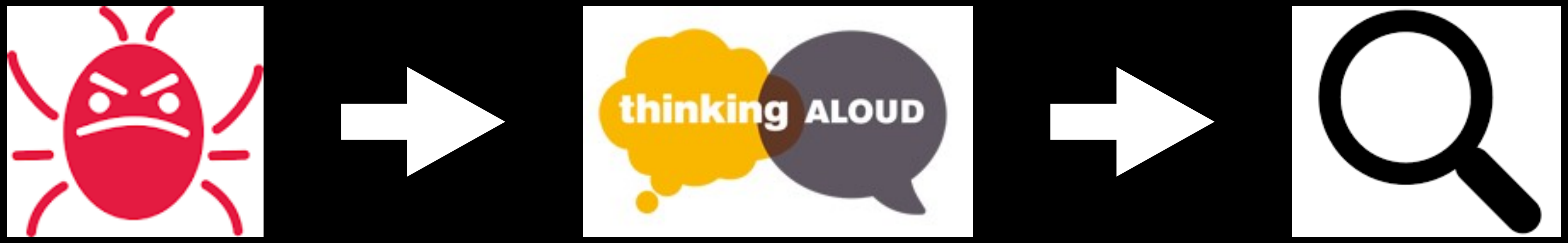
A better understanding framework application debugging process could benefit

- **Debugging tool developers**
- **Framework designers**
- **Framework application developers**

Investigate framework application debugging challenges through a human-focused study



Create debugging scenarios

Record participants

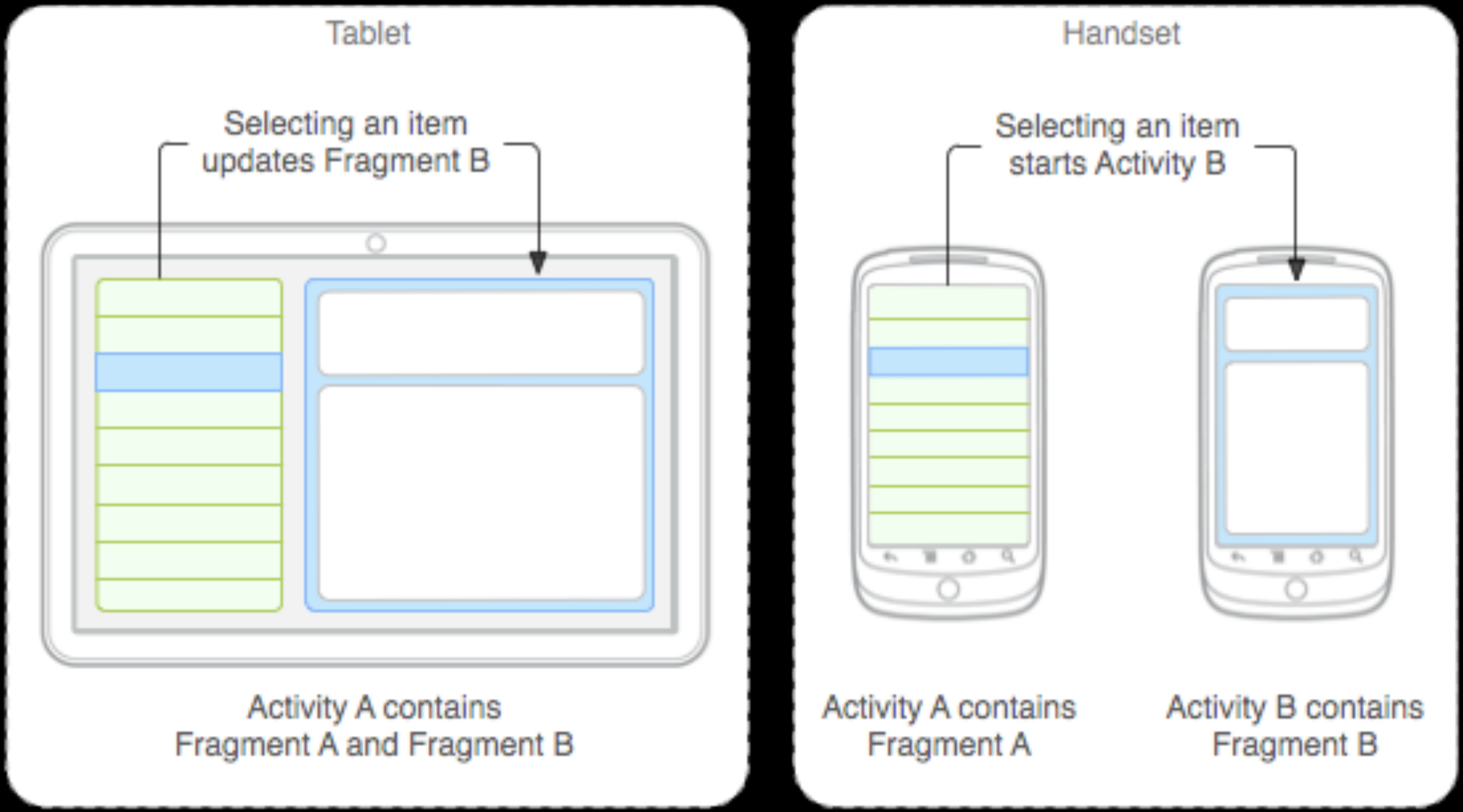
Analyze recordings

Directive definition

Directive - method specification that conveys an important yet often unexpected instruction to callers[1]

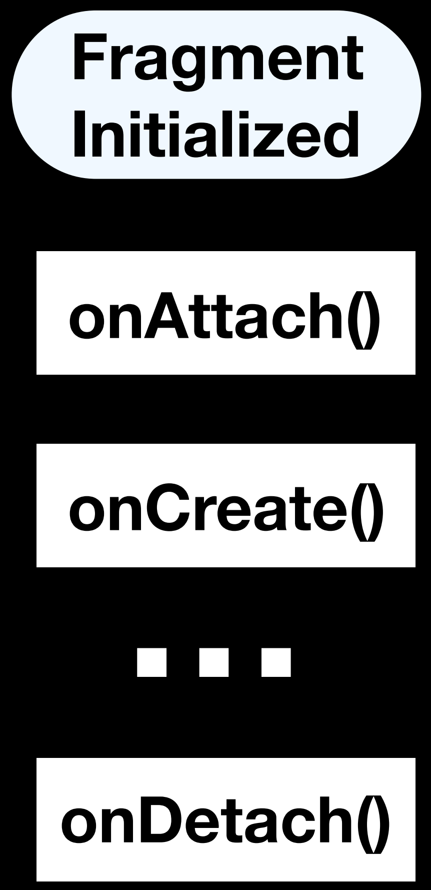
[1] Dekel, Uri. *Increasing Awareness of Delocalized Information to Facilitate API Usage*. Carnegie Mellon University, 2009.

Android Fragments


Tablet
Selecting an item updates Fragment B
Activity A contains Fragment A and Fragment B
Handset
Selecting an item starts Activity B
Activity A contains Fragment A
Activity B contains Fragment B

Directive example

Only call `getActivity` if the `Fragment` is attached to the `Activity`



Fragment Initialized

onAttach()

onCreate()

...

onDetach()

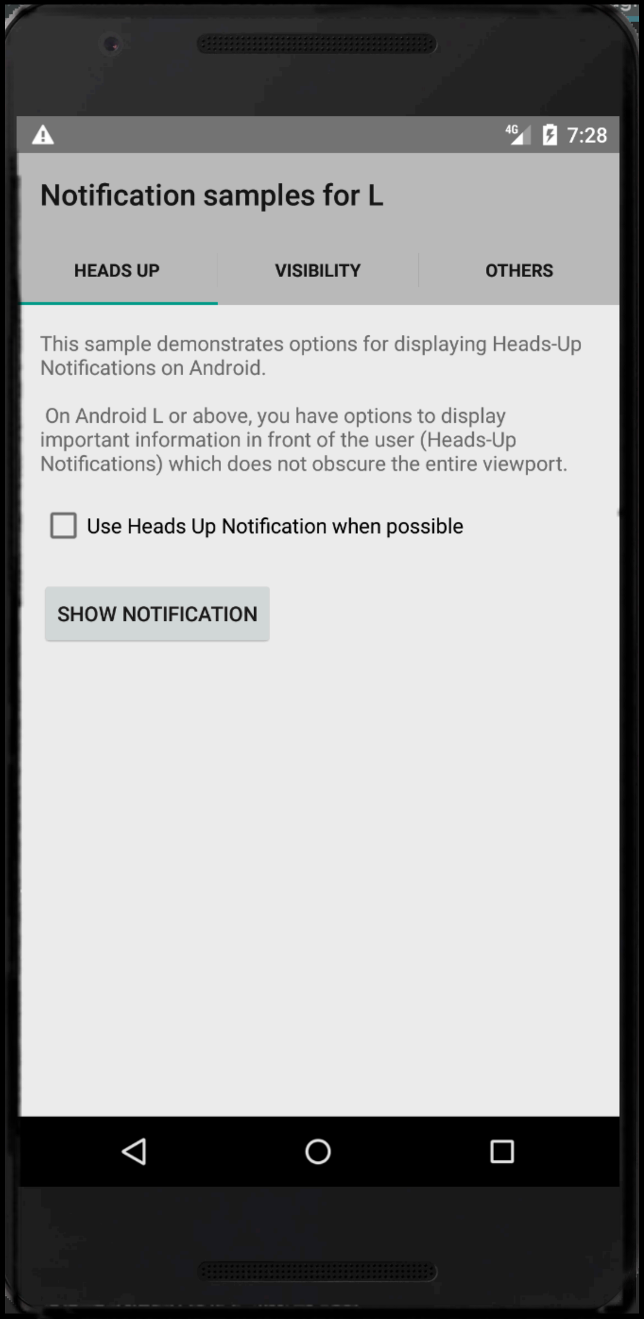
Framework selection

Directive violations produce a variety of symptoms

Manually collected 45 Android Fragment directives from 3 sources

- **Compiler error**
- **Crash with reference to directive**
- **Crash without reference to directive**
- **Missing feature**
- **No obvious effect**
- **Tool warning**
- **Wrong value returned**

Task creation and study process



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Notification samples for L

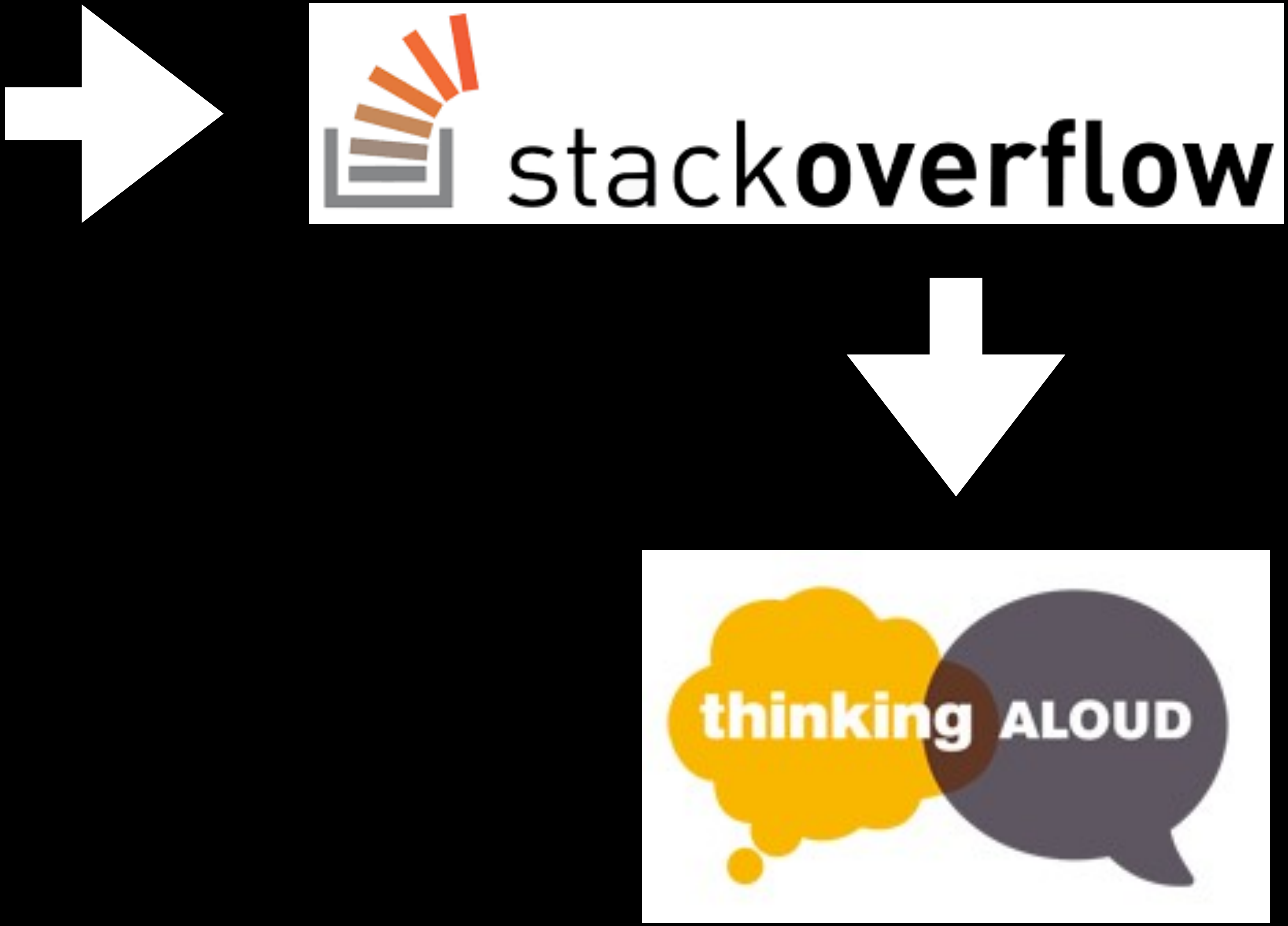
HEADS UP | VISIBILITY | OTHERS

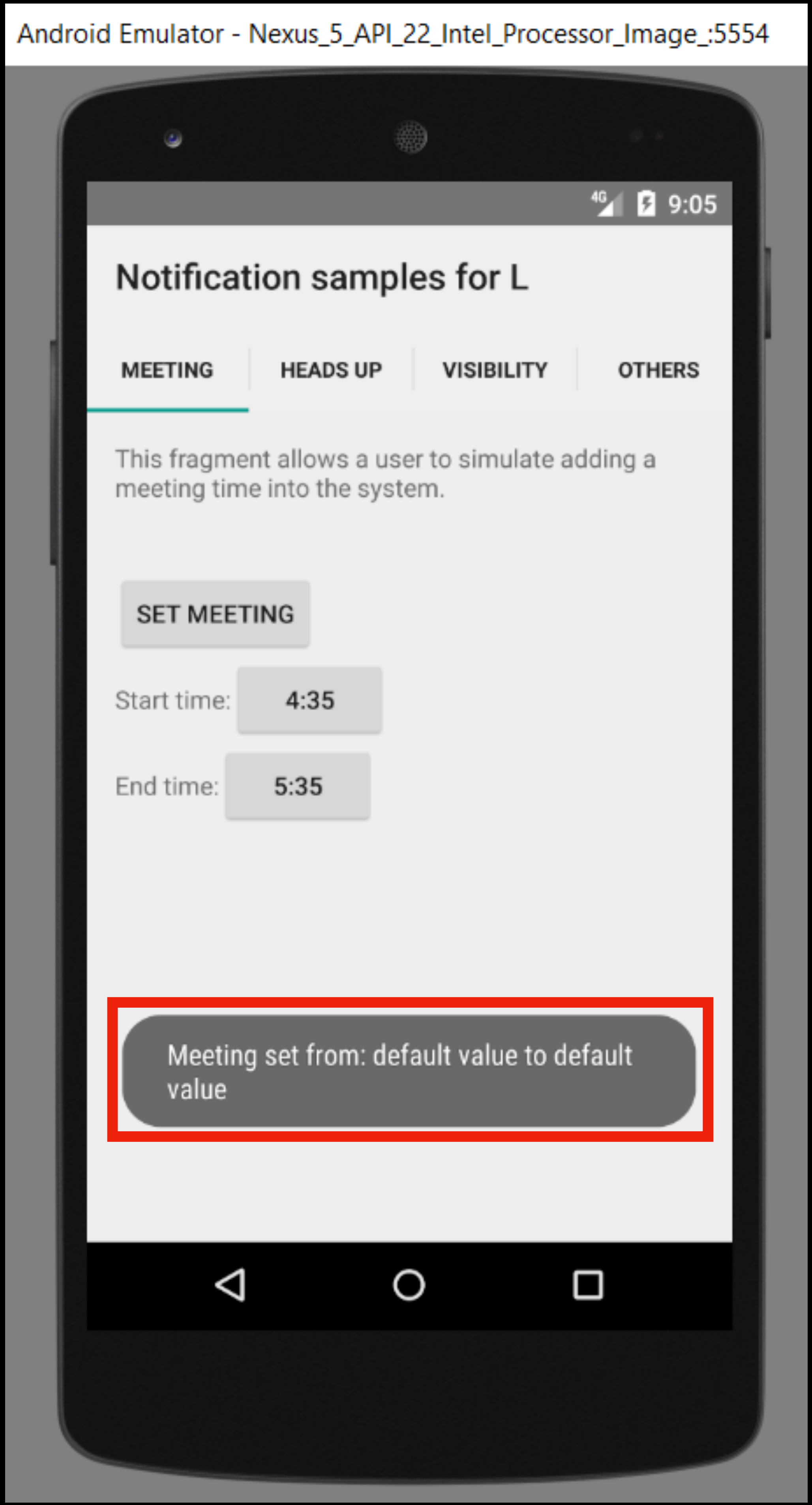
This sample demonstrates options for displaying Heads-Up Notifications on Android.

On Android L or above, you have options to display important information in front of the user (Heads-Up Notifications) which does not obscure the entire viewport.

□ Use Heads Up Notification when possible

SHOW NOTIFICATION





Android Emulator - Nexus_5_API_22_Intel_Processor_Image_:5554

Notification samples for L

MEETING | HEADS UP | VISIBILITY | OTHERS

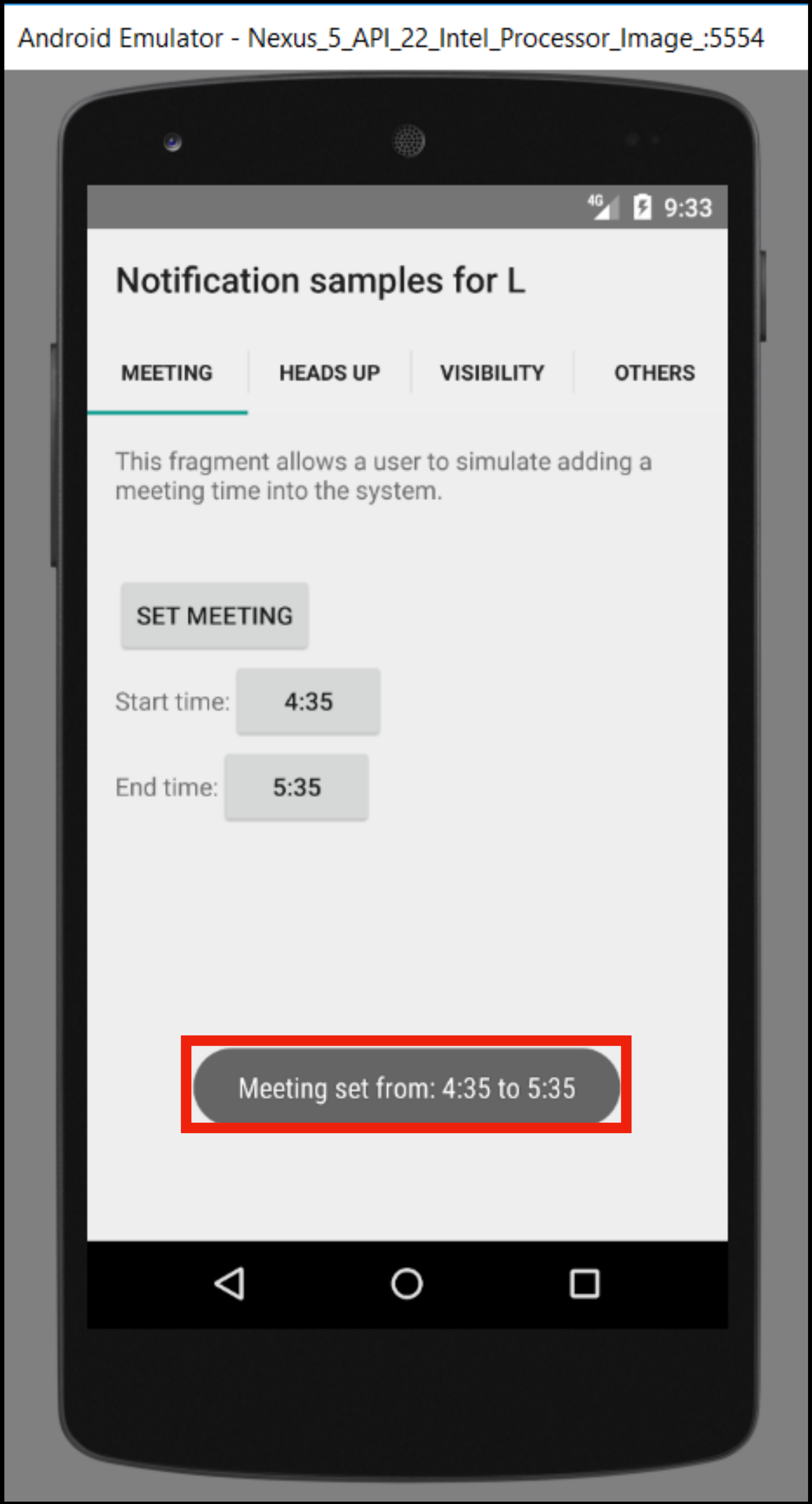
This fragment allows a user to simulate adding a meeting time into the system.

SET MEETING

Start time: 4:35

End time: 5:35

Meeting set from: default value to default value



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Participants in study

	Android	ROS
Total Participants	15	12
Over two years of experience	11	2
Over one year of experience	14	5
Current developers	2	0
Research Staff	0	3
Graduate Students	13	8
Undergraduate Students	0	1

We recruited over 10 participants for each study

	Android	ROS
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We focused on recruited participants with experience

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We coded the trials using qualitative content analysis

Benefits and Challenges

Each with subcategories of dynamic, static, and historical

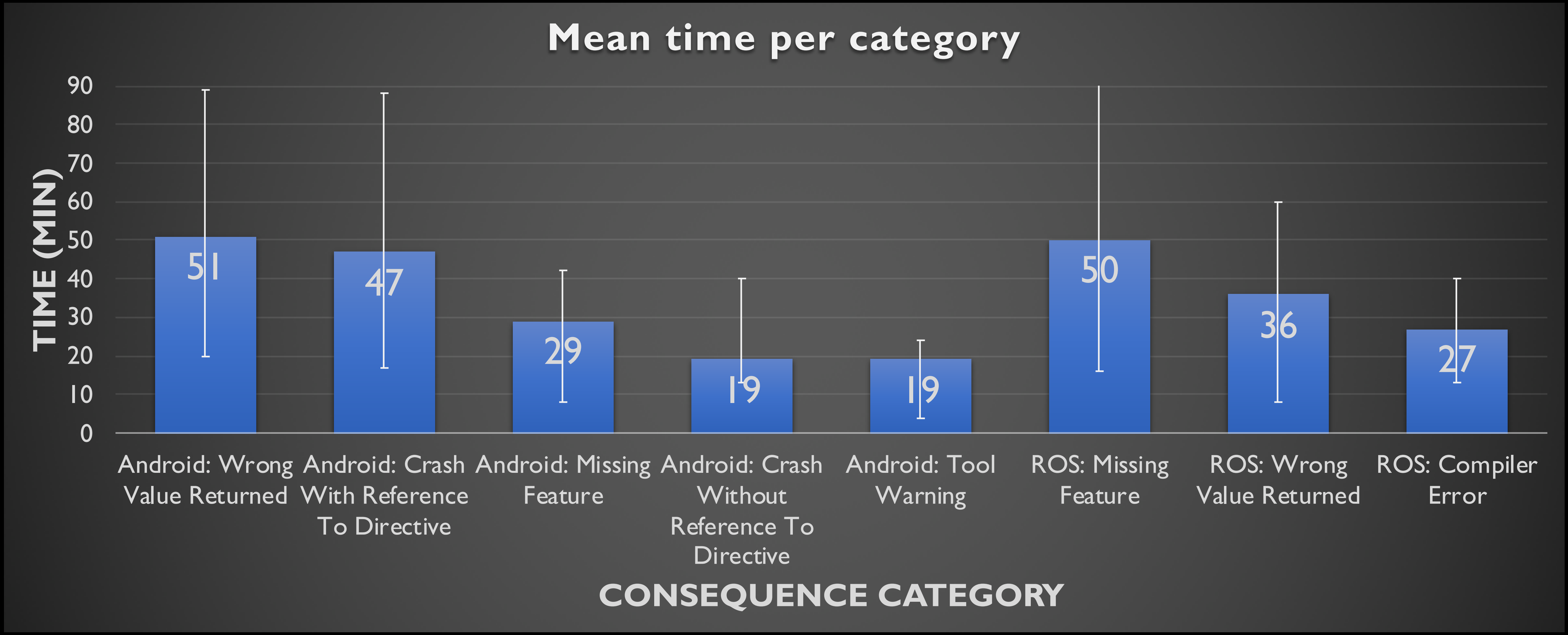
Research Question:
When developers are notified of the problem, are they able to quickly solve the problem?

Key findings from study

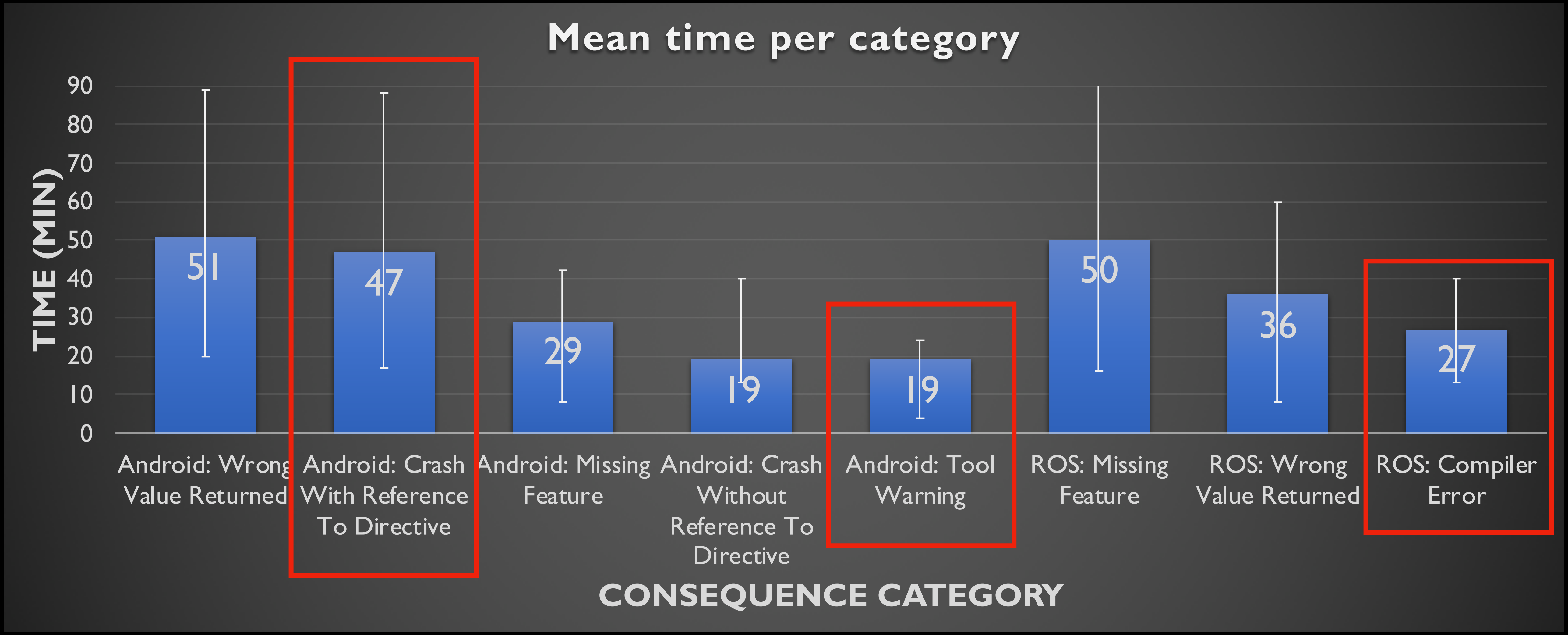
Developers are not always able to solve the problem as soon as they find the directive violation

"Why don't they tell me the right thing to use? They tell me it is going to cause a problem but they don't tell me what the alternative is."

The way that plugins present errors to developers influences the difficulty of debugging the problem



Notifying developers of the directive does not always significantly reduce the time to find a fix



Examples of debugging problems

- Multiple participants tried to access data before it was set by the user

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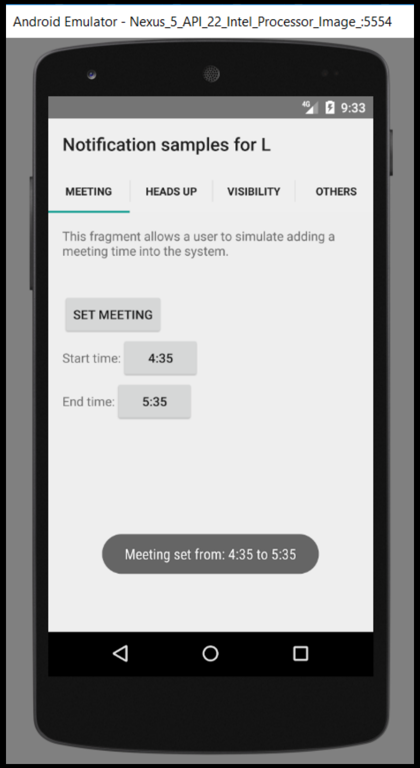
- Multiple participants tried to access data before it was set by the user
- In ROS, participants incorrectly diagnosed that the framework was configured to not call certain sections of code
- In Android, participants were unsure if the application was violating a state-based aspect of the framework, or violating another framework constraint (e.g., if `getActivity` was called at the wrong time or if the `Fragment` had been initialized incorrectly)

Implications of study

- Providing an alternative solution can be more helpful than identifying the fault location
- State-based problems were challenging



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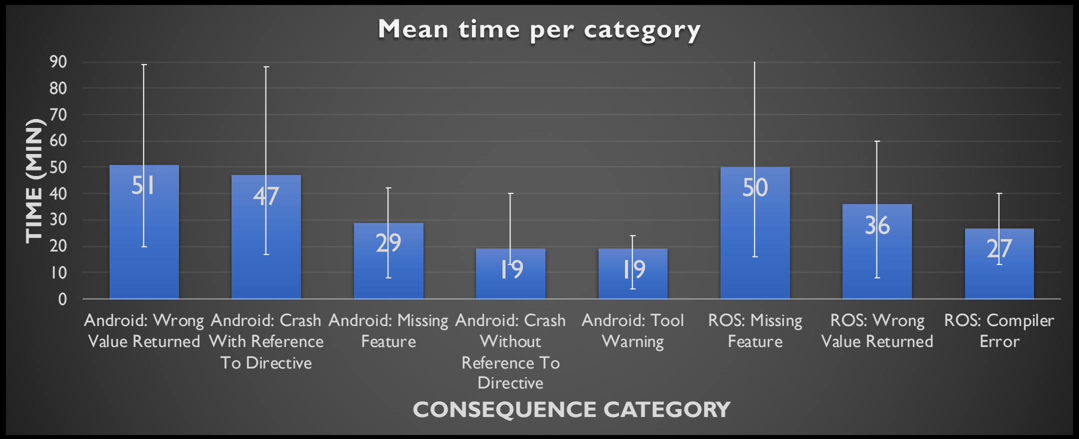

Looking for an industrial research job

Plan to graduate March 2020

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