# Correlating UI Contexts with Sensitive API Calls: Dynamic Semantic Extraction And Analysis

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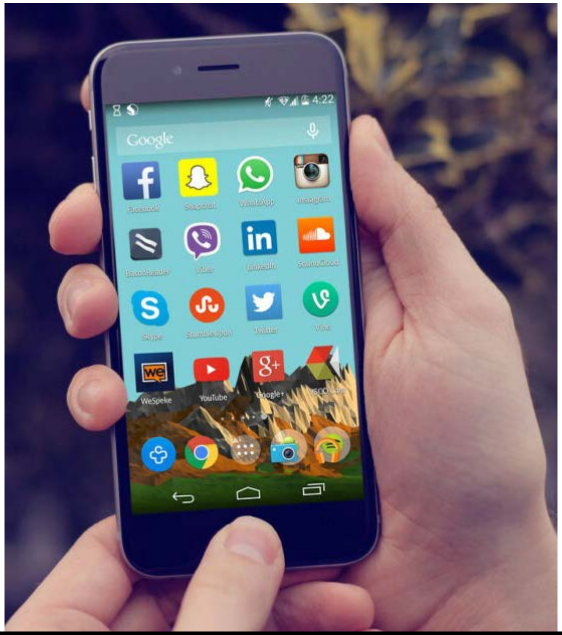
# Problem: Is the Sensitive API Invocation legal?

Tik Tok

GET IT ON
Google Play



```
# ...
# ...
# invoke sendTextMessage(...)
```

# Existing Solution I: app-level techniques

**Sensitive API Invocation,**
e.g., sendTextMessage

| Apps | Legitimacy |
|---|---|
| Message Apps | ✓ |
| Google Maps<br>Non-messaging Apps | ✗ |

Could not distinguish API invocation with its calling context

Suffer from many false positive or many false negative.

# Existing Solution II: API-level techniques

**Sensitive API Invocation,**
e.g., sendTextMessage

static analysis →

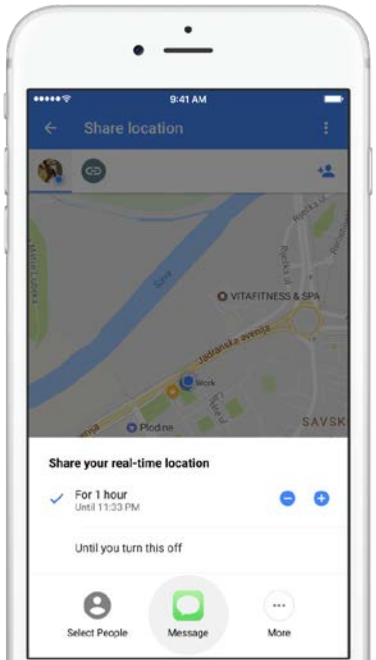
**UI components,**
e.g., text, ...

Dynamic features, e.g., reflection, dynamic class loading

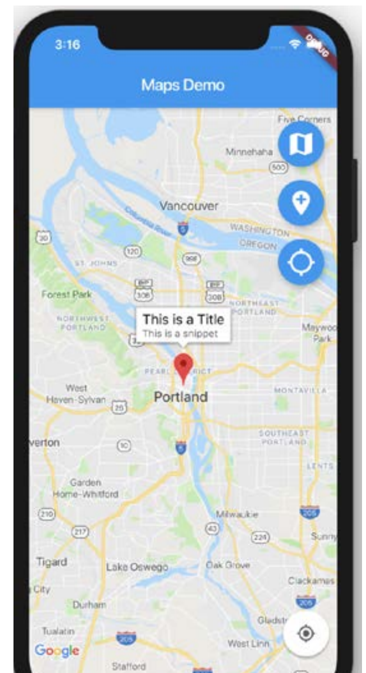
Attributes, e.g., text, could be null or statically unknown.

- ICSE 14, USENIX Security 18

# Our Key Insight: Correlating UI Contexts with Sensitive API Calls dynamically.

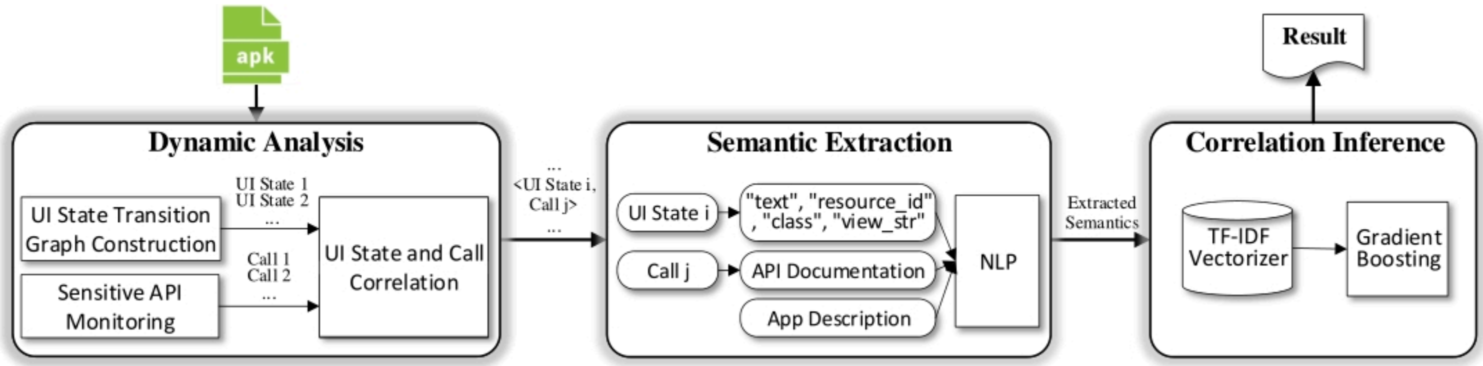



```
# ...
# ...
# invoke sendTextMessage(...)
```




```
# ...
# ...
# invoke sendTextMessage(...)
```

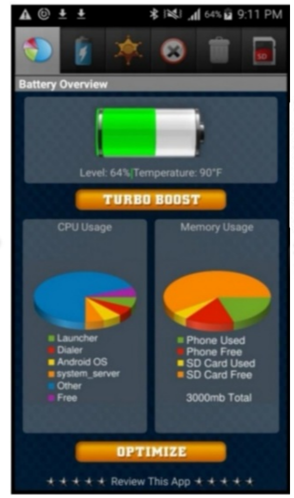
# Our Approach: APICOG Overview




- **Dynamic Analysis:**
  - Associate sensitive API call with its related top Activity
- **Semantic Extraction:**
  - Extract Activity semantics from saved screenshot, UI layout and App description.
  - Extract API semantics from API documentation.
- **Correlation Inference:**
  - Determine if semantics provides enough information to justify the legitimacy of the usage.

# Our Approach: Dynamic Analysis

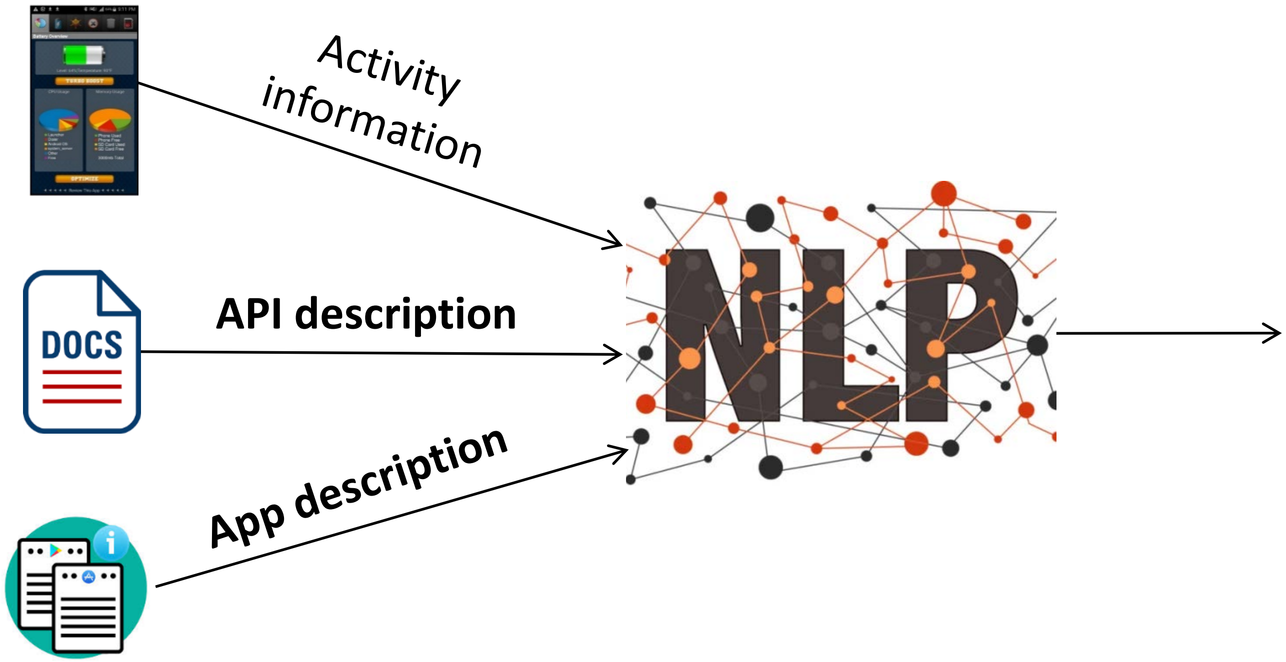

<BoosterActivity, LocationManager getLastKnownLocation()>




Snippet from BoosterActivity:onClick

```
String service = CipherUtil.decrypt("bG9jYXRp");// service = "location";
Object lm = ctx.getSystemService(service); // get LocationManager object
// mtdName = "getLastKnownLocation";
String mtdName = CipherUtil.decrypt("WpMUG6kCL/VztBsv");
Method mtd = lm.getClass().getMethod(mtdName, String.class);
// get the current location
Object location = mtd.invoke(lm, provider);
```

# Our Approach: Semantics Extraction




(boost, battery),
(null, memory),
…

# Our Approach: Correlation Inference

callsite:

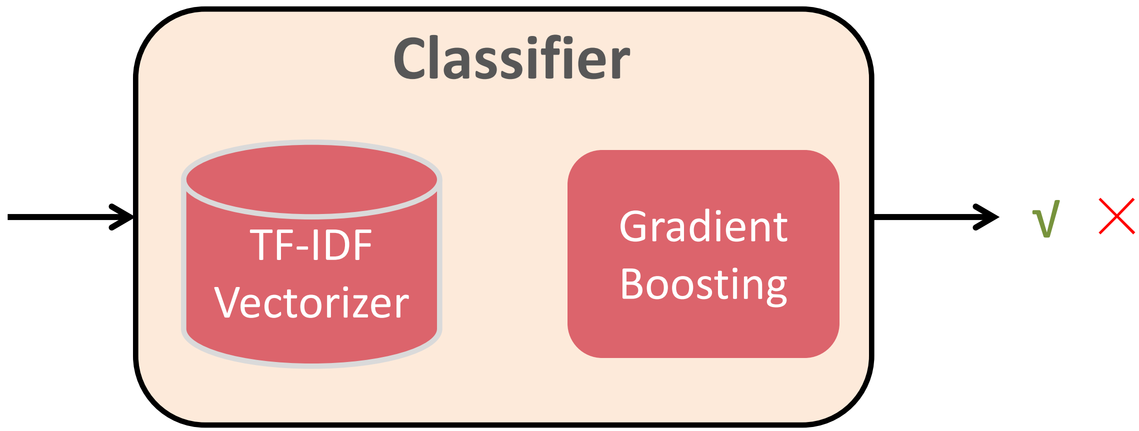
getLastKnownLocation

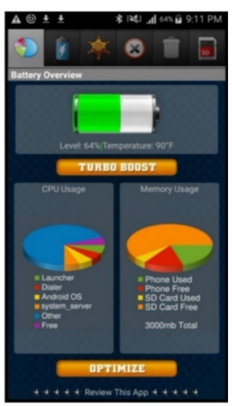
action resources:

(boost, battery),

(null, memory),

…



# Evaluation

-  1500 malware apps from Drebin dataset [1]

-  All 1625 benign apps from F-Droid[2]

Manually-annotated Ground Truth

| App Type | # of Apps | # of Apps with Activity-callsite Pairs | # of Total Activity-callsite Pairs | # of Positive Activity-callsite Pairs | # of Negative Activity-callsite Pairs |
|---|---|---|---|---|---|
| Benign | 1625 | 251 | 805 | 696 | 109 |
| Malware | 1500 | 725 | 4294 | 191 | 4103 |
| Total | 3125 | 976 | 5099 | 887 | 4212 |

Half pairs for training and half for testing.

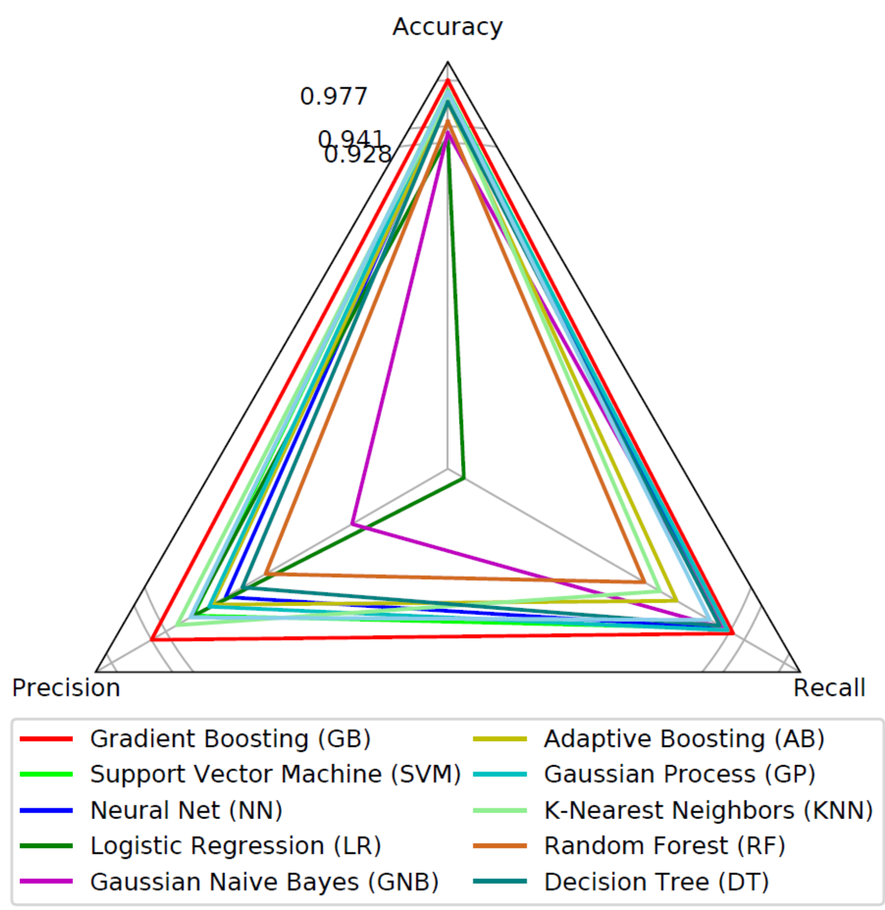
[1] D. Arp, M. Spreitzenbarth, M. Hubner, H. Gascon, K. Rieck, and C. Siemens, “Drebin: Effective and explainable detection of android malware in your pocket.” in NDSS, 2014.
[2] F-Droid. *Free and Open Source App Repository*. https://f-droid.org/. 2019.

# RQ1: Precision, Recall and Accuracy

Overall Performance of APICOG against the Ground Truth

| App Type | # of Testing Activity-callsite Pairs | TP | FN | FP | TN | Accuracy | Precision | Recall |
|---|---|---|---|---|---|---|---|---|
| Benign | 410 | 339 | 12 | 15 | 44 | 93.4% | 95.8% | 96.6% |
| Malware | 2140 | 72 | 20 | 11 | 2037 | 98.6% | 86.7% | 78.3% |
| Total | 2550 | 411 | 32 | 26 | 2081 | 97.7% | 94.1% | 92.8% |

# RQ2: Classification Approaches



# RQ3:Effectiveness of Different Semantics

Compare of APICOG with different Semantics:

- $APICOG_{des}$ = API semantics + App description semantics.
- $APICOG_{asd}$ = API semantics + UI state semantics.
- APICOG = API semantics + App description semantics + UI state semantics.

| Tool | Accuracy | Precision | Recall | F1 Score |
|---|---|---|---|---|
| $APICOG_{des}$ | 94.8% | 91.4% | 77.2% | 83.7% |
| $APICOG_{asd}$ | 95.7% | 91.1% | 83.5% | 87.2% |
| APICOG | 97.7% | 94.1% | 92.8% | 93.4% |

# Our Contributions

- First dynamic description-to-permission fidelity approach for Android.
- Open-sourced tool:
  - http://www.cse.unsw.edu.au/~corg/apicog/

THANK YOU.