Verifying Configuration Files in Software Frameworks

Aileen Alba, Shih-Wei Fang and You Lu

Computer Science Department

CAL POLY POMONA

Introduction

Software frameworks provide large reuse benefits for the software engineering community. However, figuring out which lines and where they belong, is a difficult task. Android requires both an object-oriented language (Java) and declarative code (XML). The code must follow certain protocols and failure to do so will result in exceptions or unusual runtime behavior. Our contribution is an in-depth case study to determine whether the Fusion static analysis tool can detect these problems at compile time.

Not following protocol:

setContentView must be called before findViewById

```
protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        fl = (FrameLayout) findViewById(R.id.credits_screen);
        fl.setOnTouchListener(this);
        setContentView(R.layout.credits);
}
```

Causes

NullPointerException:
doesn't give line number where error occurs

```
java.lang.RuntimeException: Unable to start activity ComponentInfo{com.example.framelayout/com.example.framelayout.Credits}: java.lang.NullPointerException
Caused by: java.lang.NullPointerException
```

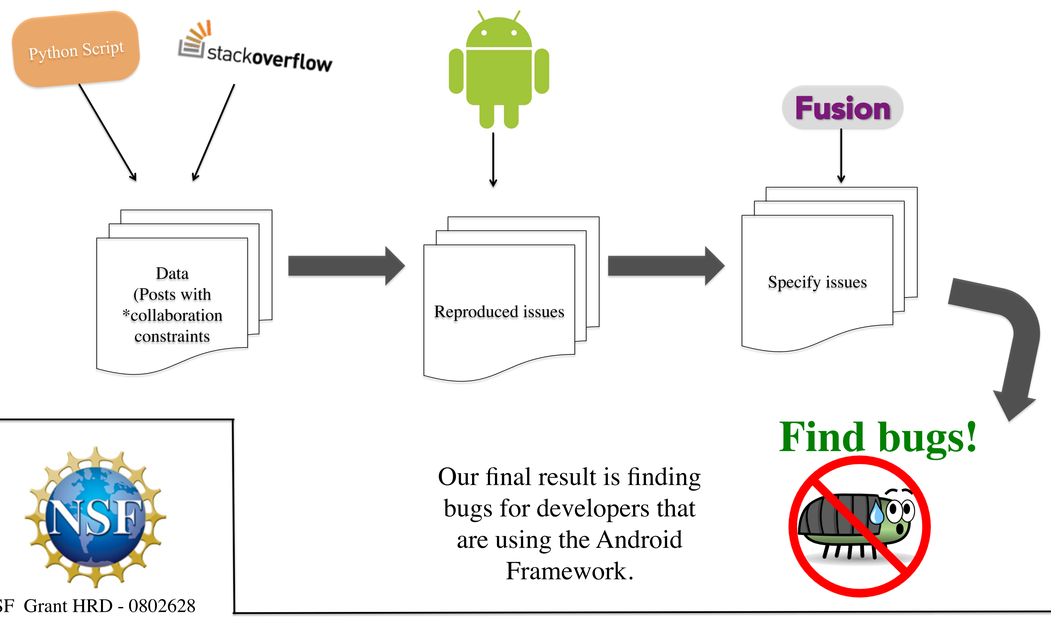
Working code :

```
protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.credits);
        fl = (FrameLayout) findViewById(R.id.credits_screen);
        fl.setOnTouchListener(this);
}
```

This is an example of a **collaboration constraint**, a multi-object protocol problem. Here we see that calling methods in the wrong order cause an error.

Method

- Fusion is a new static analysis tool which uses lightweight specifications written on the framework to statically verify that code that utilizes the framework does so correctly.
- In order to gather data, a python script was created to find posts with collaboration constraints users were having on the Android framework.
- After finding collaboration constraints, we reproduce the issues using Eclipse and the Android SDK.
- Next we wrote some XQuery to create new XML relationships.
- Lastly, we specified constraints on Fusion which would check if users were following protocols set by the Android Framework.



Our final result is finding bugs for developers that are using the Android Framework.

NSF Grant HRD - 0802628

Results

The Android framework auto-generates source code making it difficult to specify the protocols on Fusion. Because of this we needed to create new relationships using XQuery to be able to specify these issues on Fusion. The new XML relationships allowed us to then create constraints on Fusion to show that it would have helped the developer find these issues.

XQuery needed to generate a View relationship

```
for $x in doc($doc)/node()
return <Relationship name="View" effect="ADD">
    <Object name ="{substring(data($x/@android:id), 6)}"type="android.widget.{name($x)}"/>
    <Object name ="{substring(data($x/@android:id), 6)}"type="java.lang.String"/>
    <Object name ="{substring(data($x//@android:src),11)}"
        type="com.example{lower-case(name($x))}.{substring(data($x//@android:src),11)}"/>
  </Relationship>
```

New relationships were needed because of the auto-generated file.

OUTPUT:

```
<Relationship name="View" effect="ADD">
    <Object name ="credits_screen" type="android.widget.FrameLayout"/>
    <Object name ="credits_screen" type="java.lang.String"/>
    <Object name ="credits" type="com.example.framelayout.Credits"/>
</Relationship>
```

Constraint for findViewById() requires ContentView() to exists. If ContentView() doesn't not exist before findViewById() an error will occur.

```
@Constraint(
    op = "Activity.findViewById(int id): View",
    trg = "true",
    req = "Field(R.id, screenID) and R.id.screenID == id and
          ActivityView(result, screenID, target) and
          ContentView(*, *, target)
)
```

Future Work

The Android Framework works a lot differently then any other Framework we have seen. It creates an auto-generated file which maps out the relationships for the different XML objects. With our XQuery we were able to specify two constraints using Fusion.

However, two doesn't provide us enough data to find bugs on the Android Framework. This is why we will continue our research by adding more constraints so that Fusion is able to detect many different protocol issues users are having. Our long-term goal is to extend Fusion to work with any framework that uses auto-generated source code.