Dangerous Hare: Hanging Attribute References Hazards Due to Vendor Customization

Speaker: Nan Zhang

System Security Lab, Indiana University

Dangerous Hare

- Hare Hunting in the Wild Android: A Study on the Threat of Hanging Attribute References. (CCS '15)

  [Yousra Aafer, Nan Zhang]*, Zhongwen Zhang, Xiao Zhang, Kai Chen, XiaoFeng Wang, Xiaoyong Zhou, Wenliang Du, and Michael Grace.

- Perplexed Messengers from the Cloud: Automated Security Analysis of Push-Messaging Integrations. (CCS '15)
  - **[Yangyi Chen, Tongxin Li]*,** XiaoFeng Wang, Kai Chen, and Xinhui Han. 2015.

*** Co-first Author**

Who are we?

INDIANA UNIVERSITY

- System Security Lab, Indiana University
- Focus on novel problems in system security
- High-impact publications on IEEE S&P, ACM CCS, Usenix Security, NDSS

Sunk In Thought

System Security Lab, Indiana University

sit.soic.indiana.edu/

Android Customization

Google

Manufacturer

Carrier

Not just UI, Components too

"Among all the apps pre-installed by the major smartphone vendors (Samsung, HTC, LG, Sony) on their phones, only about 18% come from AOSP."

Android Customization Process

- Unregulated, Decentralized
- Android Compatibility Program (ACP)
- Fails when proper precautions have not been taken

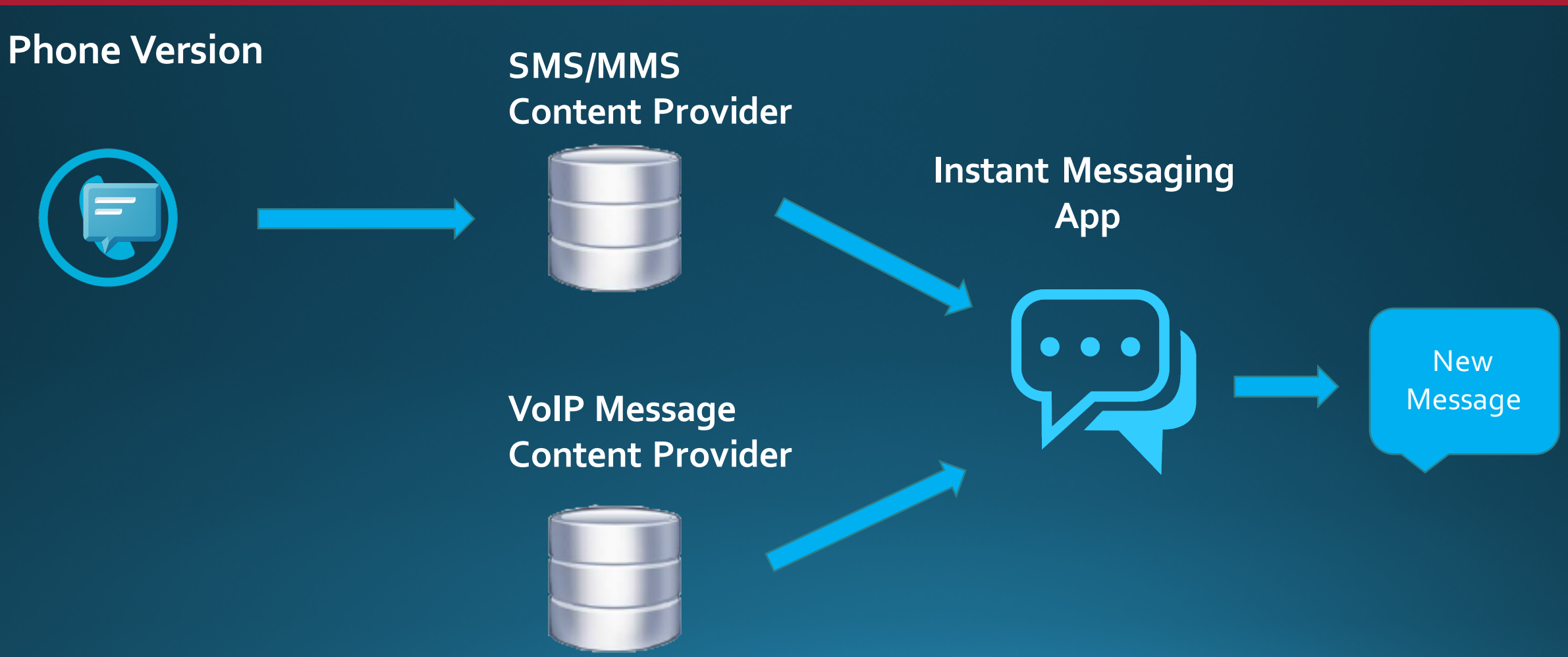
“Hare” Problem

- Hanging Attribute REferences
- An attribute is used while the party defining it has been removed
- A type of problem never investigated before

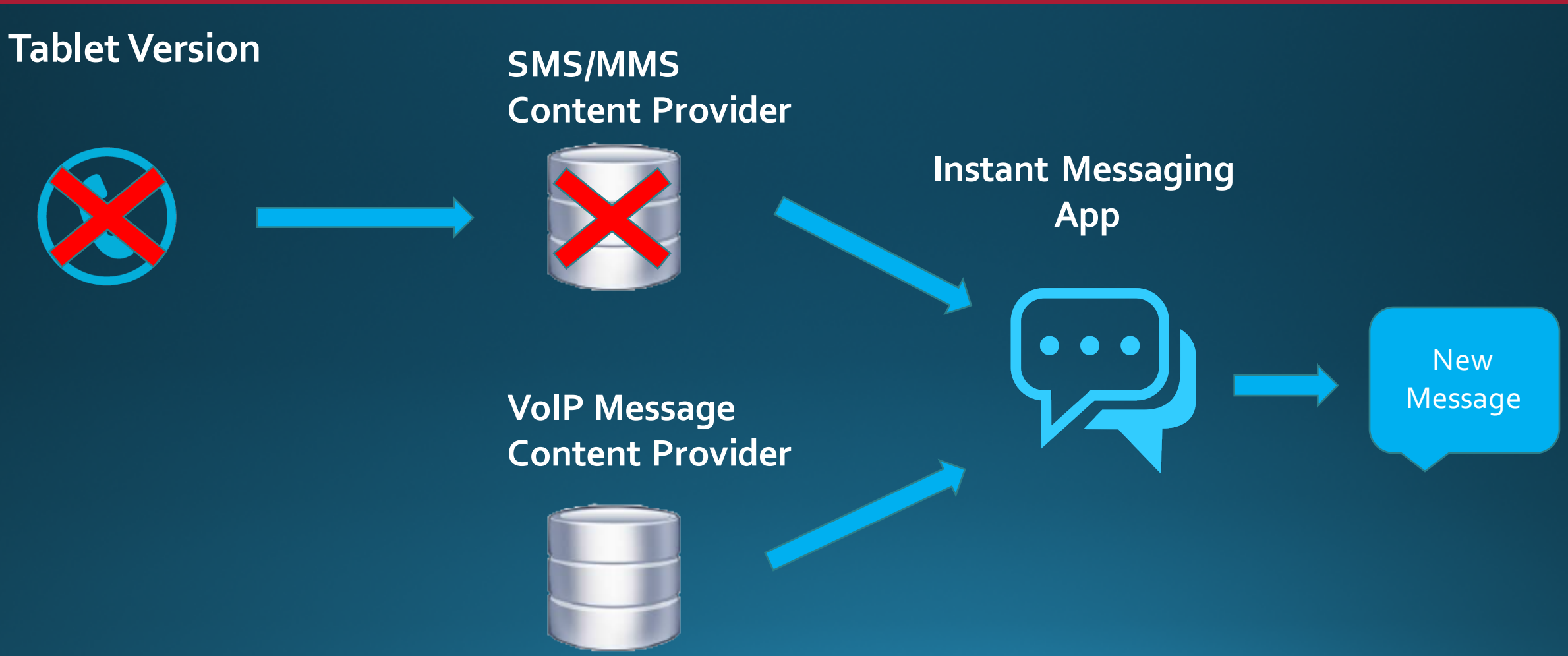
Attributes of Hares

- Package, Activity, Action names
- Content Provider
- Permission

An example

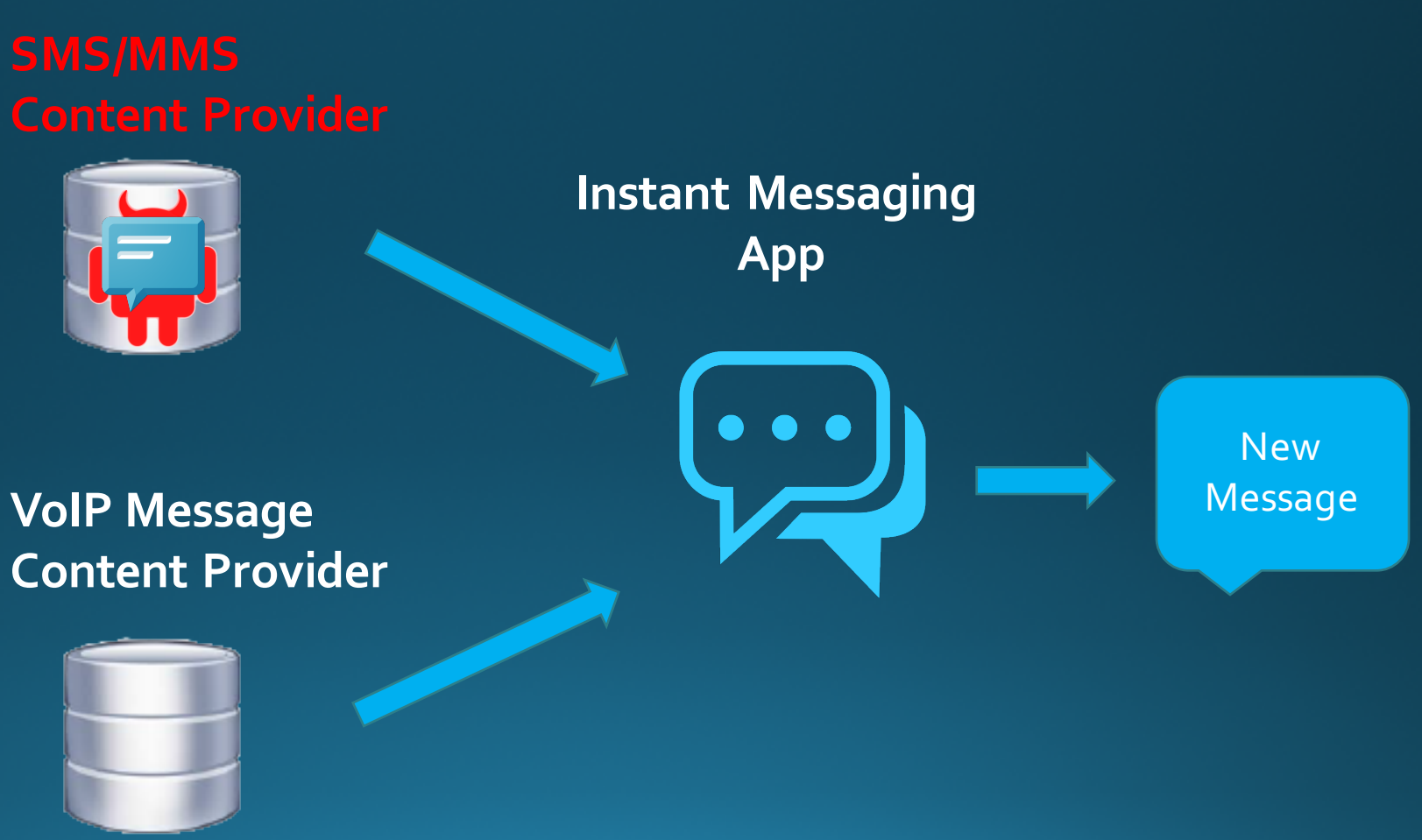

Phone Version
SMS/MMS
Content Provider
Instant Messaging
App
VoIP Message
Content Provider
New
Message

An example


Tablet Version
SMS/MMS
Content Provider
Instant Messaging
App
VoIP Message
Content Provider
New
Message

An example

Tablet Version



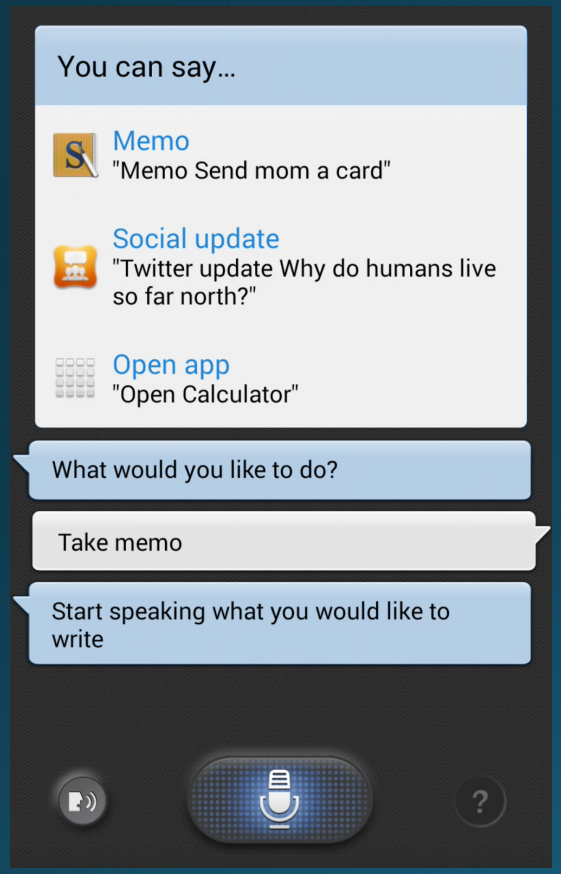
Hares are

- Not random, isolated bugs.
- Caused by the fundamental conflict between the under-regulated Android Customization process and the complicated relationship among apps.

Exploiting Hares

Missing Packages, Activities, Actions

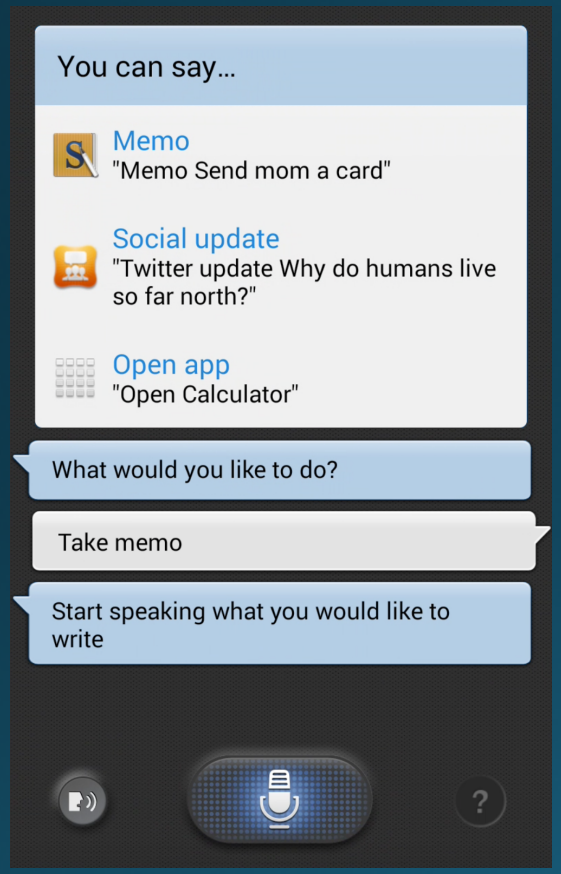
Stealing Voice notes



If **com.samsung.android.app.memo** exists

If **com.sec.android.app.smemo** exists

Stealing Voice notes



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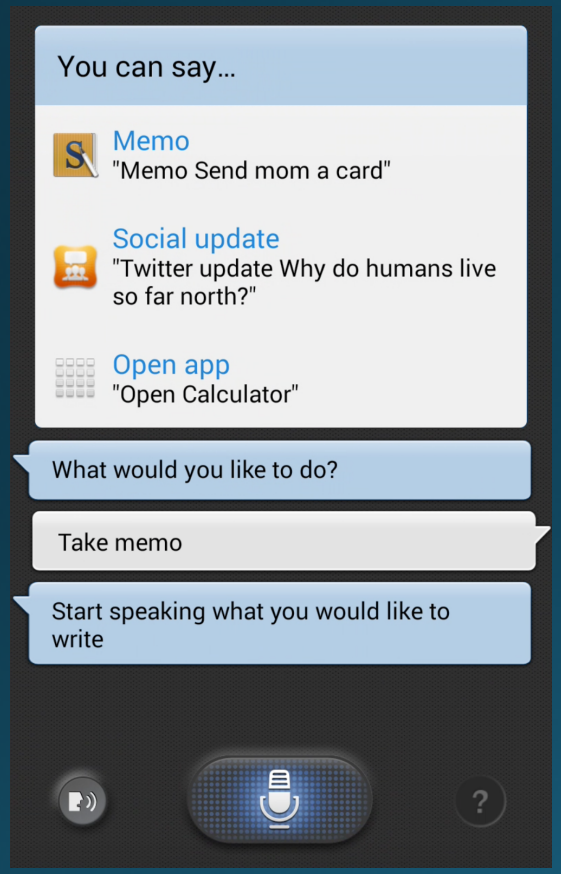


If **com.samsung.android.app.memo** exists

com.samsung.android.app.memo

If **com.sec.android.app.smemo** exists

Demos

- Stealing voice note

- Faking Dropbox on LG

- Replacing official voice recorder

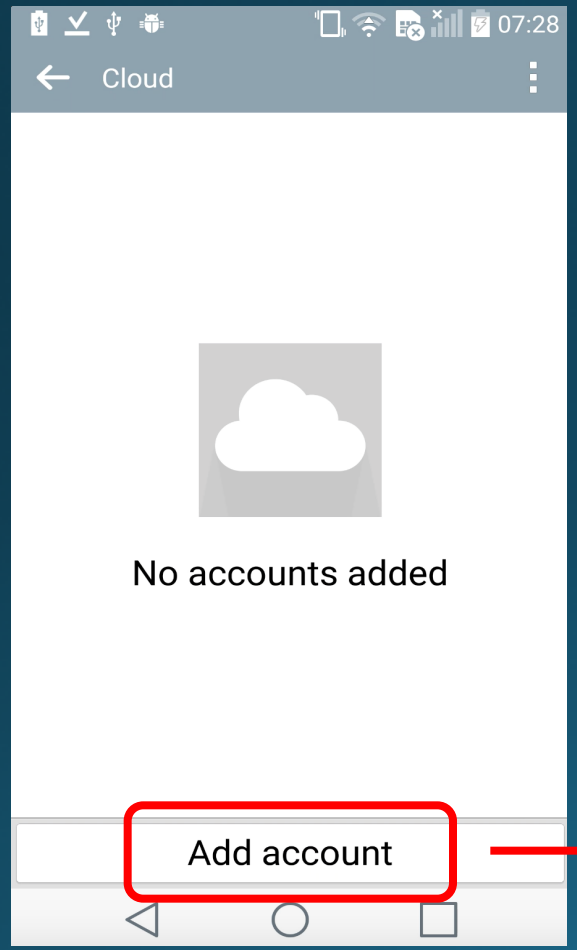
- Hulu on Watch

All deomos can be found at https://sites.google.com/site/androidharehunting/

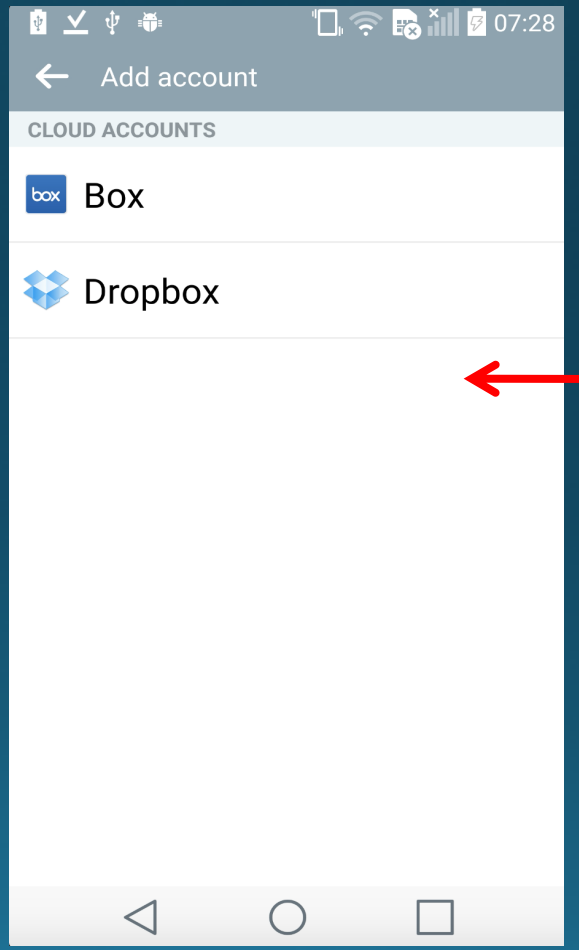
Exploiting Hares

Missing Content Providers

LG Cloud Scam

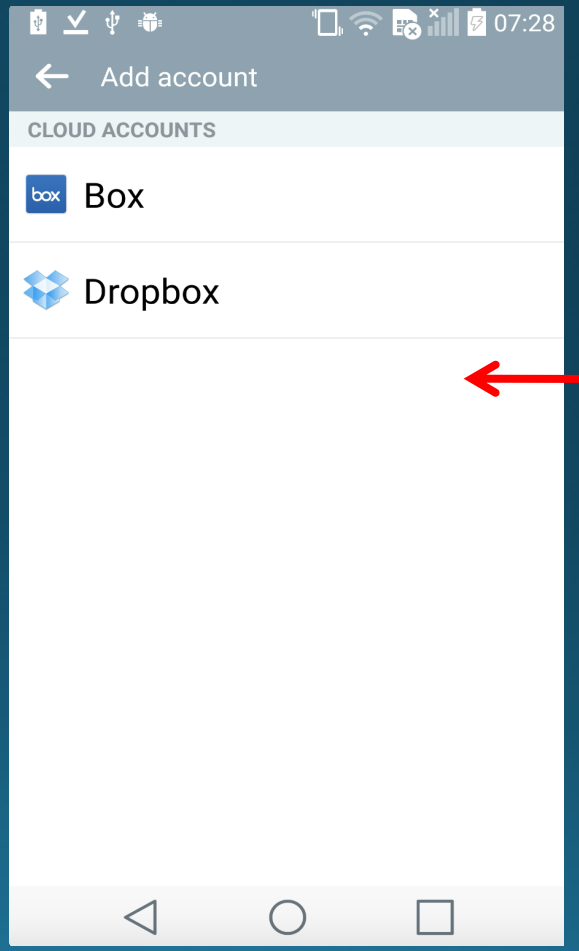


LG CloudHub App



Query "com.lge.lgaccount.provider" for additional Cloud Services and add an item

LG Cloud Scam



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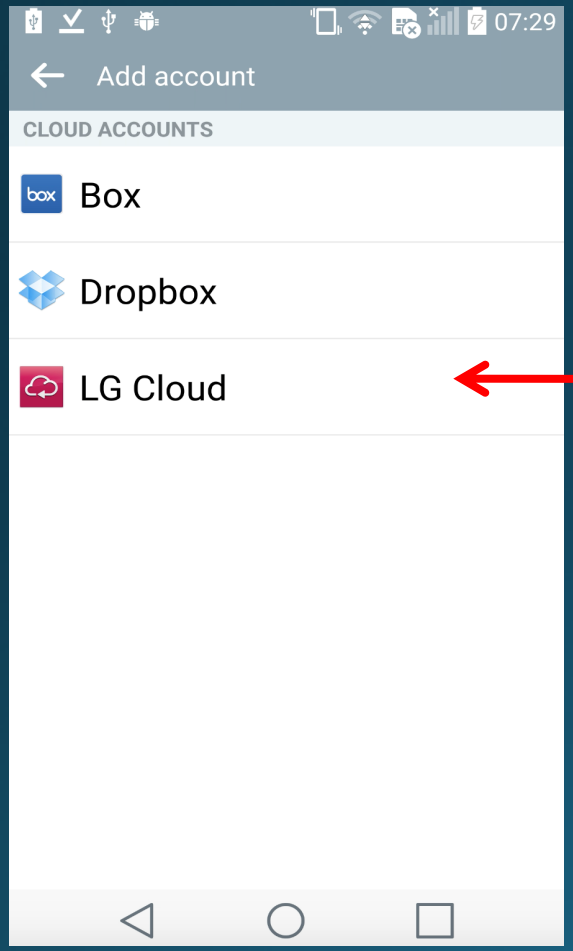
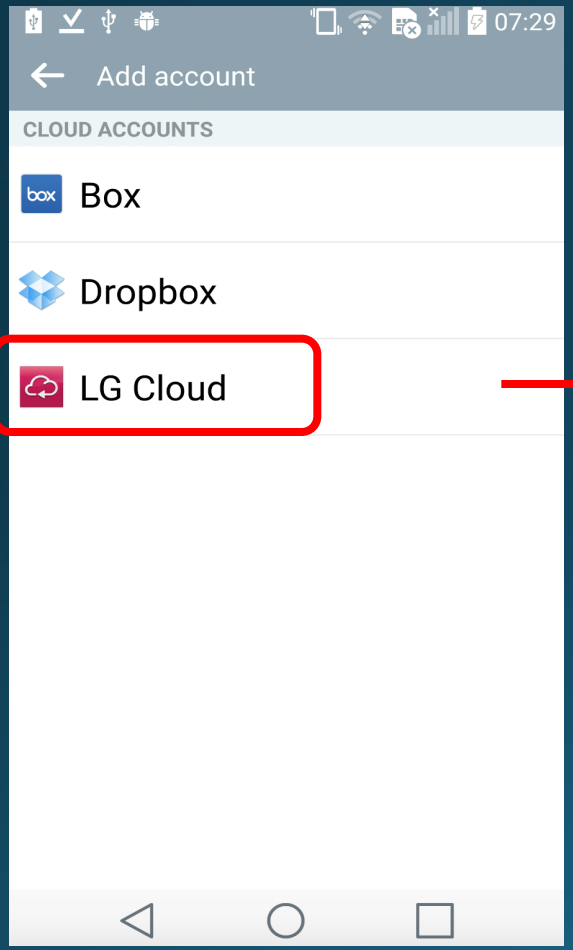
LG Cloud Scam

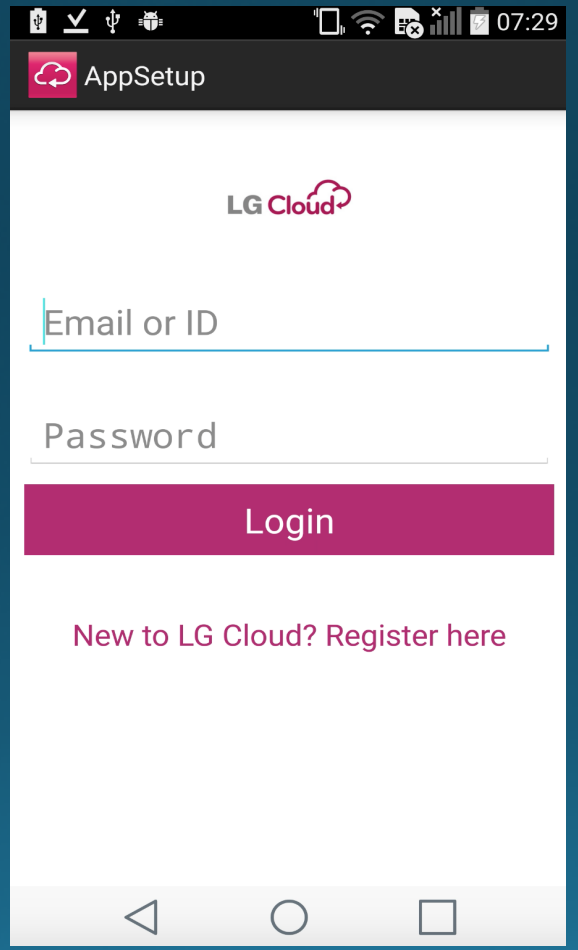


Own

com.lge.lgaccount.provider

LG Cloud Scam



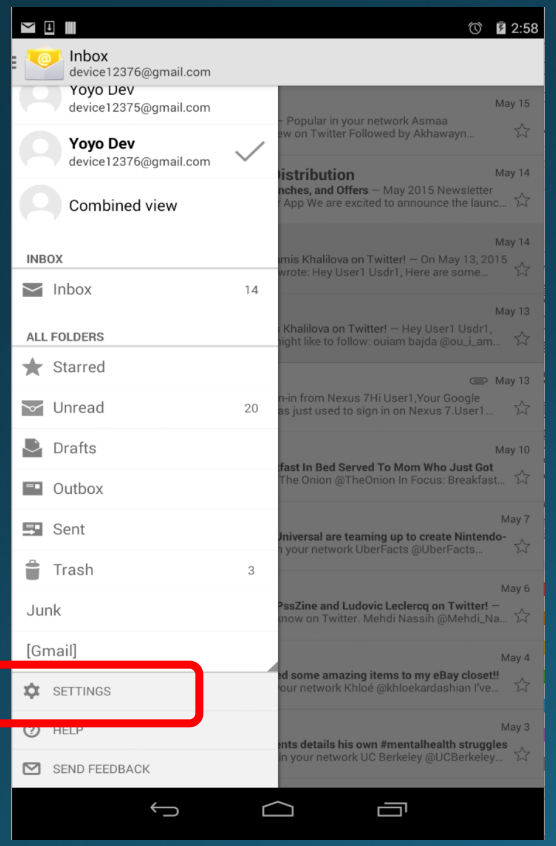


Handle
com.lge.ADD_ACCOUNT

Intent Hijacking

Google Email App

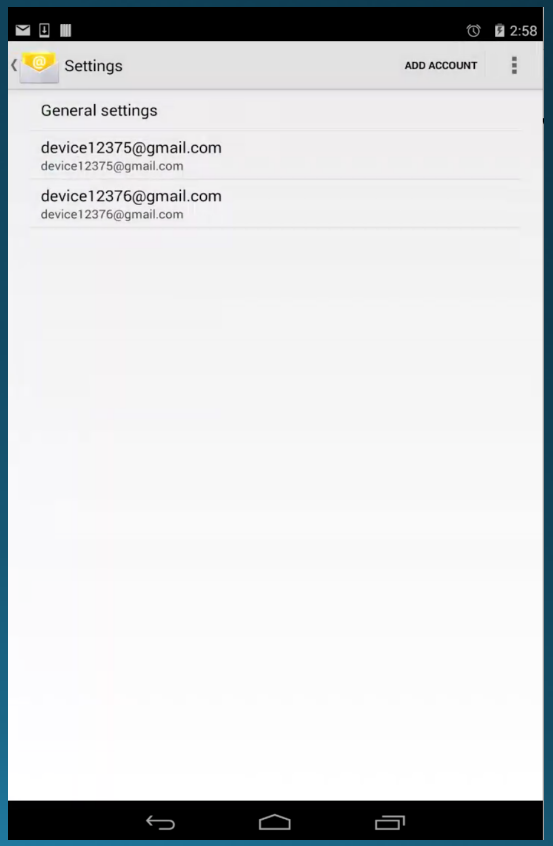
version 6.3-1218562



Action: android.intent.action.EDIT
Data: content://ui.email.android.com/
settings?account=id

```
<!-- Account Settings Intent Filters-->
<activity
  android:name=".activity.setup.AccountSettings"
       android:exported="true">
  <intent-filter>
      <action android:name="android.intent.action.EDIT"/>
      <category android:name=
           "android.intent.category.DEFAULT"/>
      <data android:scheme="content"
        android:host="ui.email.android.com"
        android:pathPrefix="/settings"/>
  </intent-filter>
```

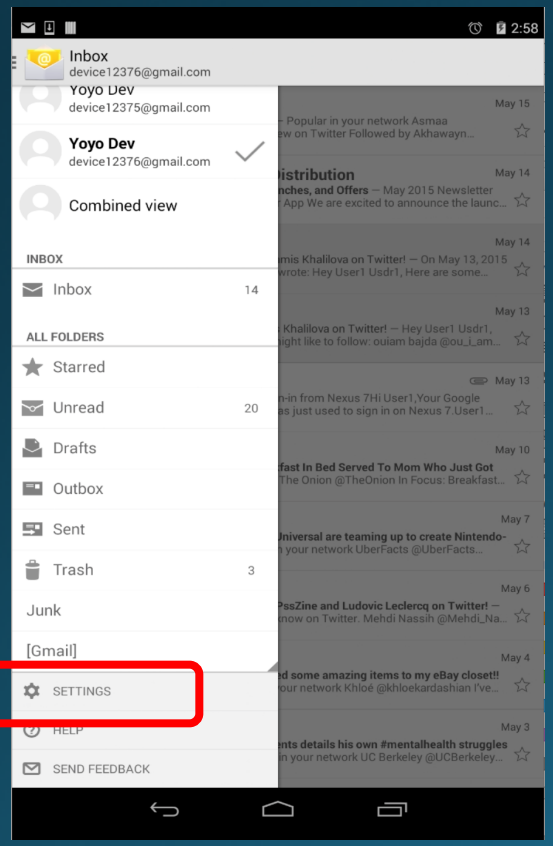
AccountSetting Activity Within Google Email App

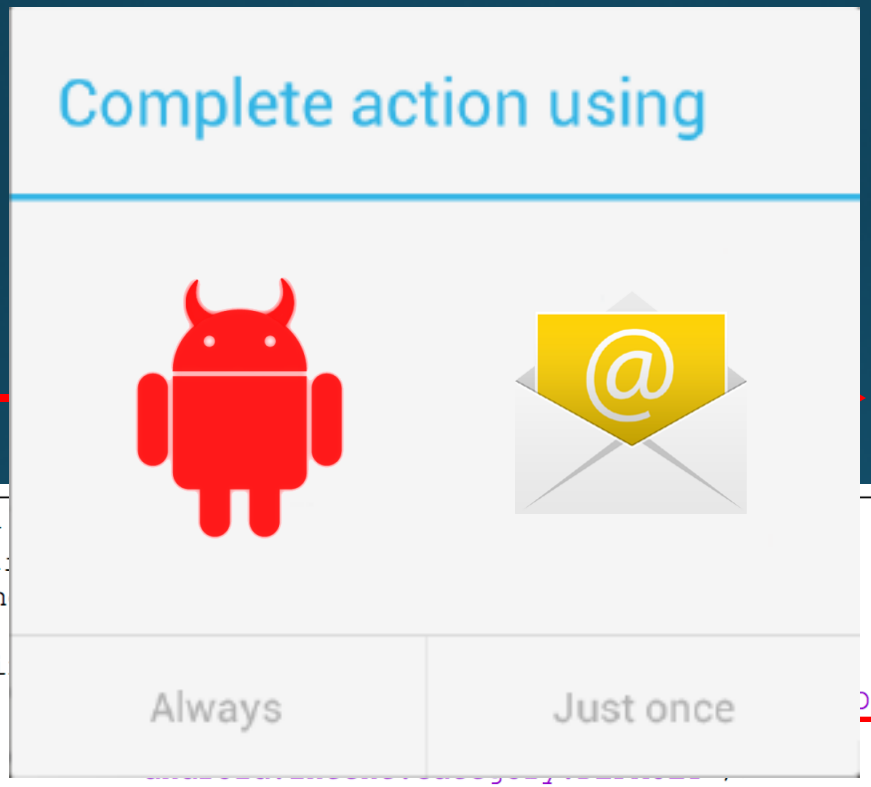


Intent Hijacking

Google Email App

version 6.3-1218562

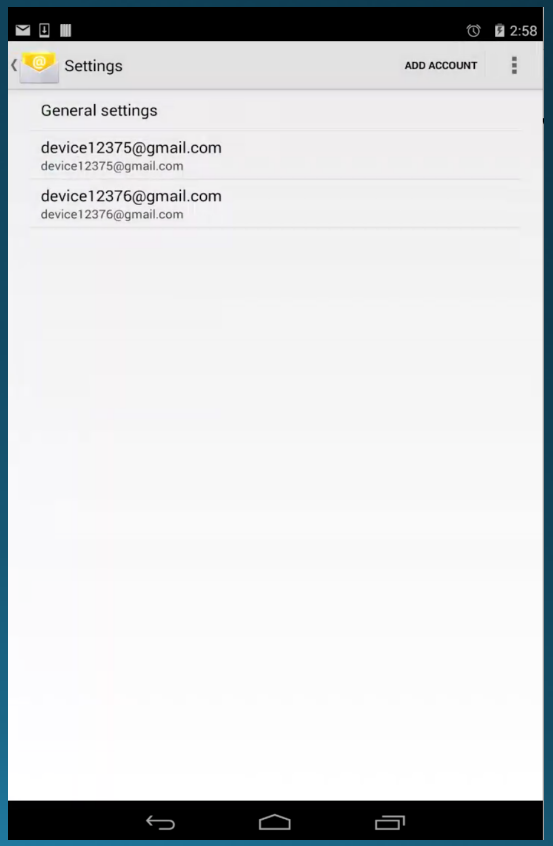





```
<!--
<acti
  an

  <i                                              DIT"/>
      <data android:scheme="content"
        android:host="ui.email.android.com"
        android:pathPrefix="/settings"/>
  </intent-filter>
```

AccountSetting Activity Within Google Email App

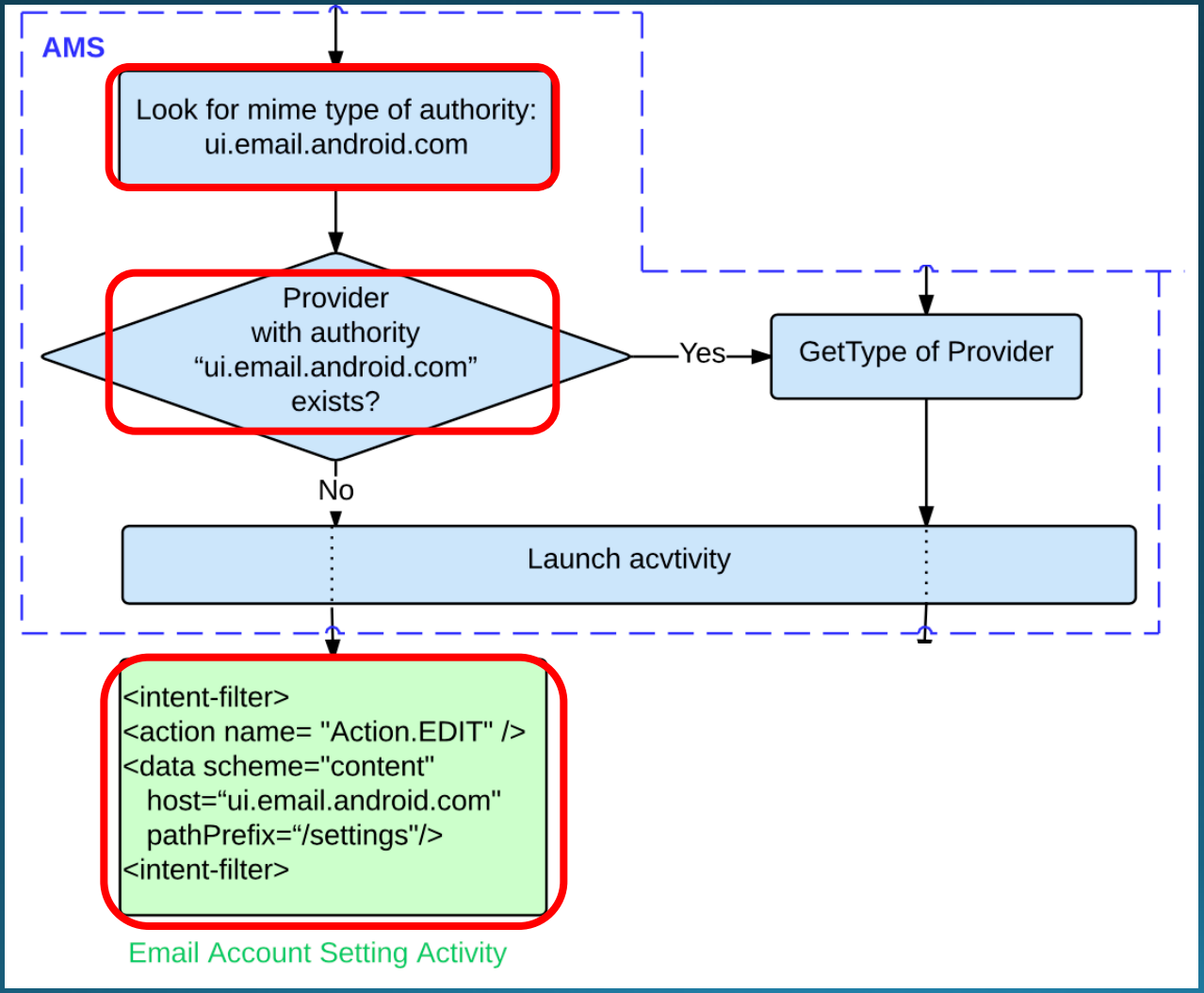


Intent Hijacking

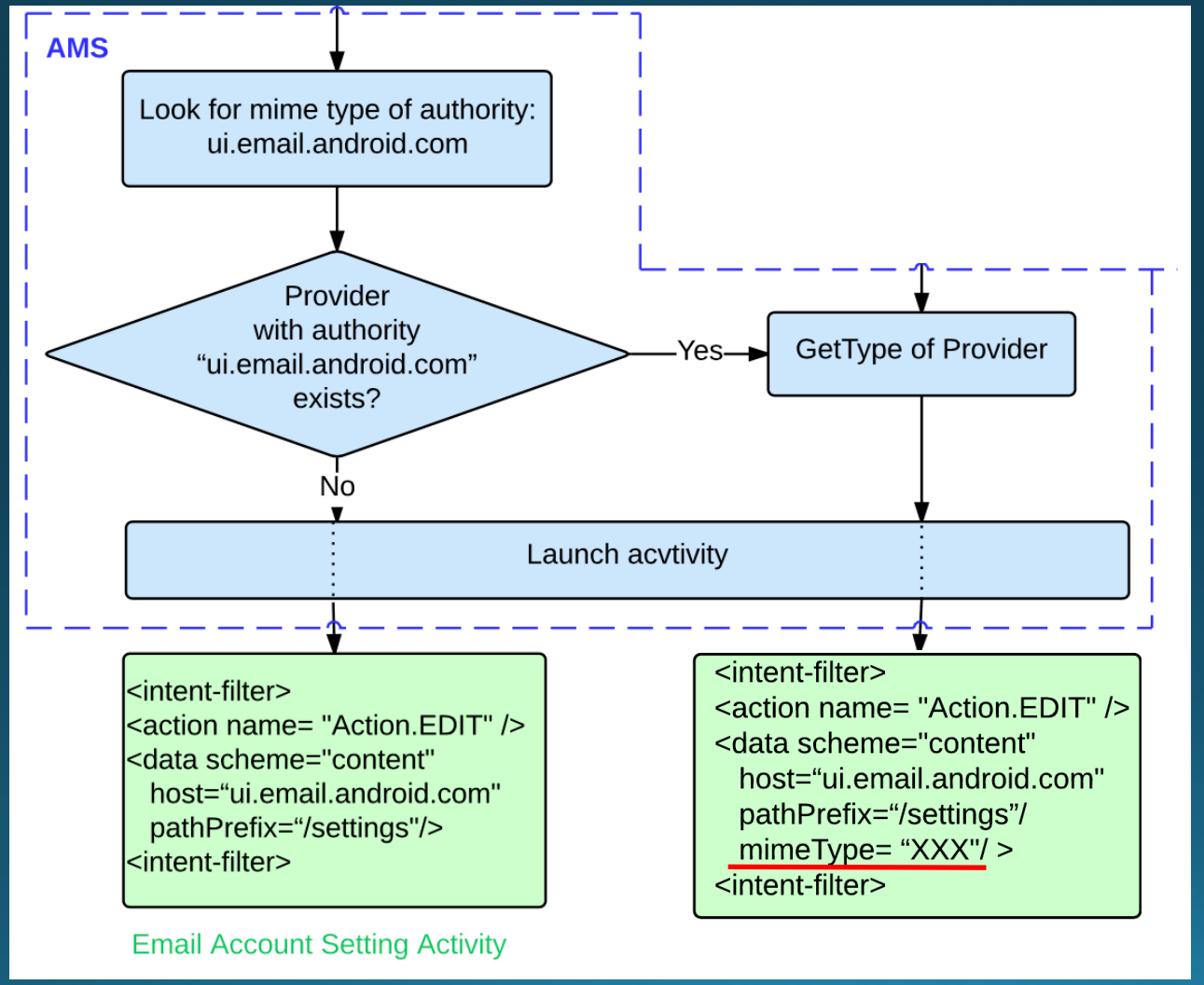
The authority of content provider "ui.email.android.com" does not exist.

How do we leverage this to be the only one to receive the intent?

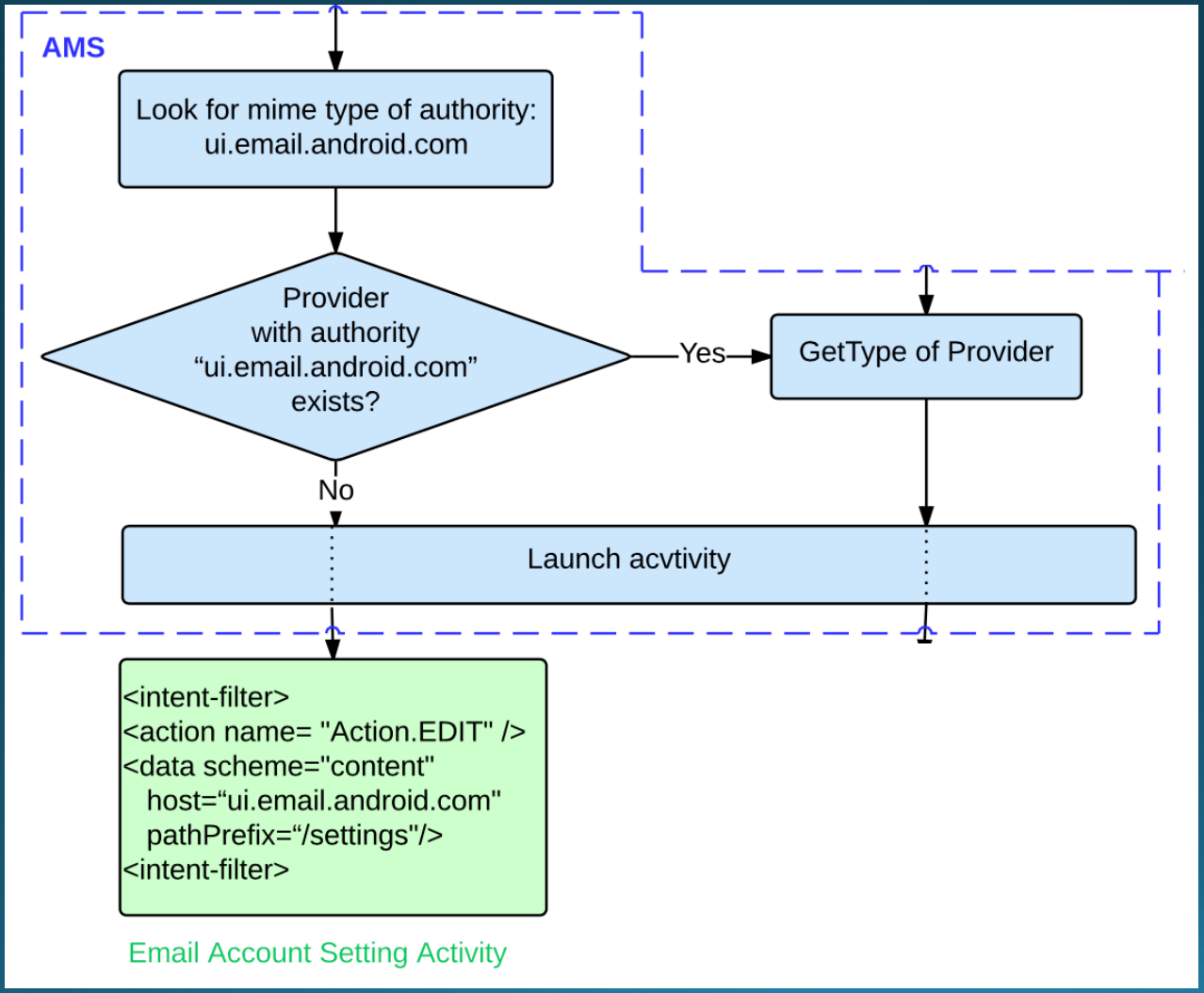
Intent Hijacking



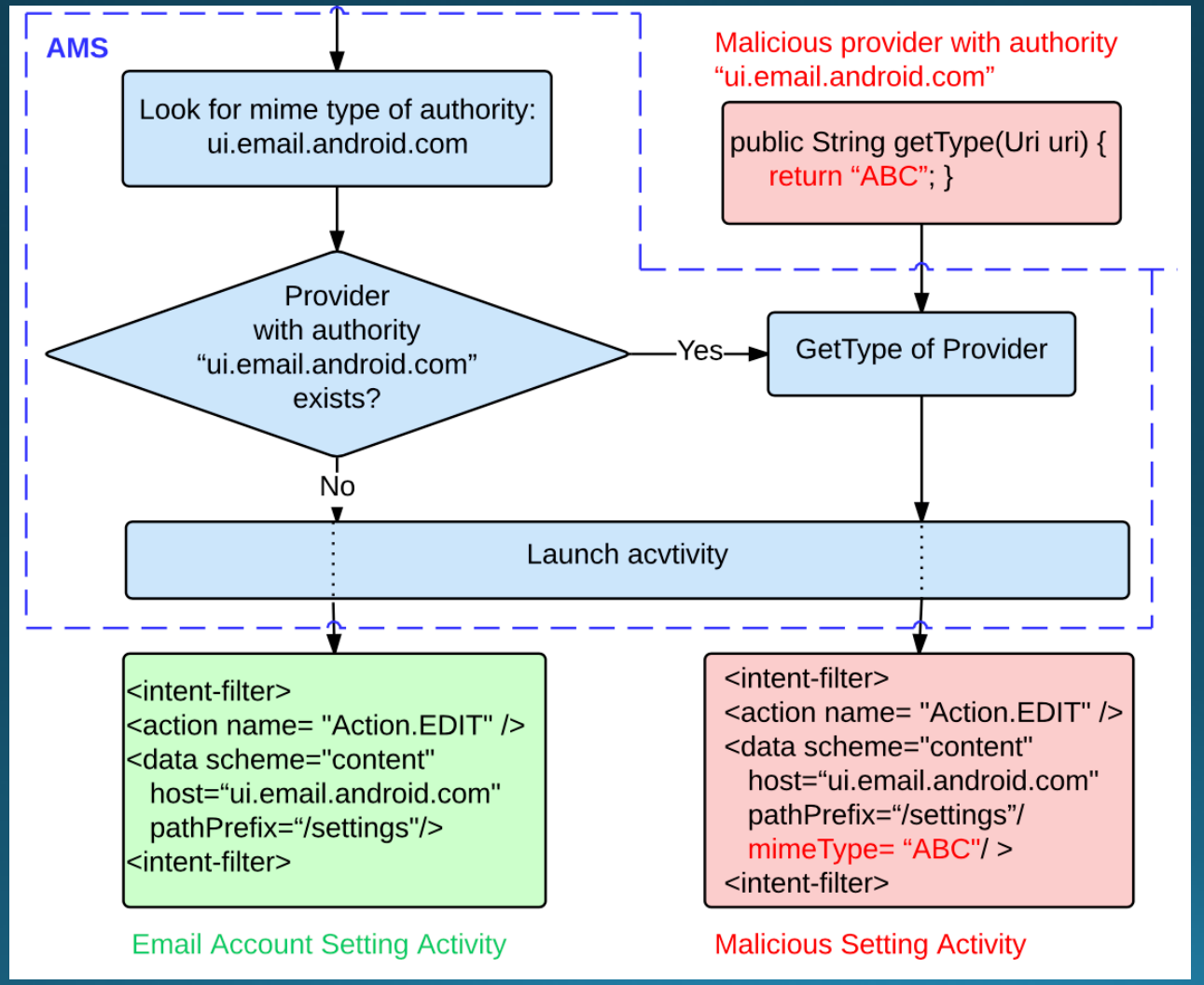
Intent Hijacking



Intent Hijacking



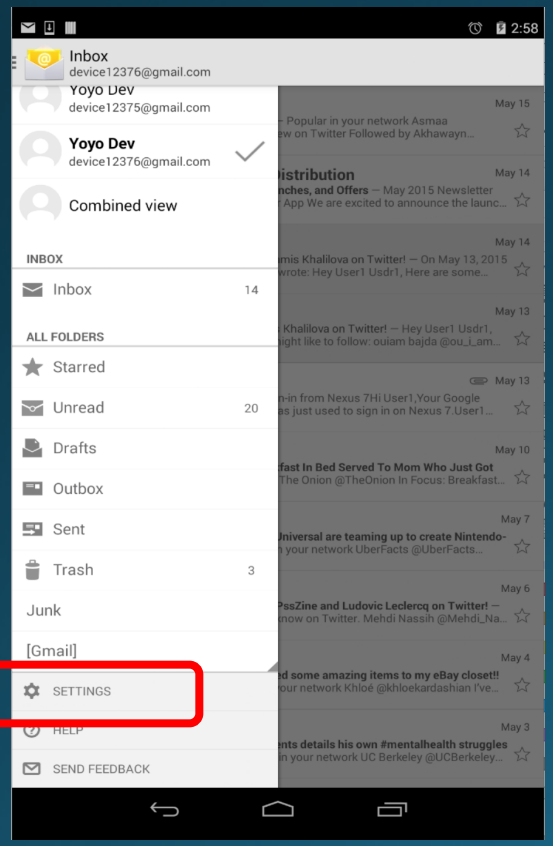
Intent Hijacking



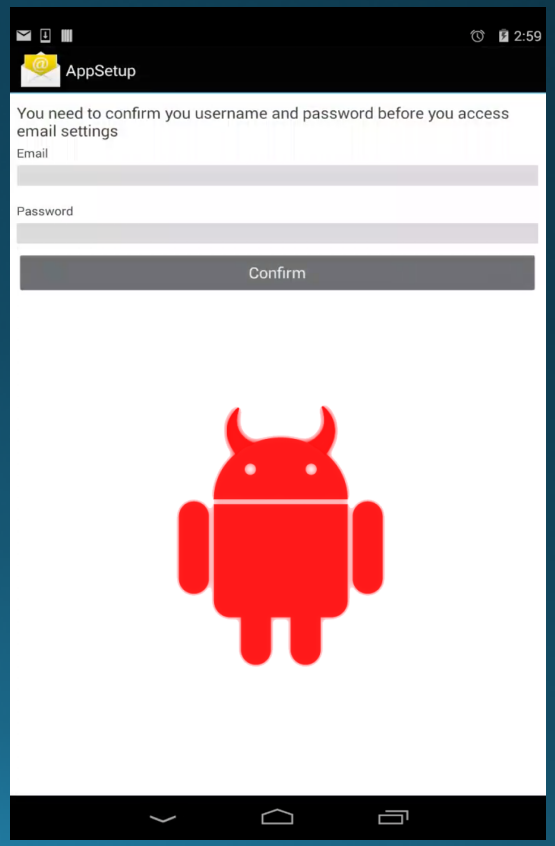
Intent Hijacking

Google Email App

version 6.3-1218562



Malicious App



Demos

- Google Email Attack
- LG CloudHub Attack
- Facebook Service Confusion
- Skype Service Confusion

All deomos can be found at https://sites.google.com/site/androidharehunting/
and https://sites.google.com/site/perplexedmsg/

Exploiting Hares

Missing Permissions

Service Confusion

Apps use multiple push-messaging services, including

- Google Cloud Messageing (GCM)

  com.google.android.c2dm.permission.SEND

- Amazon Device Messaging (ADM)

  com.amazon.device.messaging.permission.SEND

- Nokia Notification

  com.nokia.pushnotifications.permission.SEND

Service Confusion

Google Cloud Messaging

GCM Receiver

ADM Receiver

Amazon Device Messaging

Service Confusion

On Kindle Fire

GCM Receiver

ADM Receiver

Google Cloud Messaging

Amazon Device Messaging

Service Confusion

On Kindle Fire

GCM Receiver

ADM Receiver

Push Message

Malicious App

Amazon Device Messaging

Demos

- Google Email Attack
- LG CloudHub Attack
- Facebook Service Confusion
- Skype Service Confusion

All deomos can be found at https://sites.google.com/site/androidharehunting/
and https://sites.google.com/site/perplexedmsg/

App Store Submission

- We have submitted some of attack apps to several app stores (e.g. Google, Amazon, Samsung).
- Passed vetting process easily.
- Removed immediately after approval.

Responsible Disclosure

- All vulnerabilities we have discovered have submitted to vendors at least 3 months prior to publication.
- Most of them have been acknowledged and fixed.

Not All Hare are Exploitable

- Certain apps are aware of the fact that a referenced resource might not exist on the image.
  - Before invoking a certain resource within an app, the app will first **check its signature**.
  - Other apps will **check the image properties** before invoking a non-existing app.

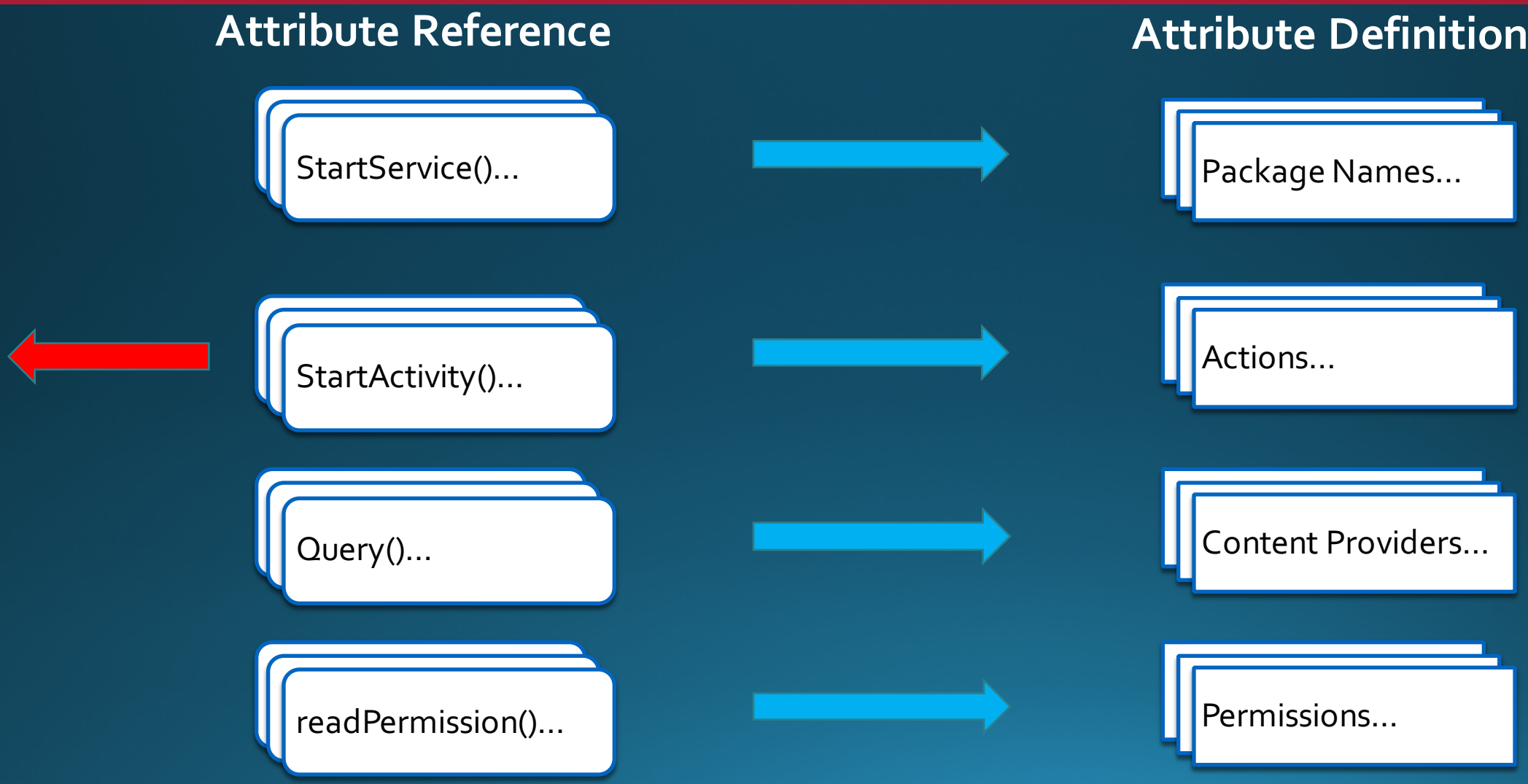
Signature Guard Example

```
1  public boolean extendAccessToken(Context context,
       ServiceListener servicelistener){
2    Intent intent = new Intent();
3    try{
4      PackageInfo pi =
           context.getPackageManager().getPackageInfo
           ("com.facebook.katana",
           PackageManager.GET_SIGNATURES);
5      // Compare signature to the legitimate Facebook
6      // app Signature
7      if (!compareSignatures
           (pi.signatures[0].toByteArray())){
8        return false;
9      } else{
10       intent.setClassName("com.facebook.katana",
             "com.facebook.katana.platform.
             TokenRefreshService");
11       return context.bindService(intent, new
             TokenRefreshServiceConnection(context,
             servicelistener), 1);}
12   }catch(PackageManager.NameNotFoundException e){
13     return false;
14   }
15 }
```

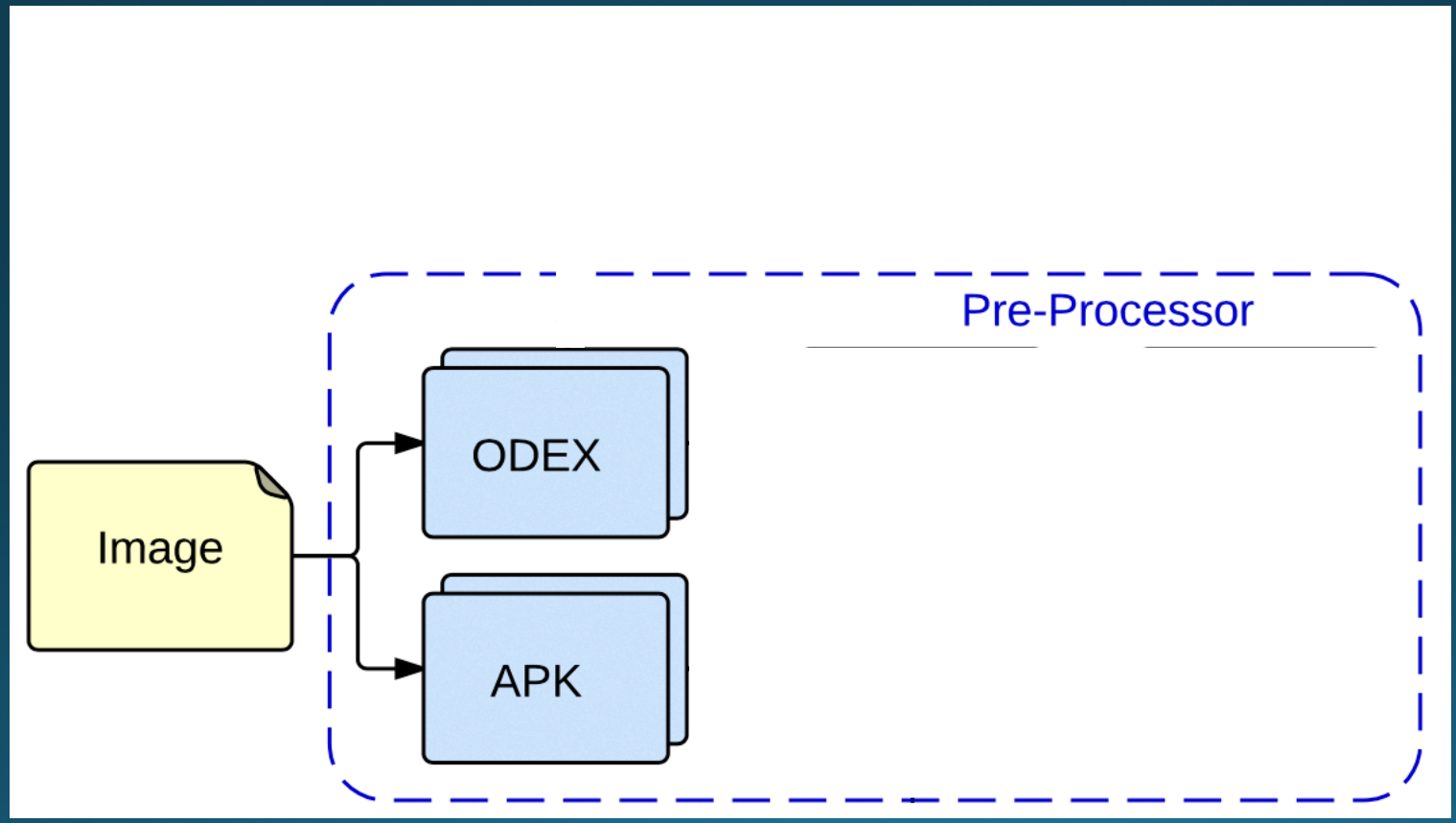
Property Guard Example

```
1  private void ViewVideo(Uri uri){
2     Intent intent = new
           Intent("android.intent.action.VIEW", uri);
3     if (getPackageManager().hasSystemFeature
           ("com.google.android.tv")){
4        intent.setPackage("com.google.android.youtube.googletv");
5     } else{
6        intent.setPackage("com.google.android.youtube");
7     } startActivity(intent);
8  }
```

Automatically Detect Hare



Construct APK



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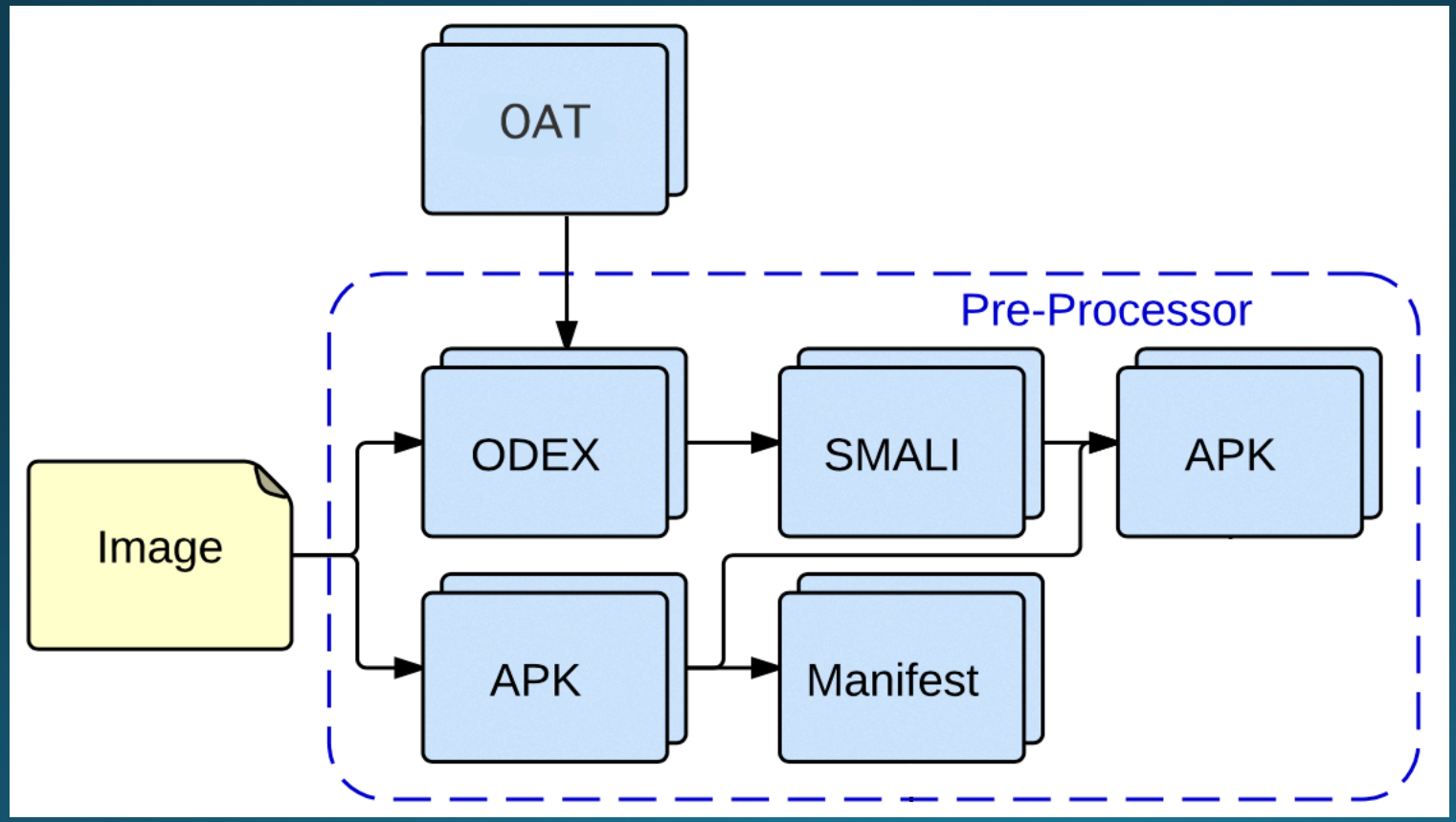
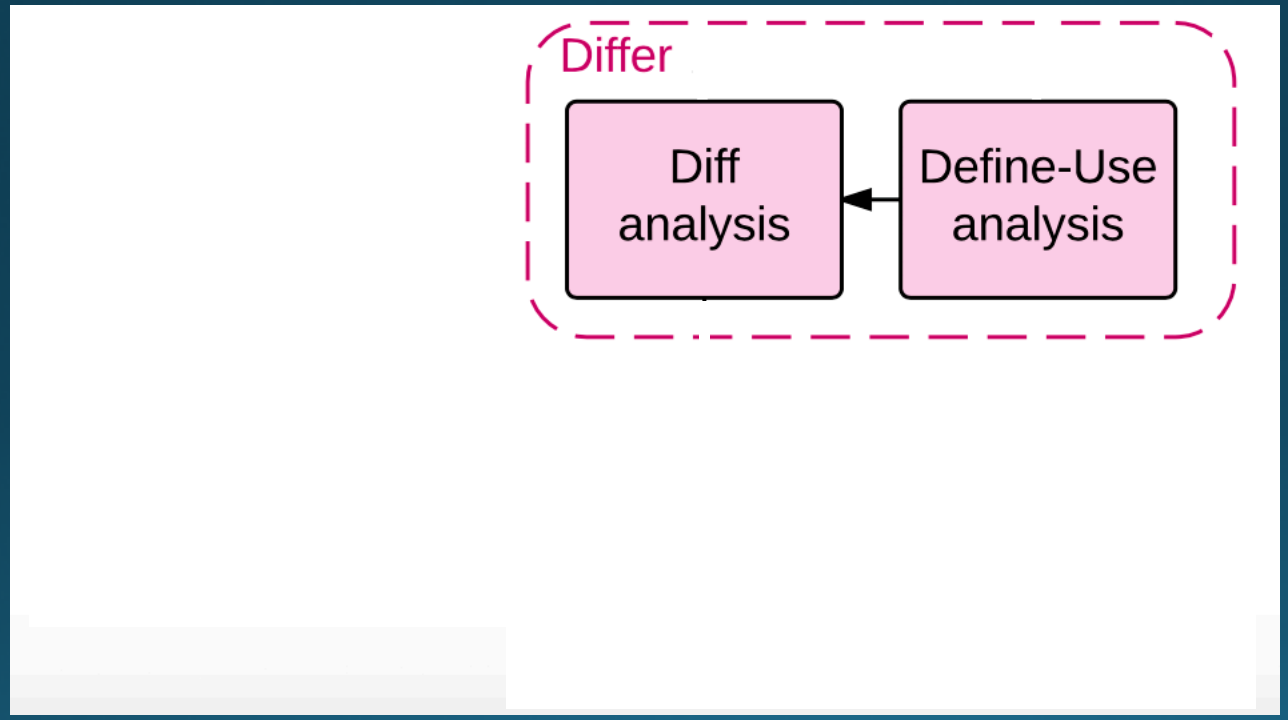


Generate Likely Hare

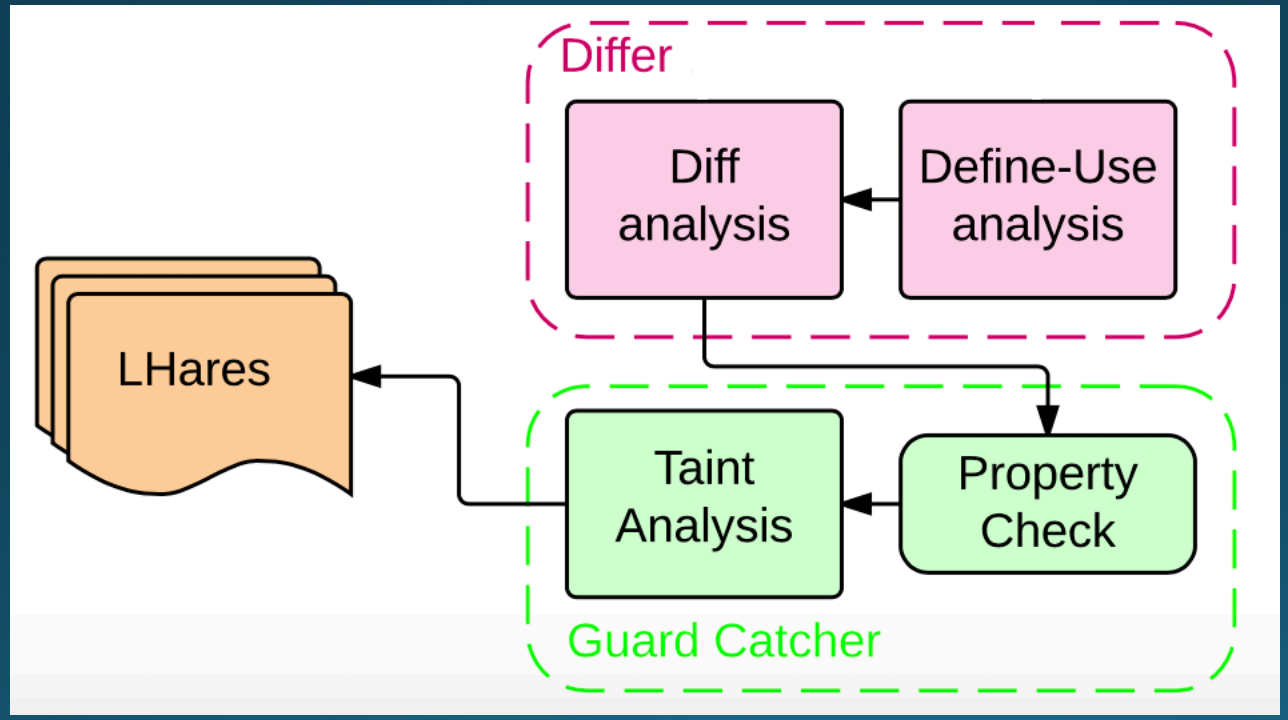


Guard Detection

- Taint Analysis
  - Source: guard API
  - Sink: Attribute reference API

- If a relationship is established between the source and the sink, then the Attribute Reference API is guarded.

Generate Likely Hare



Large Scale Measurement

Vendor	# of Images	# of System Apps	Avg # of System Apps Per Images	# of Countries	# of Carriers	# of OS Versions
A	83	21733	261	36	23	10
B	7	1561	223	1	1	4
C	1	174	174	1	1	1
D	4	398	99	1	1	3
E	2	319	159	2	1	2
Total	**97**	**24185**	**183**	**36**	**23**	**10**

Findings

Vendor	Hares in Android 4.X		Hares in Android 5.X		Avg Hares per Device	Min Hares per Device	Max Hares per Device
	# of Hares	# of Vulnerable Apps	# of Hares	# of Vulnerable Apps			
A	19279	3045 (18%)	608	99 (6%)	239	23	598
B	679	121 (13.3%)	425	85 (15.5%)	157	100	224
C	N/A	N/A	248	33 (21.5%)	248	248	248
D	107	31 (12.4%)	8	5 (5%)	29	8	45
E	187	23 (15.6%)	16	8 (12.1%)	101	16	187
Total	**20252**	**3220 (14.3%)**	**1305**	**230 (11.7%)**	**153**	**8**	**598**

Discussion

- In the absence of sufficient guidance and a proper enforcement mechanism, hanging references become inevitable.
- Systematic efforts should be made to secure attributes and to document interdependent relations between components.

Thank you!

Any questions?