Computer Science
NC STATE UNIVERSITY

Detecting Passive Content Leaks and Pollution in Android Applications

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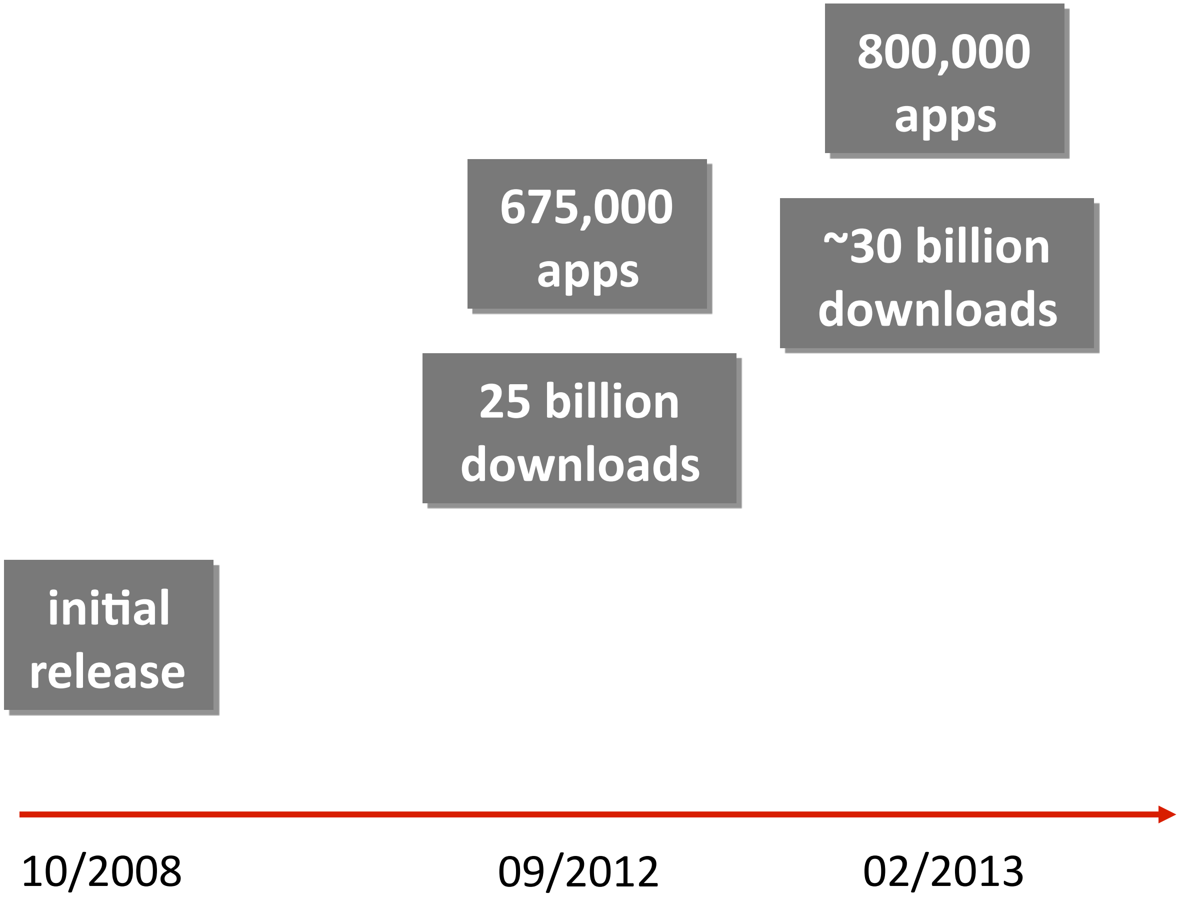
NDSS
SYMPOSIUM

Apps Are Becoming Popular

Google play



initial release

675,000 apps

25 billion downloads

800,000 apps

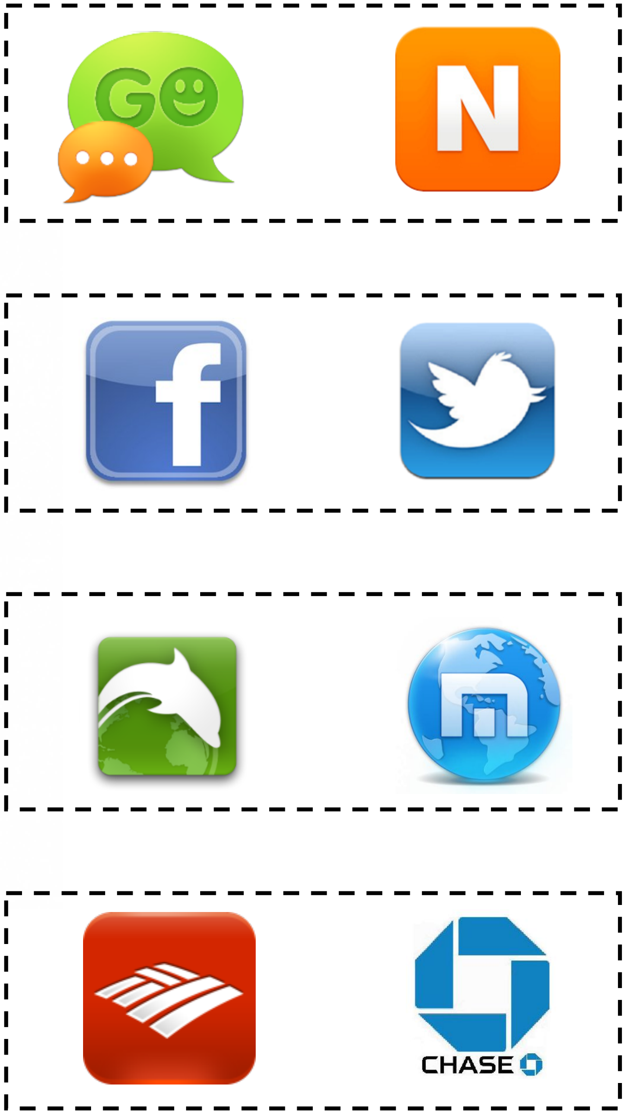
~30 billion downloads

10/2008

09/2012

02/2013

Apps Are Managing User Data



Messages

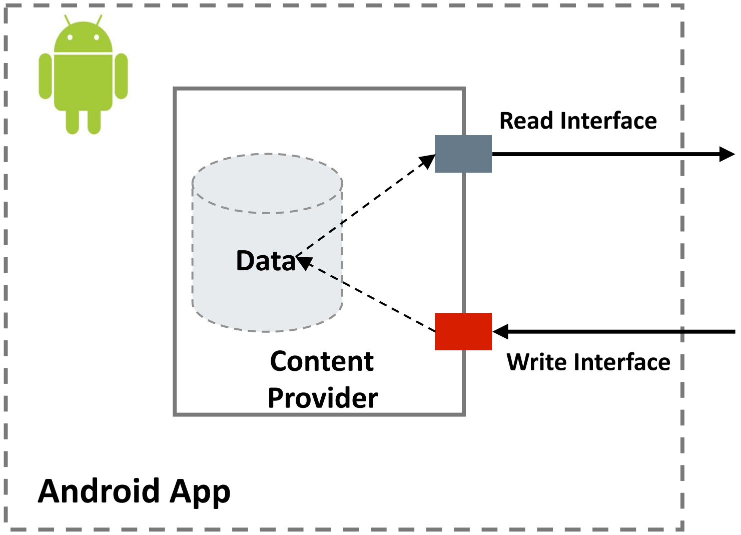
Friends

Browser Histories

Bank Accounts

Content Providers

- ❑ Manage access to a structured set of data

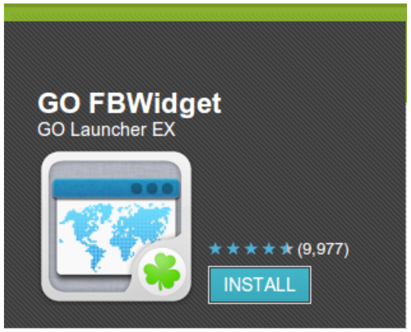


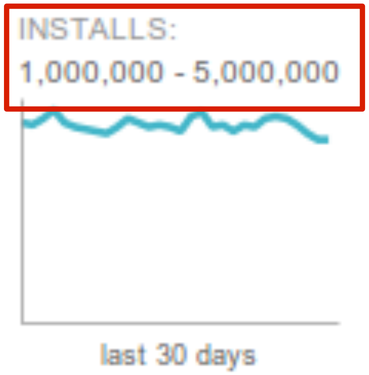
- ❑ ***By default*** *are* ***open*** to ***all*** apps on the phone
  (before Android 4.2)

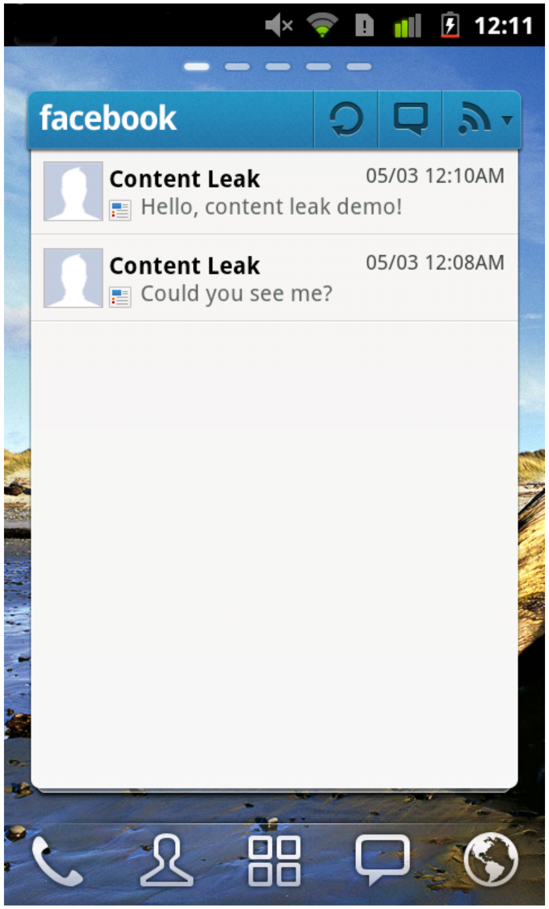
Any potential security risks?

A Motivating Example

- GO FBWidget: popular Android app with more than 1 million installs



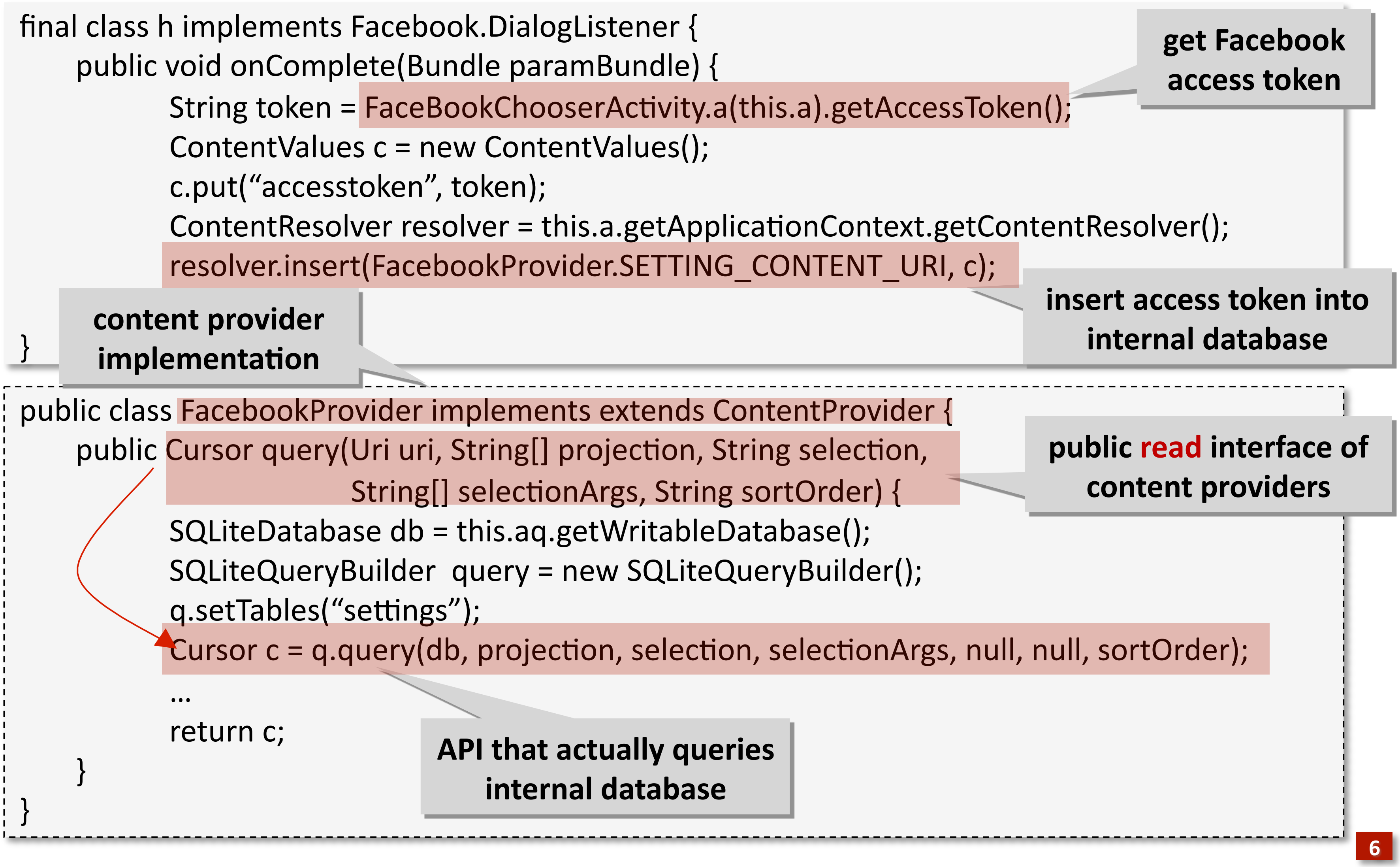




Content Leak 05/03 12:10AM
Hello, content leak demo!

Content Leak 05/03 12:08AM
Could you see me?

A Motivating Example



```
final class h implements Facebook.DialogListener {
    public void onComplete(Bundle paramBundle) {
            String token = FaceBookChooserActivity.a(this.a).getAccessToken();
            ContentValues c = new ContentValues();
            c.put("accesstoken", token);
            ContentResolver resolver = this.a.getApplicationContext.getContentResolver();
            resolver.insert(FacebookProvider.SETTING_CONTENT_URI, c);
}
```

get Facebook access token

insert access token into internal database

content provider implementation

```
public class FacebookProvider implements extends ContentProvider {
    public Cursor query(Uri uri, String[] projection, String selection,
                        String[] selectionArgs, String sortOrder) {
            SQLiteDatabase db = this.aq.getWritableDatabase();
            SQLiteQueryBuilder  query = new SQLiteQueryBuilder();
            q.setTables("settings");
            Cursor c = q.query(db, projection, selection, selectionArgs, null, null, sortOrder);
            …
            return c;
    }
}
```

public **read** interface of content providers

API that actually queries internal database

A Motivating Example

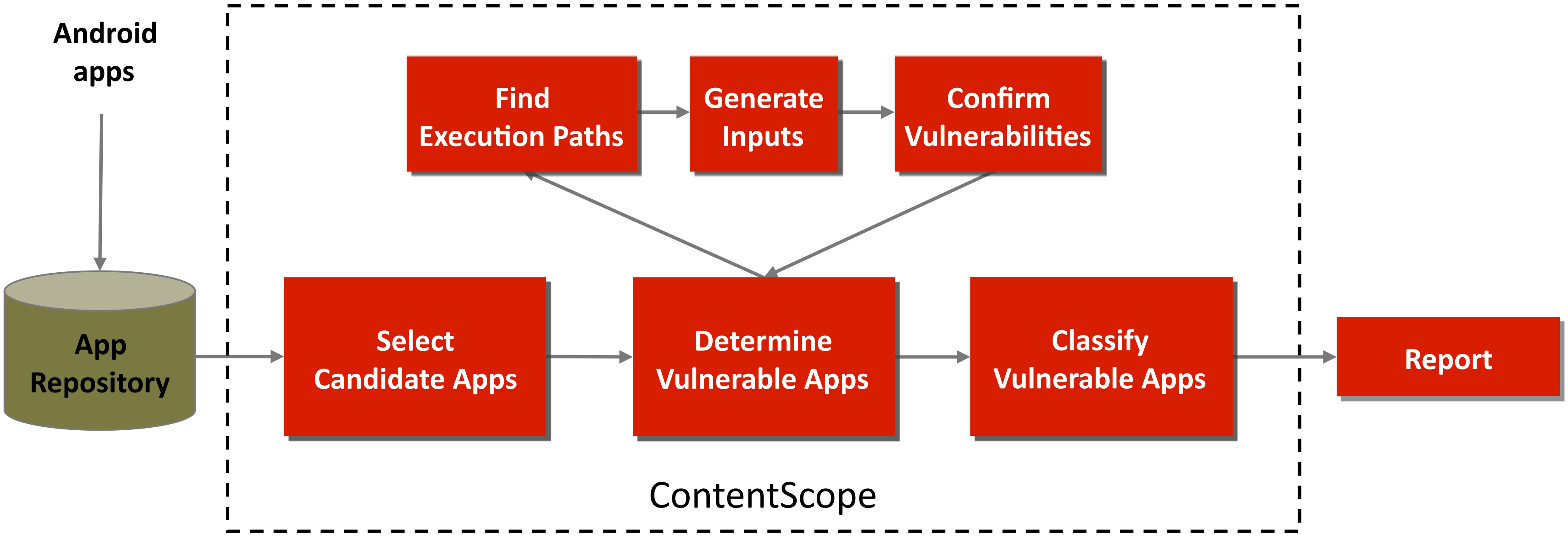
- ❑ Can be exploited to leak private data
    - ❑ *Access token,* Facebook posts

Automatically log into user's Facebook account and make posts

Our Work

- ❑ Systematically study two vulnerabilities: content leaks and content pollution
  - ❑ 2.0% and 1.4% of apps are susceptible, respectively
  - ❑ Types of information leaked
    - ❑ SMS messages, contacts, user credentials, …
  - ❑ Possible side-effects
    - ❑ Block SMS messages and phone calls
    - ❑ Download apps and prompt for installation

System Design

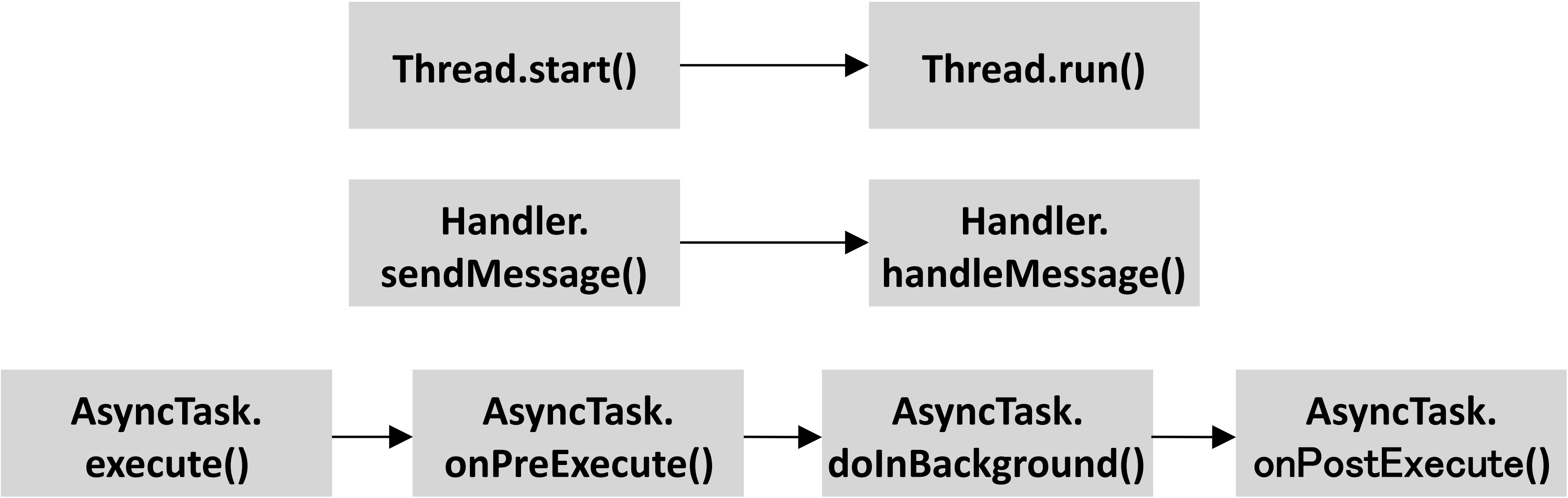


Find Execution Paths

- From public interfaces of content providers to functions that actually operate on internal database

Find Execution Paths

- Function call graph
  - Object reference resolution
  - Call graph discontinuity



Thread.start() → Thread.run()

Handler. sendMessage() → Handler. handleMessage()

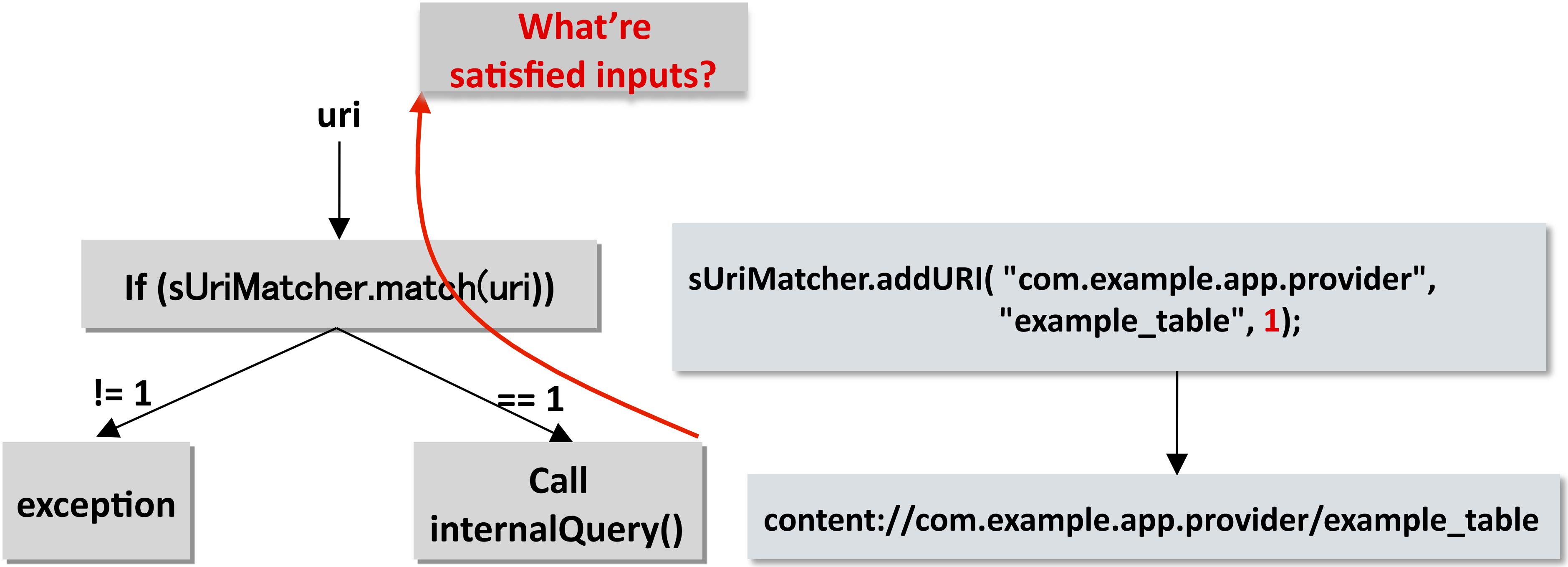
AsyncTask. execute() → AsyncTask. onPreExecute() → AsyncTask. doInBackground() → AsyncTask. onPostExecute()

Generate Inputs

- ❑ Generate control flow graph
- ❑ Obtain constraints
- ❑ Resolve constraints

Generate Inputs

- Android specific APIs
  - UriMatcher



What're satisfied inputs?

uri

If (sUriMatcher.match(uri))

!= 1

== 1

exception

Call internalQuery()

sUriMatcher.addURI("com.example.app.provider",
"example_table", 1);

content://com.example.app.provider/example_table

Confirm Vulnerabilities

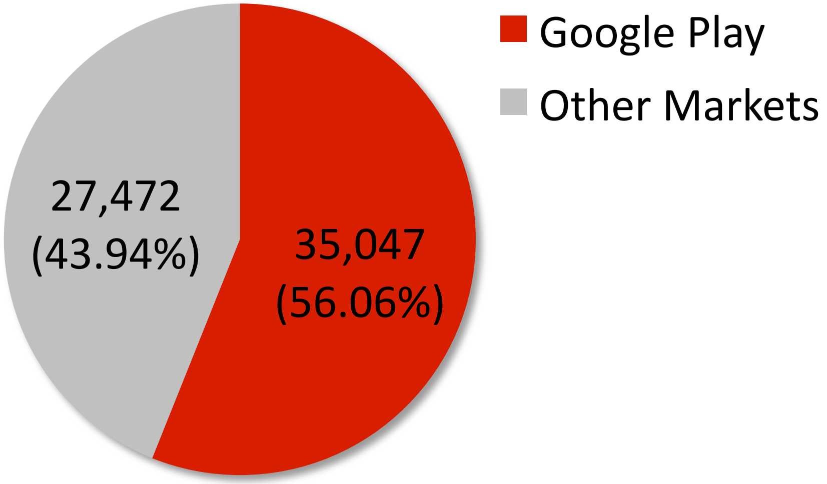
- Feed generated inputs into a test app
- Invoke public interfaces of content providers
  - query(), insert(), …
- Determine the existence of vulnerabilities based on return value
  - query(): Cursor object
  - insert(): URI object

System Implementation

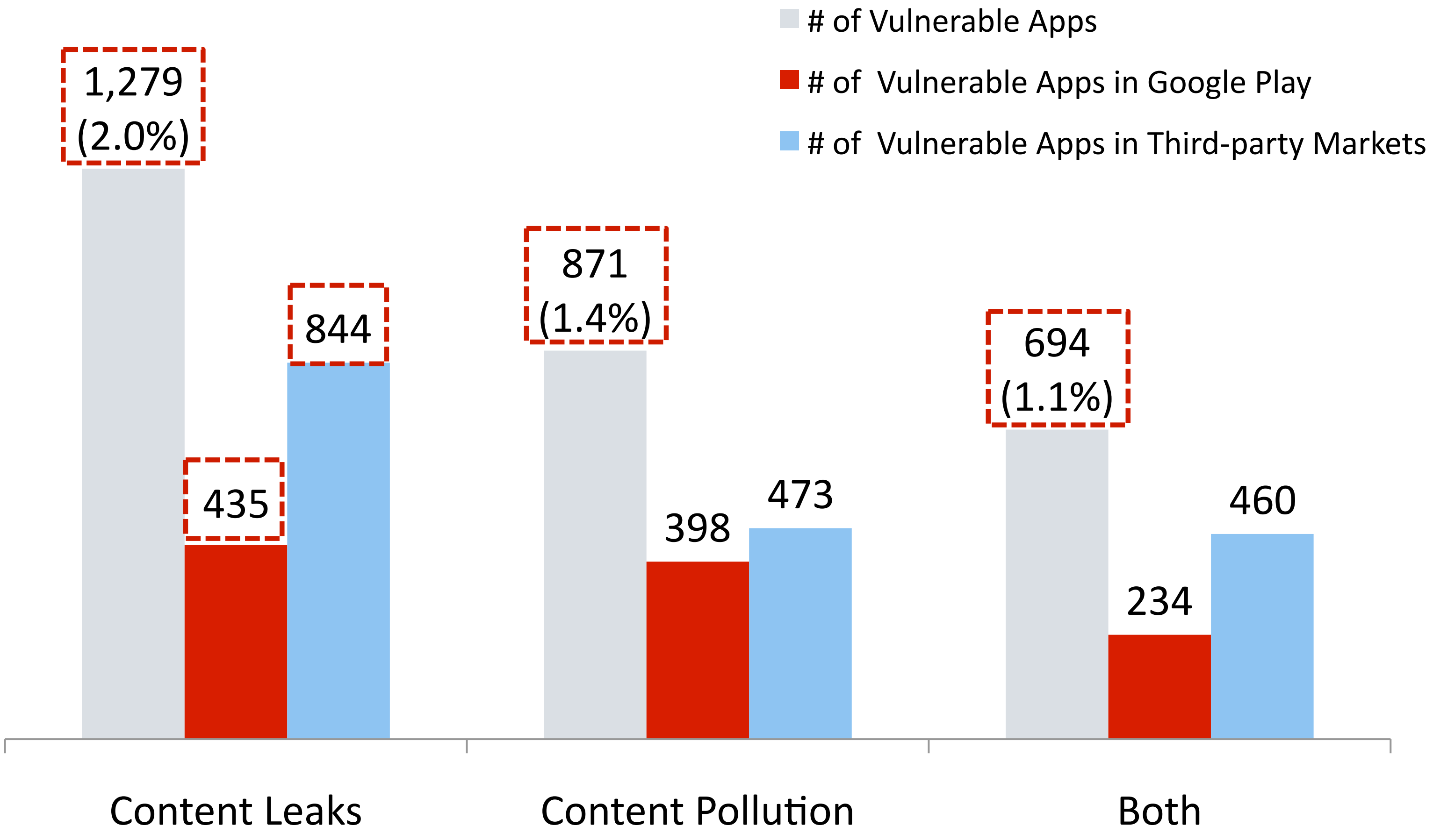
- Around 6,500 SLOCs
- Public interfaces of content providers
  - query(), openFile()
  - insert(), update()
- APIs that actually read or write internal database
  - SQLiteDatabase.query(), SQLiteDatabase.insert(), SQLiteQueryBuilder.query(), …

Evaluation

- Dataset: 62,519 free apps
  - Sources: Google Play and ten other Android markets
  - Time: February 2012



Overall Results



Main Types of Leaked Data

Category	# of apps	Representative App	# of Installs
SMS messages	268	Pansi SMS	500,000 – 1,000,000
Contacts	128	mOffice – Outlook sync	100,000 – 500,000
Private information in IM Apps	121	Messenger With You	10,000,000 – 50,000,000
User credentials	80	GO FB Widget	1,000,000 – 5,000,000
Browser History	70	Dolphin Browser HD	10,000,000 – 50,000,000
Call logs	61	Droid Call Filter	100,000 – 500,000
Private information In social network apps	27	Sina Weibo	100,000 – 500,000

Side-effects of Content Pollution

- Block SMS messages and phone calls: by manipulating security settings
  - DW Contacts
- Download apps and prompt for installation
  - Baidu Appsearch, Qihoo Browser

Vulnerable Security Apps

- Mobile Security Personal Ed.
  - Leak browser histories
- QQPimSecure, Anguanjia
  - Leak SMS, phone call logs
  - Block SMS and phone calls

Possible Mitigations

- App Developers
  - Patch their vulnerable apps
- Platform provider (Google)
  - Change the default setting of content provider interface

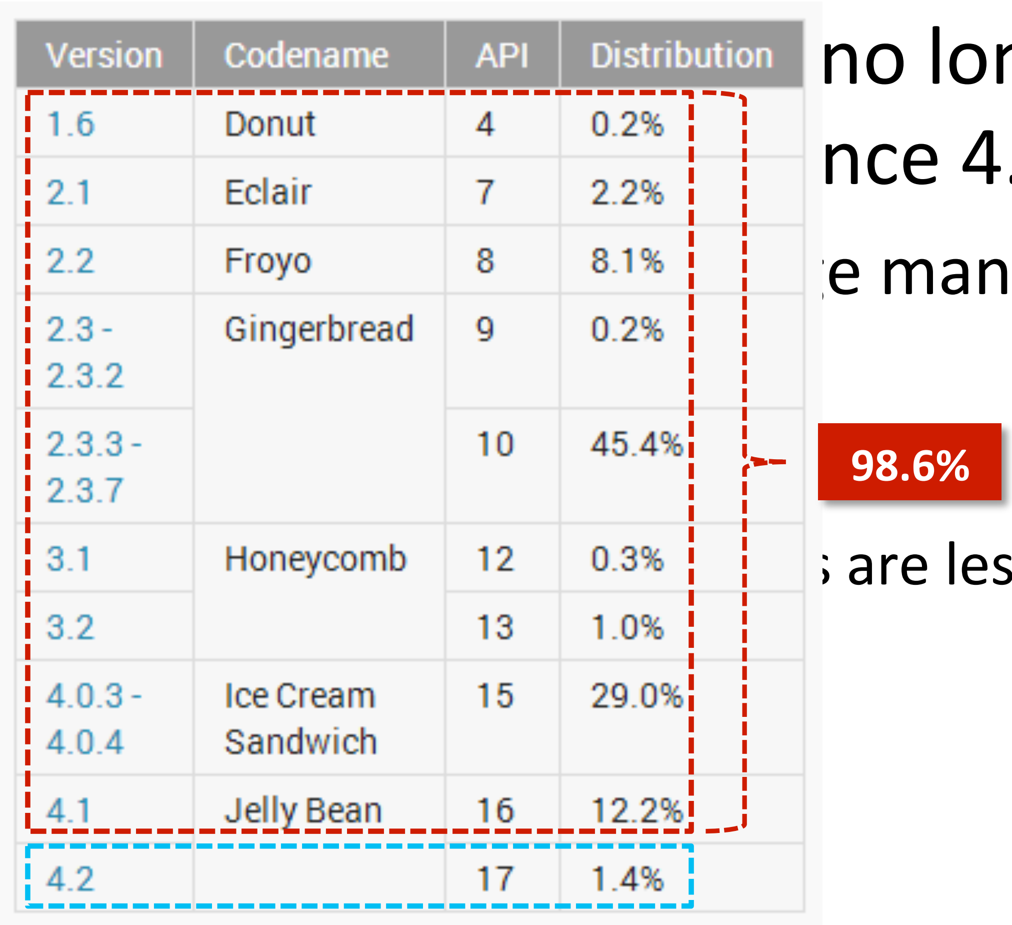
Possible Mitigations

- By Google: content providers are no longer exported by default on Android since 4.2
  - Developers need to **explicitly** change manifest file
    - Set targetSdkVersion to 17 (or higher)
  - Problems remain on old Android versions
    - The API level of ***98.6%*** Android devices are less than 17 on February 04, 2013 [1]

[1] http://developer.android.com/about/dashboards/index.html

Possible Mitigations

- By Google no longer exported nce 4.2
  - Develop e manifest file
    - Set tar
  - Problem
    - The AF ; are less than 17 on Feb



Version	Codename	API	Distribution
1.6	Donut	4	0.2%
2.1	Eclair	7	2.2%
2.2	Froyo	8	8.1%
2.3 - 2.3.2	Gingerbread	9	0.2%
2.3.3 - 2.3.7		10	45.4%
3.1	Honeycomb	12	0.3%
3.2		13	1.0%
4.0.3 - 4.0.4	Ice Cream Sandwich	15	29.0%
4.1	Jelly Bean	16	12.2%
4.2		17	1.4%

98.6%

[1] http://developer.android.com/about/dashboards/index.html

Related Work

- Smartphone privacy
  - TaintDroid [Enck *et al.*, OSDI 10], AdRisk [Grace *et al.*, ACM WiSec 12] ...
- Confused deputy
  - Woodpecker [Grace *et al.*, NDSS 12], Permission Re-Delegation [Felt *et al.*, USENIX Security 11] ...
- Vulnerability detection
  - BitBlaze [Song *et al.*, ICISS 08], KLEE [Cadar *et al.*, USENIX Security 08] ...

Conclusion

- Systematically study two vulnerabilities: content leaks and content pollution
  - 2.0% and 1.4% of apps are susceptible, respectively
  - Types of information leaked
    - SMS messages, contacts, user credentials, …
  - Possible side-effects:
    - Block SMS messages and phone calls, …

Q&A

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