Checking More and Alerting Less: Detecting Privacy Leakages via Enhanced Data-flow Analysis and Peer Voting

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In terms of privacy data…

- Are "you" contained in smartphone?
  - Contacts, photo, SMS, credentials, browse history…

Privacy Disclosures

- Privacy can be disclosed to internet or public

Prevalent Privacy Disclosures

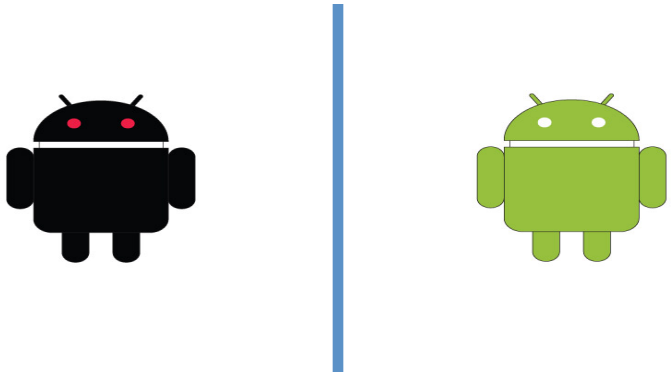
- **8%** apps failed to protect bank account and social media logins [BBC, Oct 12]
- **95%** of the top-100 free exhibited at least one kind of privacy-compromising behavior, while **78%** of paid apps disclosed similar data. [Black Hat USA, Jul 13]
- **30%** general apps have privacy disclosures, shown by AndroidLeaks [TRUST'12]

Privacy Disclosure Vs. Privacy Leak

- Privacy Disclosure == Privacy Leak ?
- MOST privacy disclosures are legitimate

Research Problem

- How can we automatically differentiate suspicious privacy leaks from legitimate privacy disclosures???



Insight

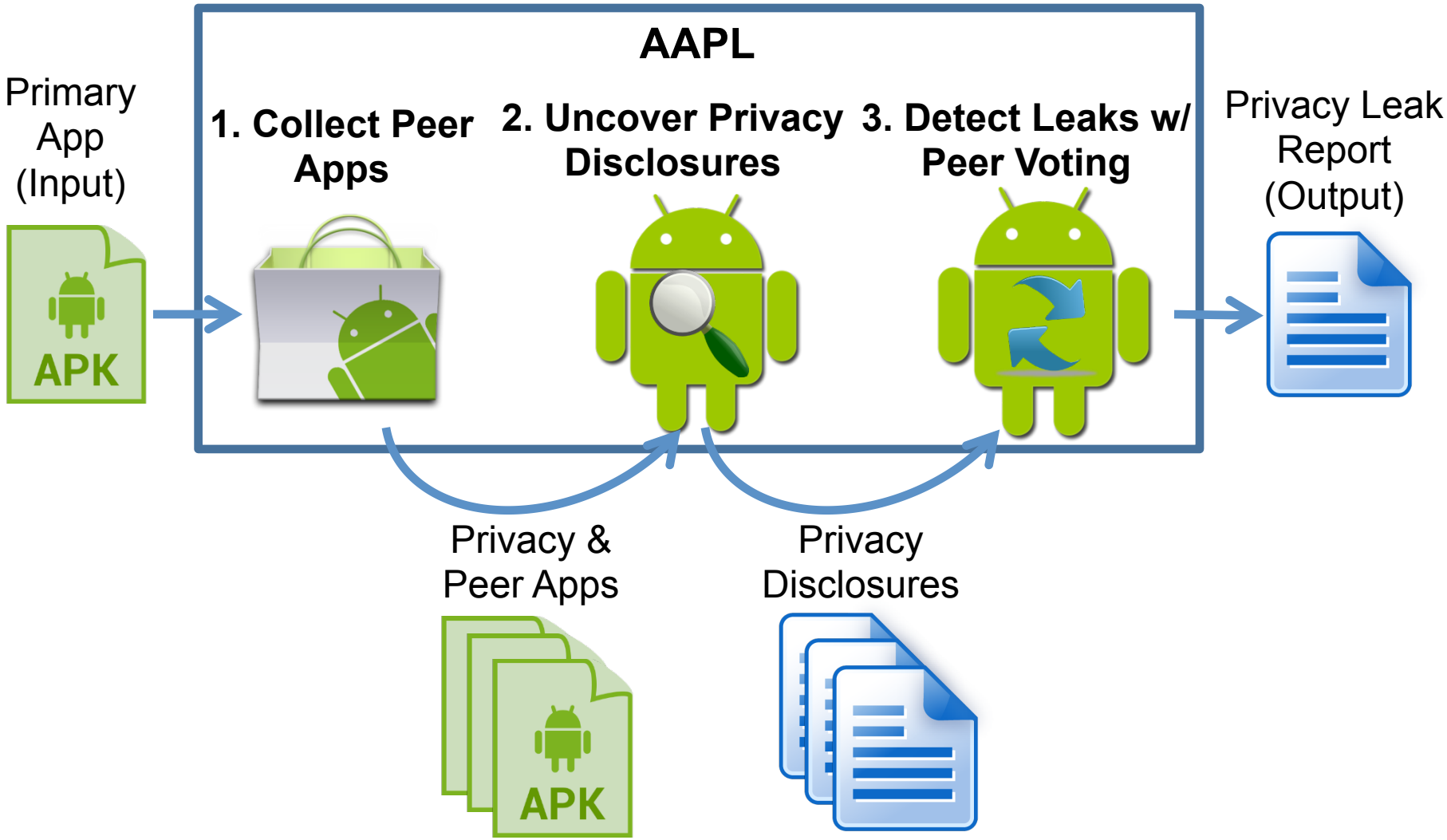
- An app's (namely primacy app) functionally similar apps (namely peer apps) are supposed to exhibit similar privacy disclosures

- If a privacy disclosure is uncommon in peer apps → likely suspicious

AAPL: Analysis of App Privacy Leak

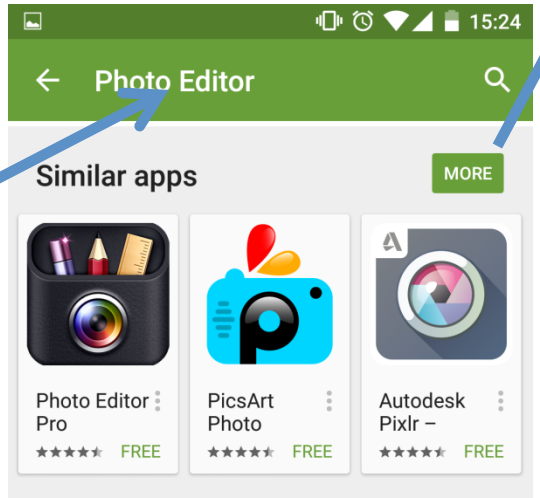
Detecting Privacy Leaks via Peer Voting Mechanism

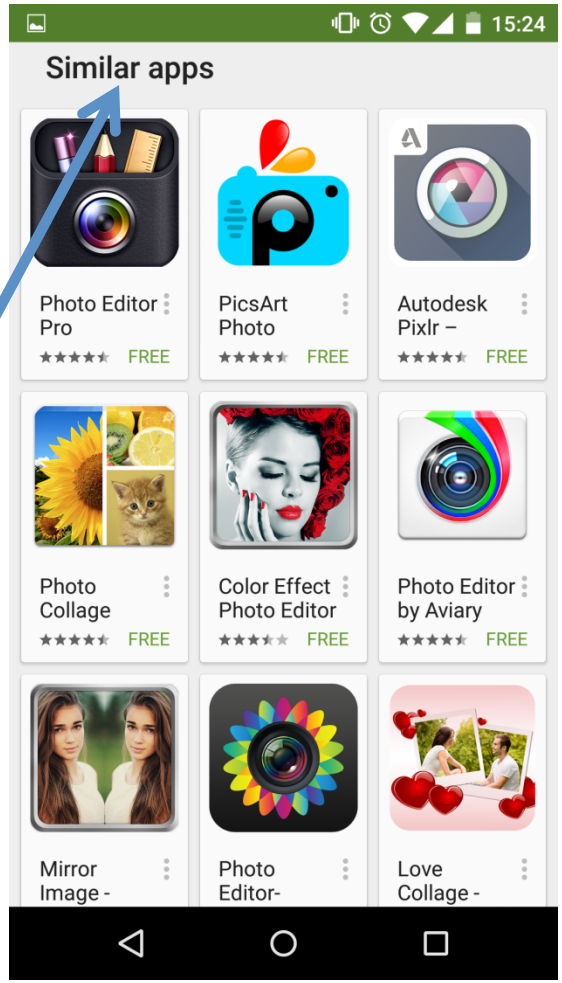
AAPL Workflow



Collecting Peer Apps

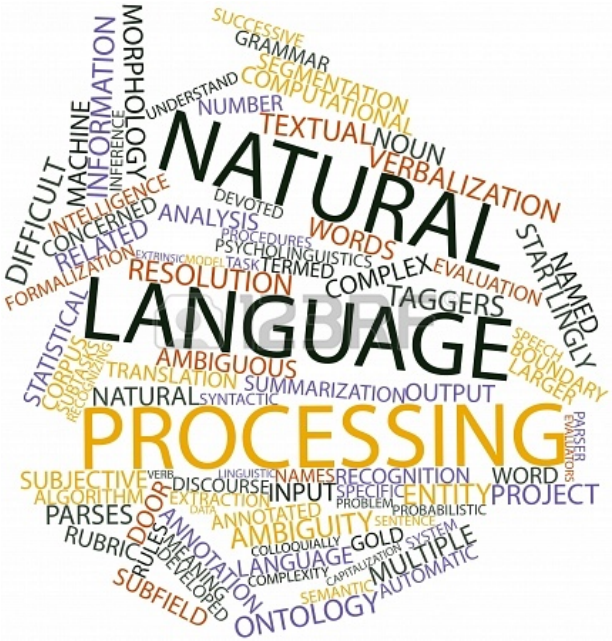
- Possible approaches
  - Apps with similar permissions ☹
  - Apps with similar text descriptions ☹
  - Similar apps suggested by Google Play,
    - derived from users' experience, ML, etc. ☺





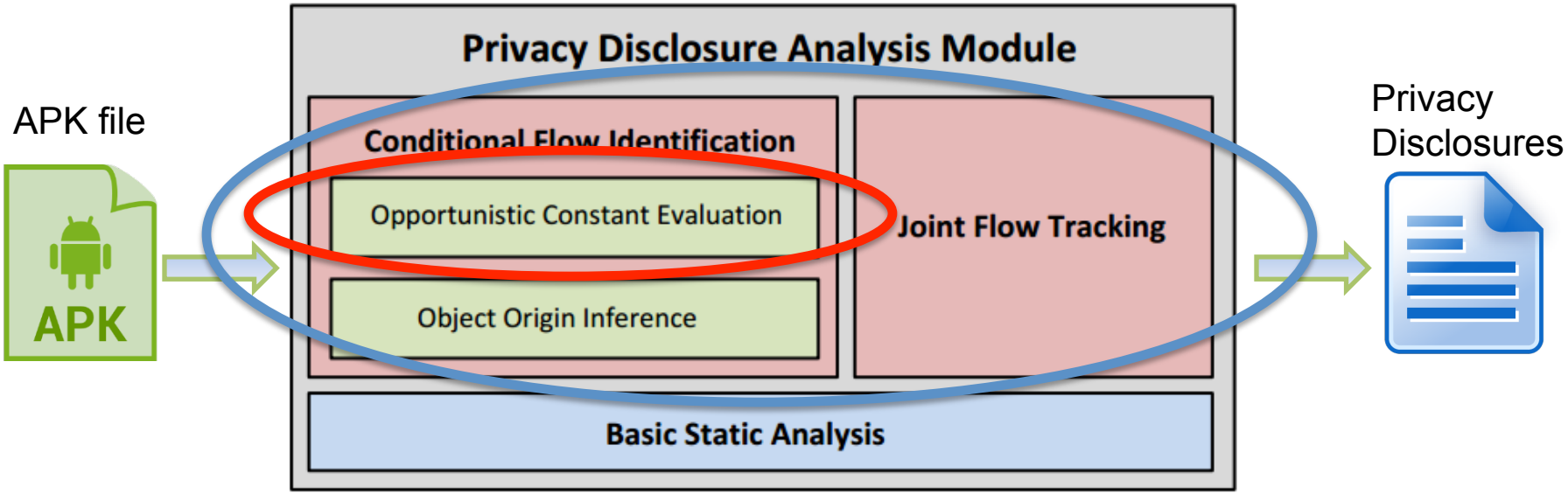
Purifying Peer Apps

- Adopt NLP
  - Parse app descriptions using NLTK[1]
  - tf-idf vectors
  - cosine similarity



[1]http://www.nltk.org/

Uncovering Privacy Disclosures



Opportunistic Constant Evaluation

- Conditional sources
  - `provider.query(uri, sql)`

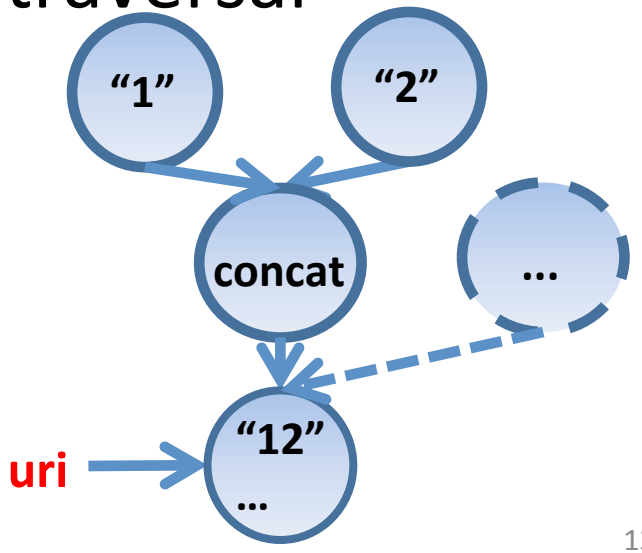
    - Contact? SMS?
    - Non-sensitive?

    Have no idea?

Most privacy data accesses follow this way

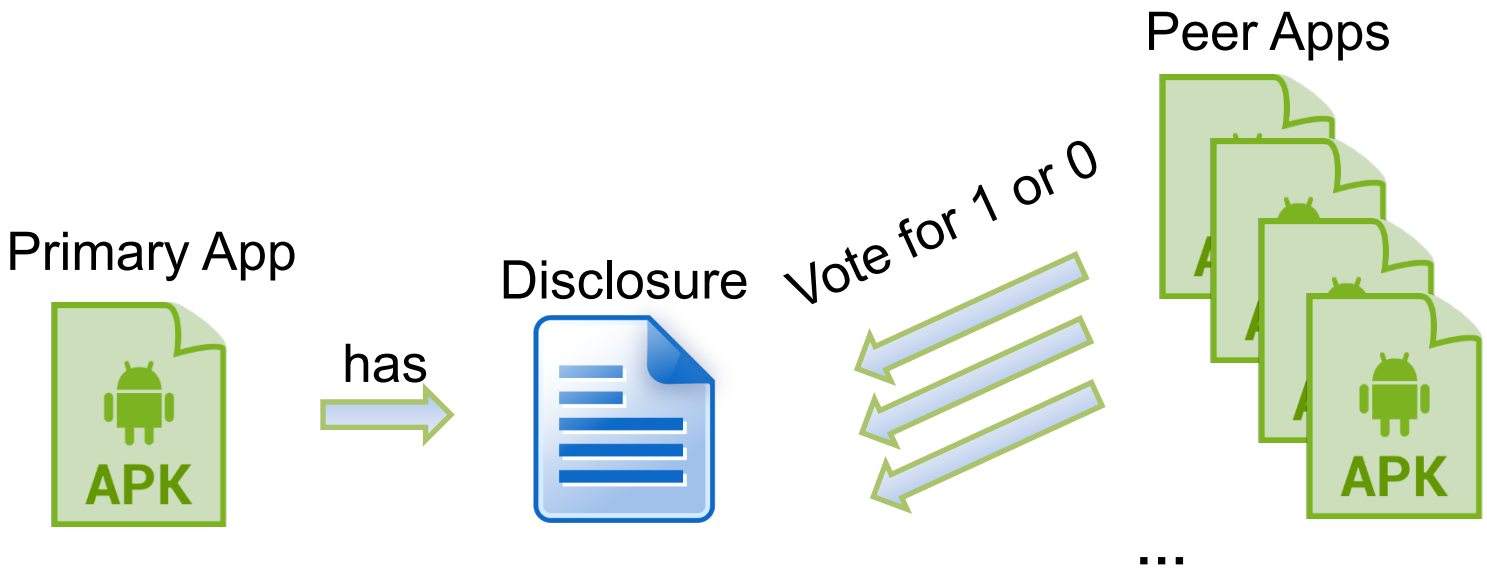
- Backward SDG slicing & DFS traversal

```
Uri uri = "1";
...
uri=uri.concat("2");
...
Data = provider.query(uri);
```



Peer Voting

- VotesNumber: the total number of peers with the same disclosure (votes with 1)
- PeersNumber: the number of peers
- Disclosure legitimacy = VotesNumber/PeersNumber



Implementation

- Built on Dalysis[CHEX CCS'12] and IBM WALA[1]

- The improvements account for about 6*K* SLoC in Java; Peer voting accounts for 1.3*K* SLoC in Python

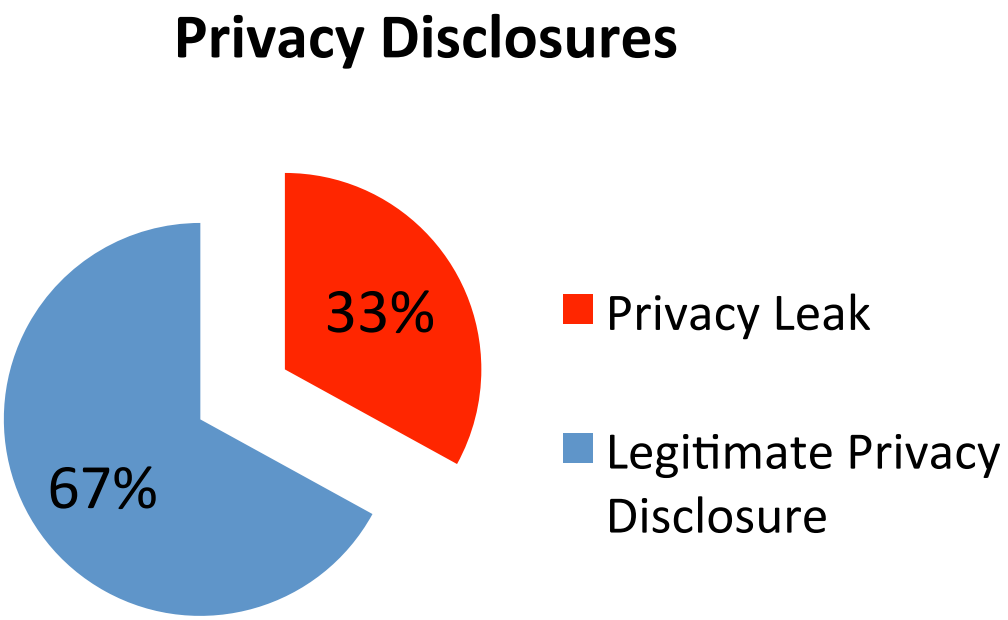
[1]http://wala.sourceforge.net/

Evaluating Disclosure Analysis

- Data set: 40,456 apps; manually examined 530 data-flows in top 300 popular apps
- Performance: 12 seconds/app
- Detection rate: 44.7% (31% increased compared with original 36.9%)
- False positive rate: 6.7% (5 times reduced compared with original 34.2%)

Evaluating Peer Voting

- Manually label 532 unique privacy disclosures from 417 randomly chosen primary apps



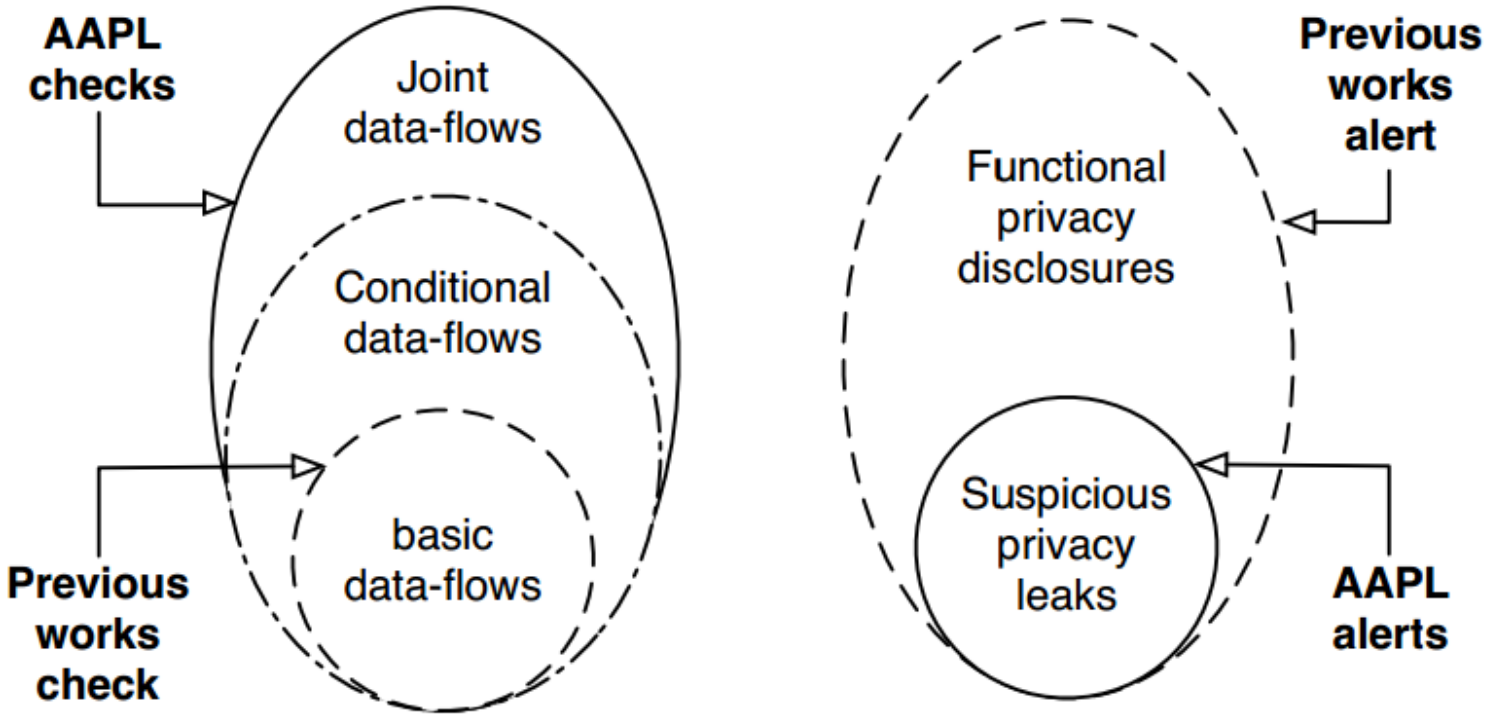
- Accuracy: 88.7% with false positive rate 10.7% and false negative rate 12.5%

Case Studies

App	App ID	Leak	# of peers	Legitimacy
	com.linpusimetc.android.linpustckbd	Contacts -> URL	20	0%
	simosoftprojects.musicplayerforpad	Phone Number -> URL	21	0%
	com.apptivateme.next.hrdp	Cookie -> Log	15	0%

Conclusion

- We propose AAPL, a novel peer voting mechanism detect suspicious privacy leaks
- Checking more and alerting less



Thank you!

Q & A