隐私消亡的移动互联时代

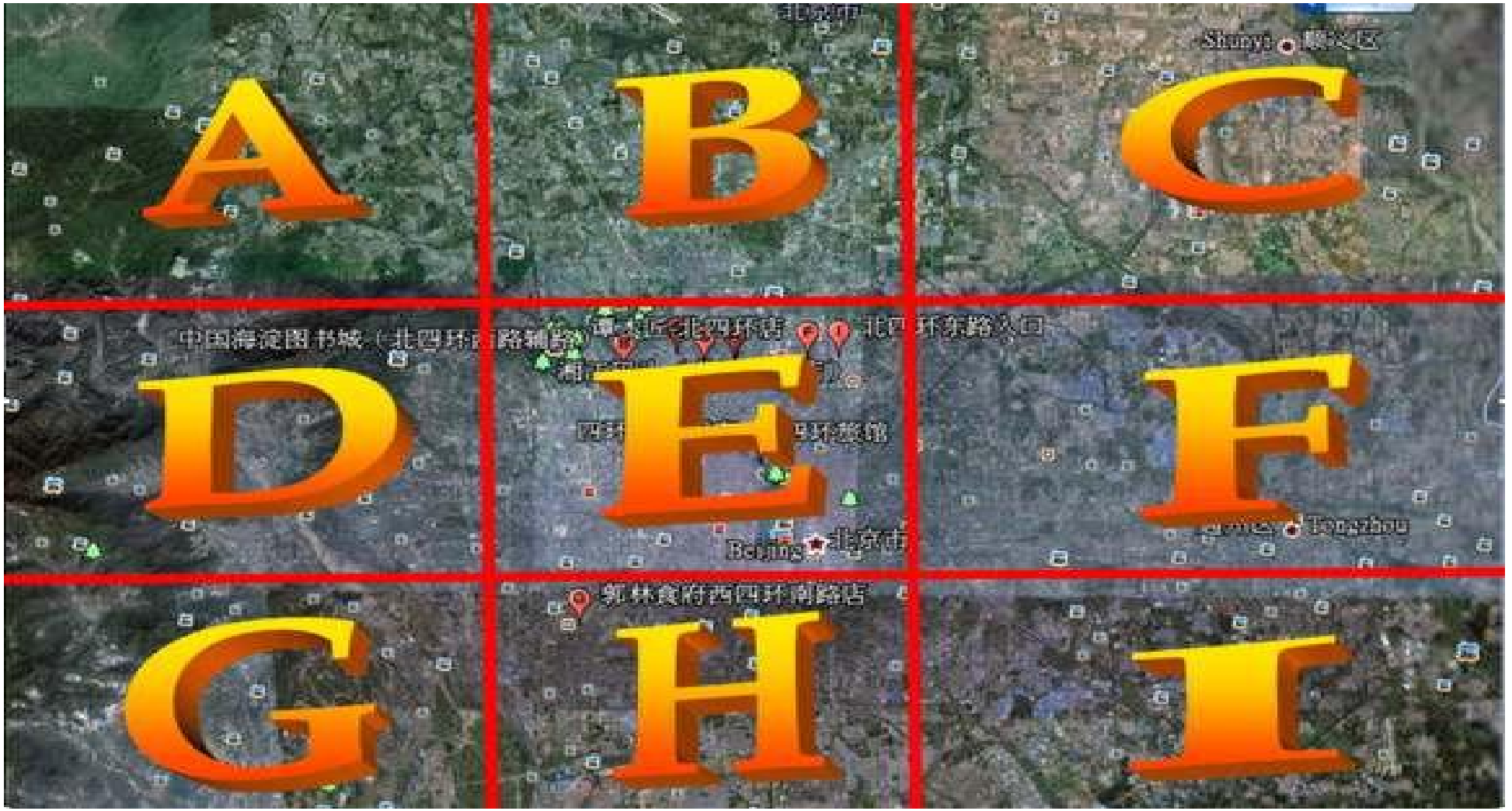
杨　珉

教授　国家973首席科学家

王珞丹住哪里？


四环堵死了！ 我联排迟到了
2010-3-6 13:46
光顾着看围脖留言忘记给老爸指路！ 都开到中关村了。 （爸爸开始叨叨我说导航吧
@王珞丹V：爸爸送我和小6去给＜无人驾驶＞配音的路上
原文转发(154) | 原文评论(310)

王珞丹住哪里？



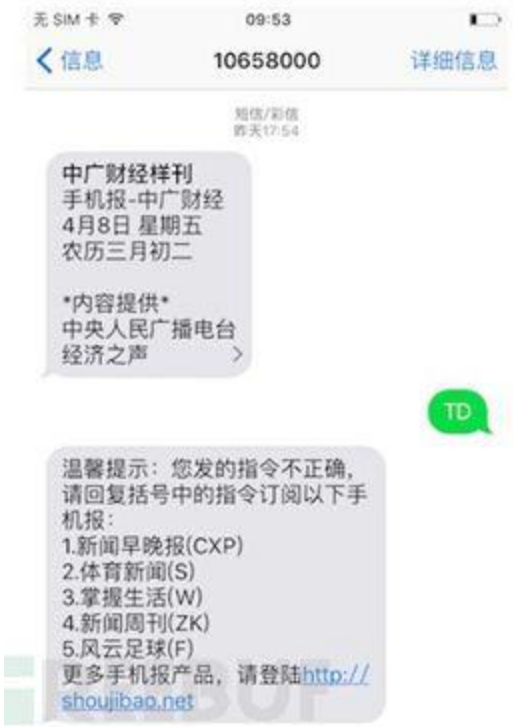
顶级信息安全专家“中招”

- 吕述望 教授，博士生导师
  - 中科院信工所，信息安全国家重点实验室。

老吕，刚才你给我发过这个短信息吗？
“严明, 我是吕述望，这是我帮你拍的小视屏 df.tc/sgND9J”。我看着可疑，没有打开它。

一条短信，支付宝沦陷了

- 2016年4月11日，“中国移动，请你告诉我，为什么一条短信就能骗走我所有的财产？”

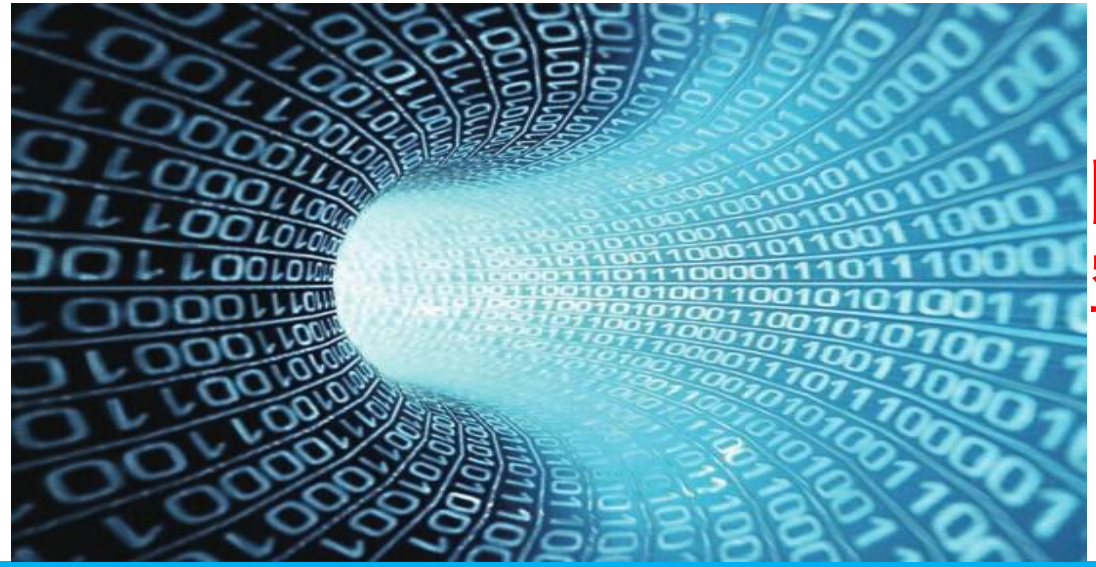


移动互联生态系统：光怪陆离

- 隐私：我是谁？我在哪里？我做了什么？

泛在智能的平行空间

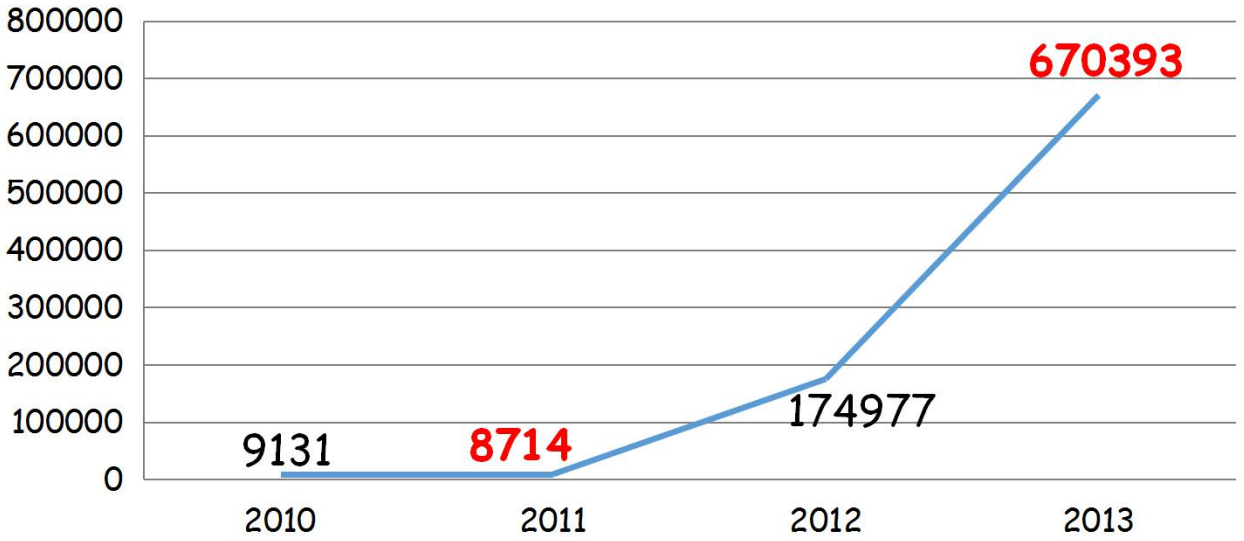
实体空间



网络空间

移动恶意软件泛滥

- 智能终端安全问题严重，成为社会热点问题。



来源：McAfee Labs, 2013 Internet Threat's Report

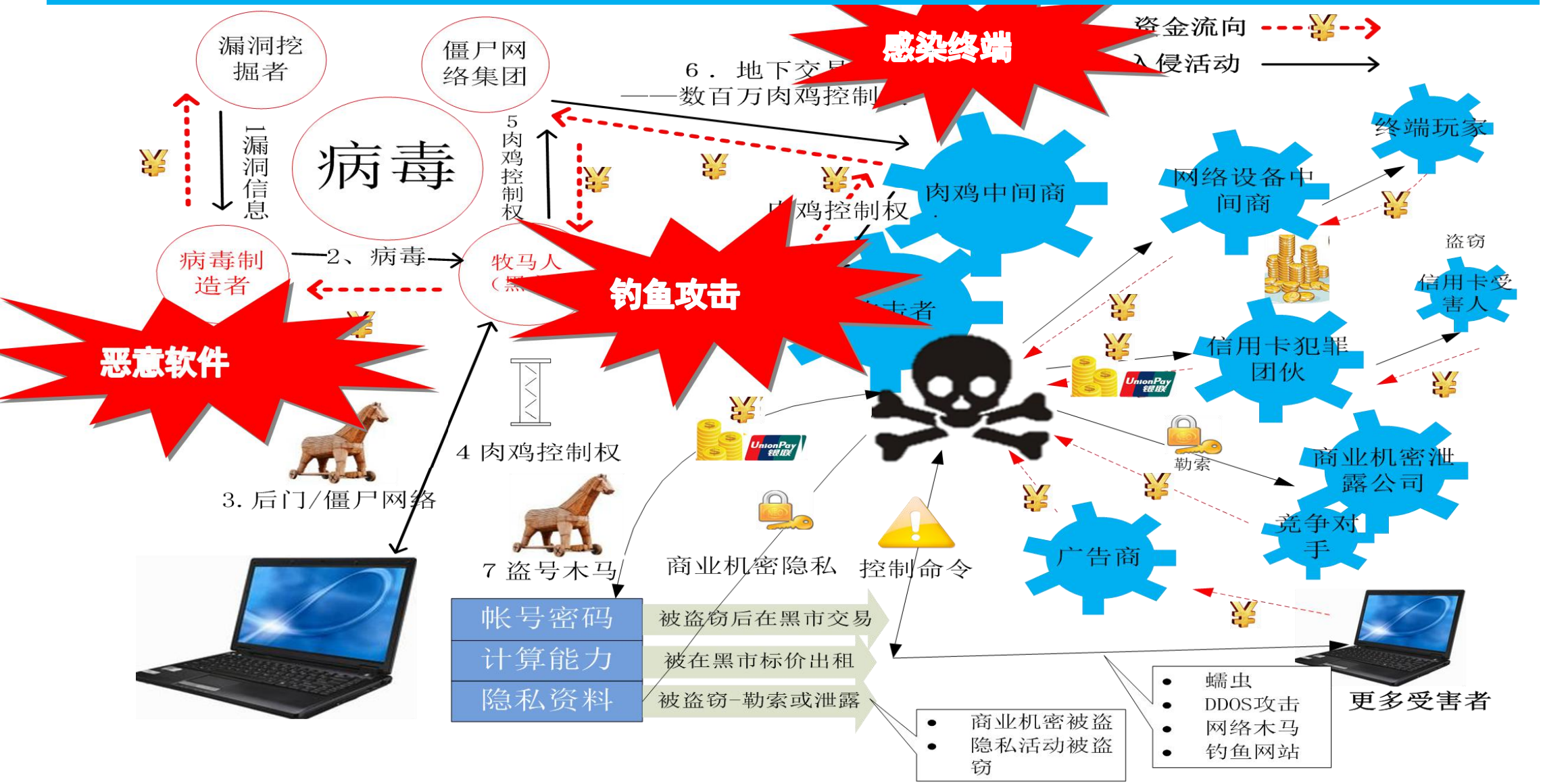
2013年，美国直接经济损失 100 亿美元。

来源：IDC，Mobile Security Threat Report，2014

2013年，中国直接经济损失超过 1000 亿元。

来源：中国互联网协会，2013年中国互联网产业发展综述

江湖：地下组织

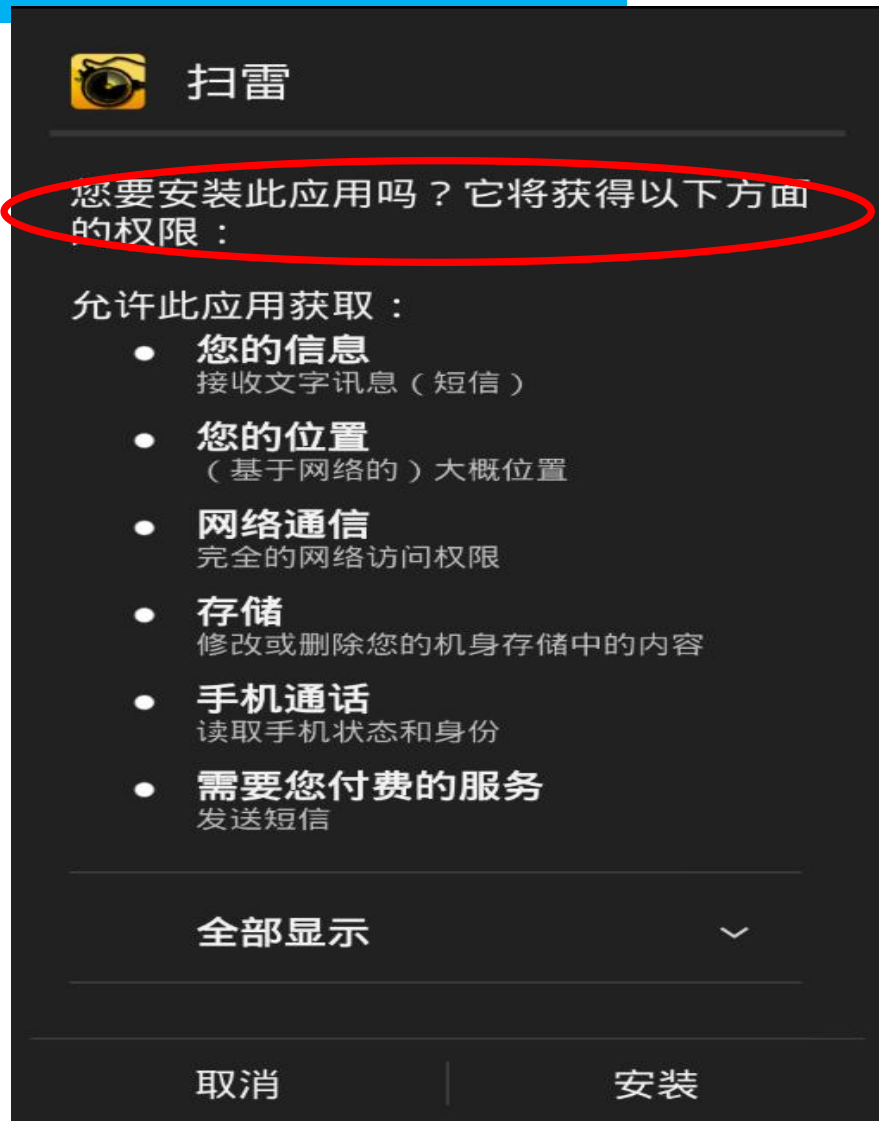

漏洞挖掘者
僵尸网络集团
病毒
漏洞信息
5 肉鸡控制权
病毒制造者
2、病毒
牧马人
感染终端
钓鱼攻击
恶意软件
资金流向
入侵活动
6．地下交易
——数百万肉鸡控制
肉鸡中间商
网络设备中间商
终端玩家
盗窃
信用卡受害人
信用卡犯罪团伙
勒索
商业机密泄露公司
竞争对手
广告商
3. 后门/僵尸网络
4 肉鸡控制权
7 盗号木马
商业机密隐私
控制命令
帐号密码
计算能力
隐私资料
被盗窃后在黑市交易
被在黑市标价出租
被盗窃-勒索或泄露
商业机密被盗
隐私活动被盗窃
蠕虫
DDOS攻击
网络木马
钓鱼网站
更多受害者

Science: The End of Privacy

- 超学科的研究范畴
  - Unmasked
  - When your voice betrays you
  - Breach of trust
  - Risk of exposure
  - Could your pacemaker be hackable?
  - Trust me, I'm a medical researcher
  - Control use of data to protect privacy
  - Privacy and human behavior in the age of information
  - Balancing privacy versus accuracy in research protocols
  - What the "right to be forgotten" means for privacy in a digital age
  - ……

移动平台的隐私保护机制

- 权限（Android、iOS）
  - 授权软件可访问和使用敏感数据
- 恶意行为检测方法
  - 静态、动态、动静态
  - Google Bouncer/iOS Vetting Process
- 安全软件
  - 腾讯、百度、360、安天、LBE



应用软件隐私泄露严重

泄露内容数目统计	商城			厂商		运营商	平台	汇总
	1	2	3	1	2			
IMEI	42	27	22	24	20	11	36	182
IMSI	14	7	5	7	1	4	2	40
ICCID	4	1	1	2	0	1	2	11
Contact	10	2	5	2	1	3	1	24
Phone Number	7	1	3	5	0	1	0	17
SMS	2	0	3	2	6	1	1	14
Location	0	1	0	2	1	0	0	4
样本数目	70	50	40	50	50	20	50	330
泄露数目	47	29	25	25	16	13	36	191
泄露比率	67%	58%	62%	50%	32%	65%	72%	58%

国内Android应用商城中程序隐私泄露分析，第五届信息安全漏洞分析与风险评估大会，2012年
AppIntent(CCS 2013),VetDroid(CCS 2013), IEEE Trans. On Information Forensics and Security等多篇CCF A类论文

UIPicker: User-Input Privacy Identification in Mobile Applications

Usenix Security 2015 （信息安全顶级会议）

Motivation

Privacy leakage

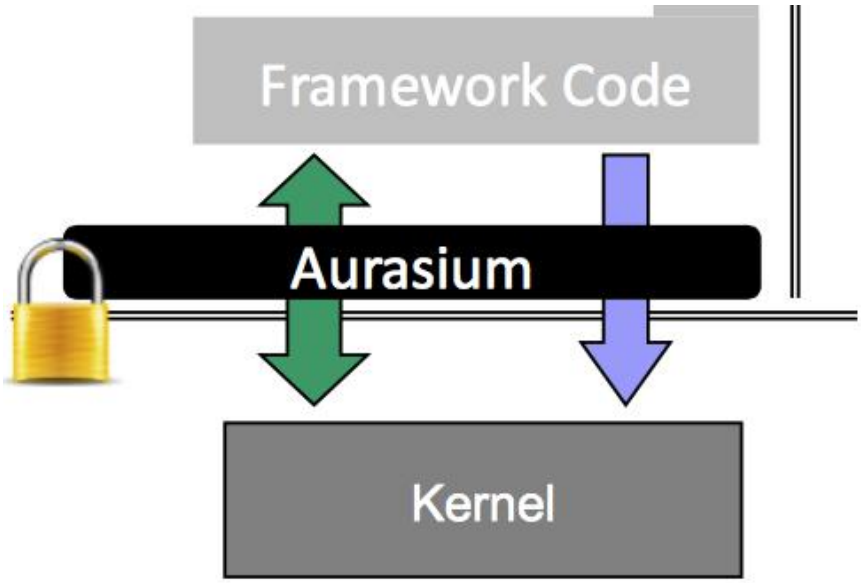
- App's insecure implementation
- Vulnerabilities in system
- Millions of Malware

Motivation

Existing Works

Dynamic/Static taint analysis

- TaintDroid [OSDI'12]
- FlowDroid [PLDI' 14]

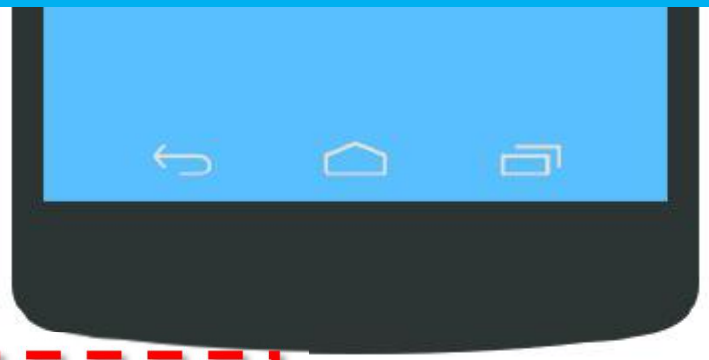



```
c = taint_source()
...
a = b + c
...
network_send(a)
```

Access control mechanisms

- SELinux on Android
- Auriasium [SECURITY'12]
- FineDroid [SecureComm'15]

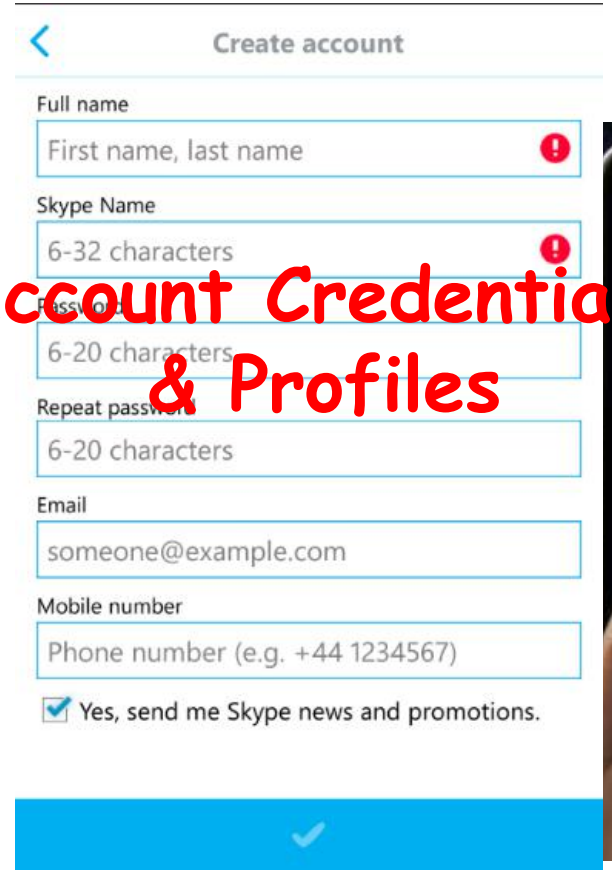
But wait …



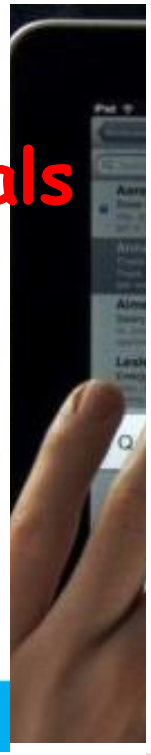
➢ Location	✓ LocationManager. getLastKnownLocation()
➢ Contact	✓ ContentResolver.query(CONTACT_URI)
➢ SMS	✓ SmsMessage. getMessageBody ()
➢ Phone Number	✓ TelephonyManager. getLine1Number()
➢ …	✓ …

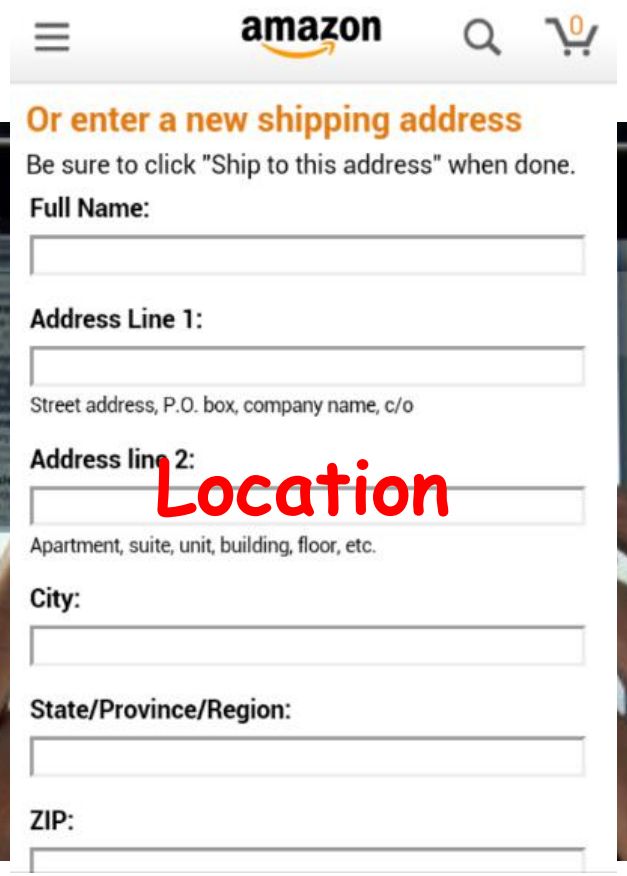
System Centric Privacy Data

But wait …



Account Credentials & Profiles





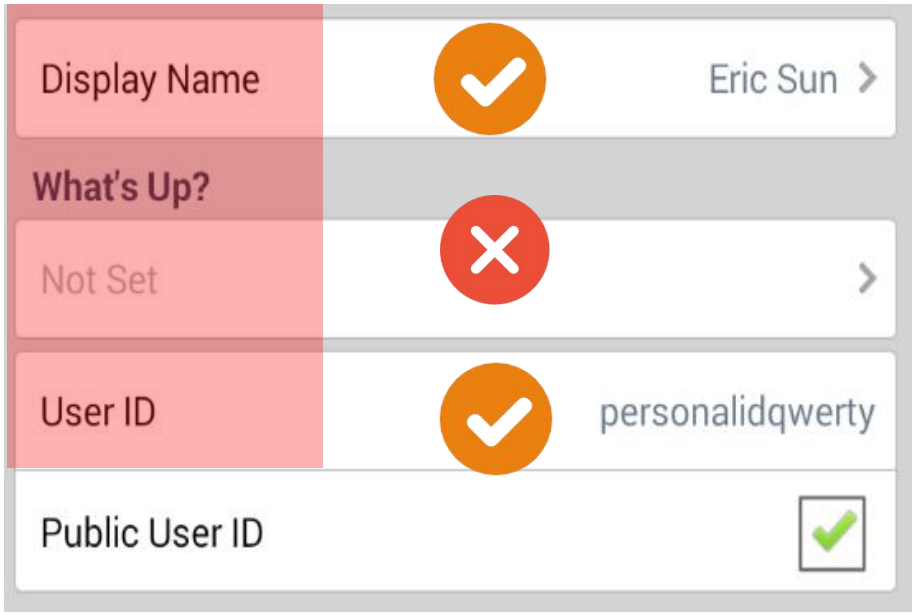
Location

Financial

User-Input Centric Privacy Data (UIP Data)

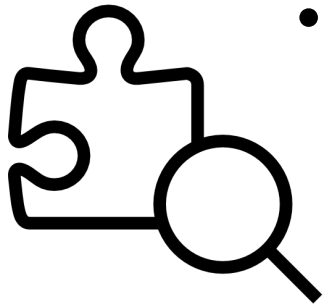
Challenges

- UIP data cannot be found without parsing the context and semantic of UIs



- Label all input as sensitive
  - Large number of false positives
- Manually specify such contents need to be protected
  - Intensive human intervention

Our Work

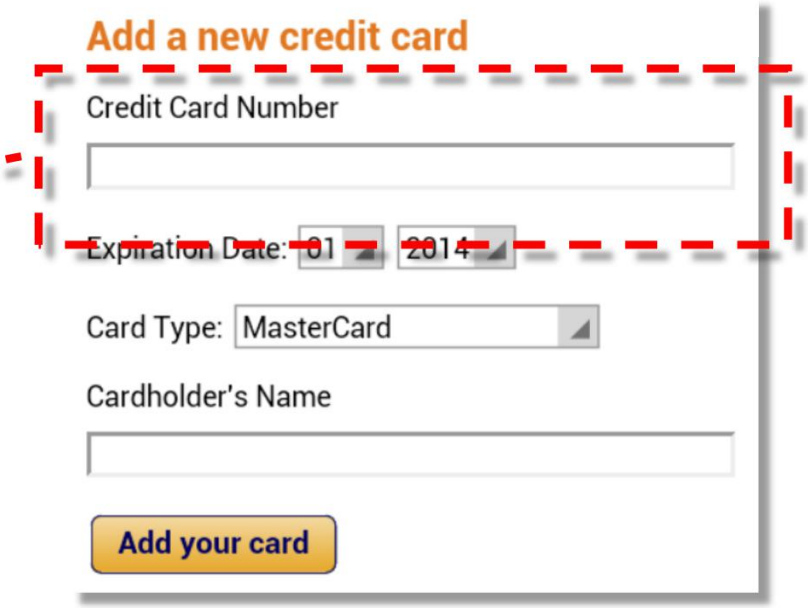


- UIPicker
  - Novel framework for automatic, large-scale User-Input Privacy (UIP data) identification within Android apps.

- Runtime Security-Enhancement Mechanism
  - Protect insecure UIP data transmission in app's runtime

Key Observation

- Privacy-related semantics exist in
  - UI Screens
  - Layout resource files



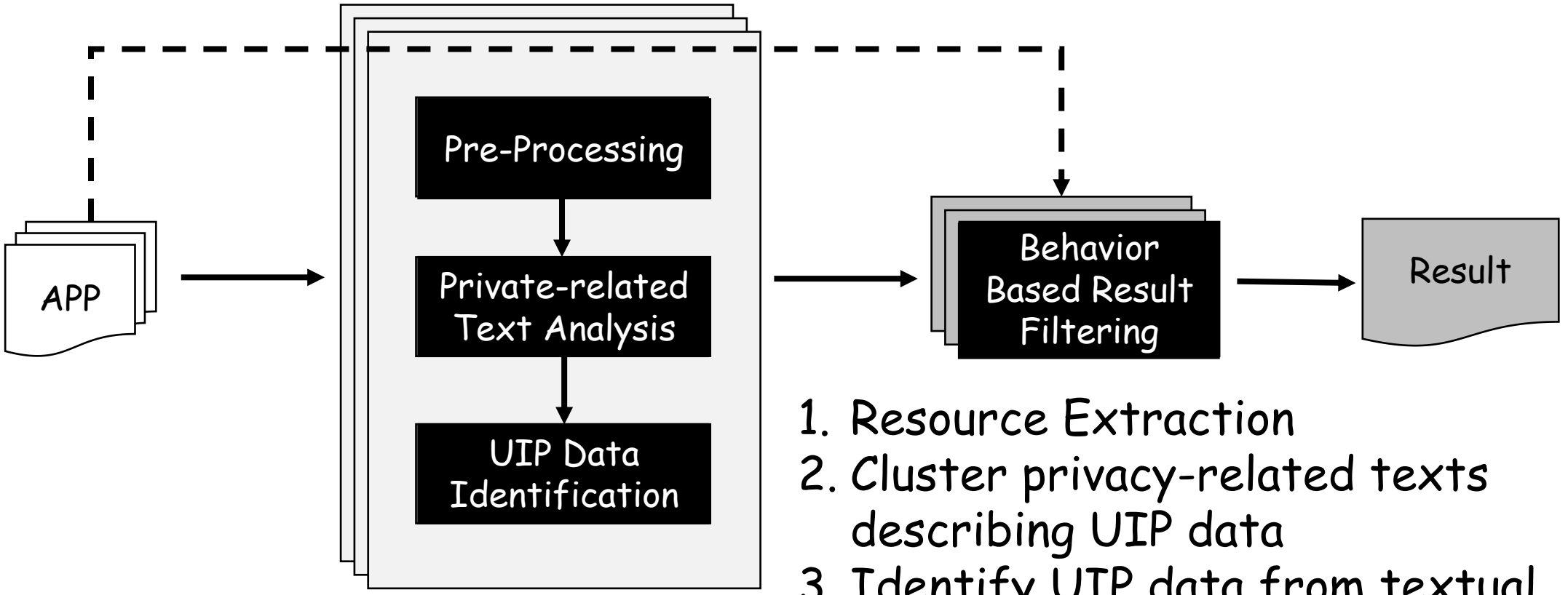

```
<TextView android:text="@string/opl_new_payment_credit_card_number" />
<EditText android:id="@id/opl_credit_card_number" android:inputType="number" />
```

Technical challenges

- How to get complete privacy-related texts
  - Highly unstructured semantics
    - E.g. password, **pass**, **pwd**, …
  - Sparsely distributed in different UIs
    - In practical for manual collecting

- To what extent, a layout element could be UIP data
  - Keyword based search? Very imprecise results
    - E.g. Split "Username" into "user" & "name"

UIPicker Overview

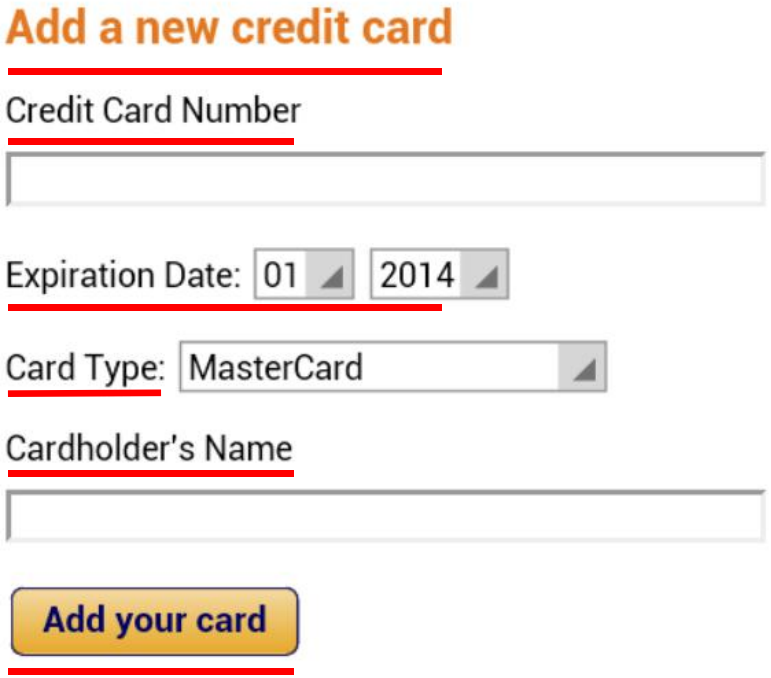


1. Resource Extraction
2. Cluster privacy-related texts describing UIP data
3. Identify UIP data from textual semantics
4. Confirm UIP data with application code behaviors

Pre-Processing

- Resource Extraction
- Word splitting
  - Delimiter/Letter-separated words
- Redundant content removal
  - Non-English strings/Stop words
- Stemming
  - Reduce the number of texts
  - E.g. Change "secured", "security" into "secure"

1 UI Texts

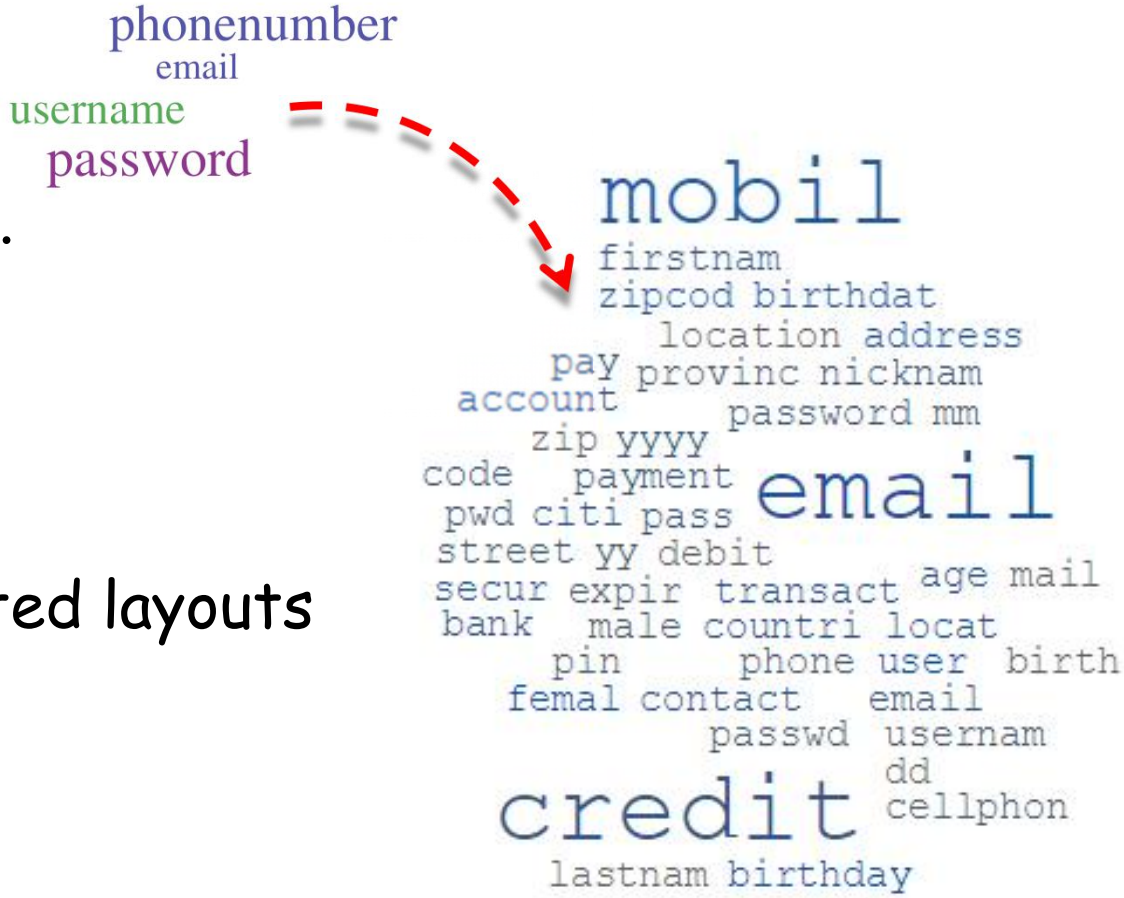


2 Layout Descriptions

@id/opl_credit_card_number
@string/opl_new_credit_card_expiration_date_month
@string/opl_new_credit_card_save_button

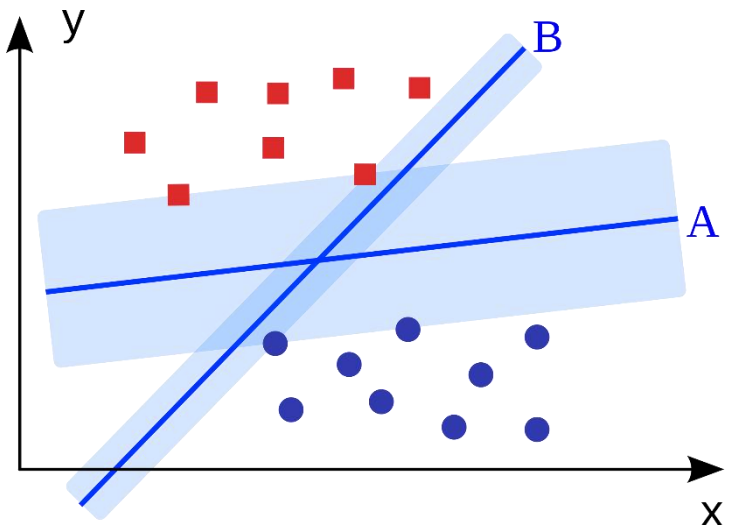
Privacy-related Texts Analysis

- Privacy-related layout Selection
  - Subset of UIP related layouts.
  - E.g. Login, Registration, settings page.
  - Initial seeds: username, password
- Privacy-related texts clustering
  - Words appeared most in privacy-related layouts rather than normal layouts.
  - By applying Chi-Square test.



UIP Data Identification

- Classifier: Support Vector Machine
- Features
  - Privacy-related texts
  - Sibling elements
    - E.g. Short phrase for describing the input field.



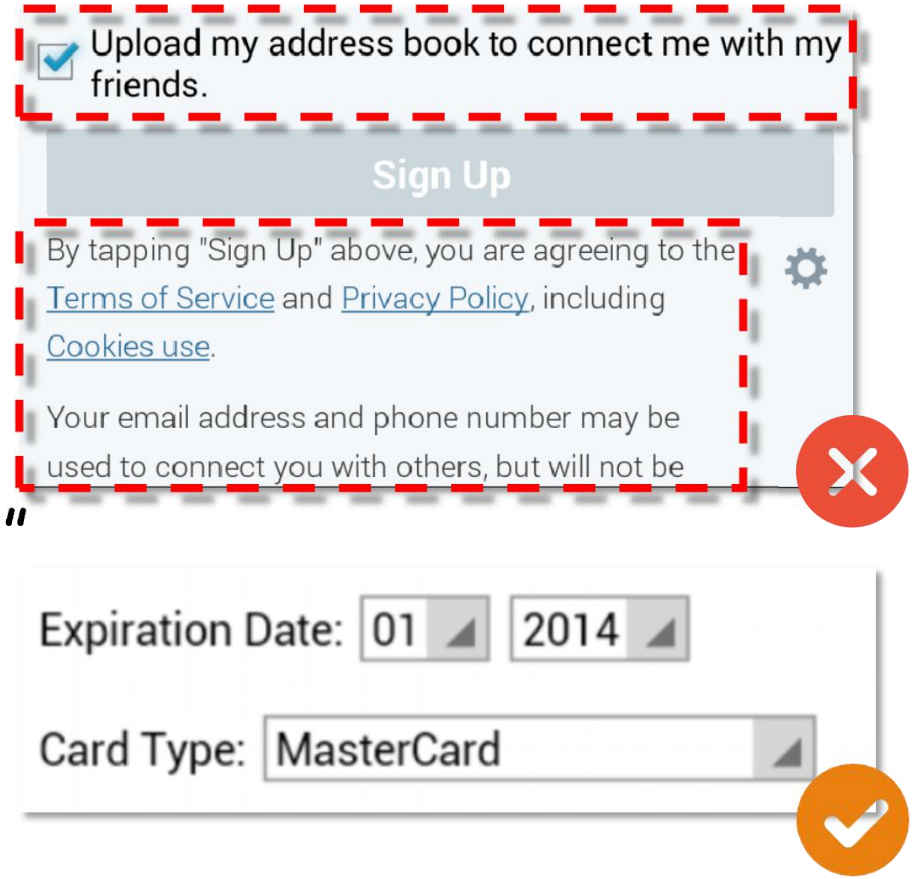
- Training Data
  - Subset of UIP data element
    - Text fields with sensitive **inputtype**.

```
<EditText android:id="@id/password_edittext"  android:inputType="textPassword" />
```

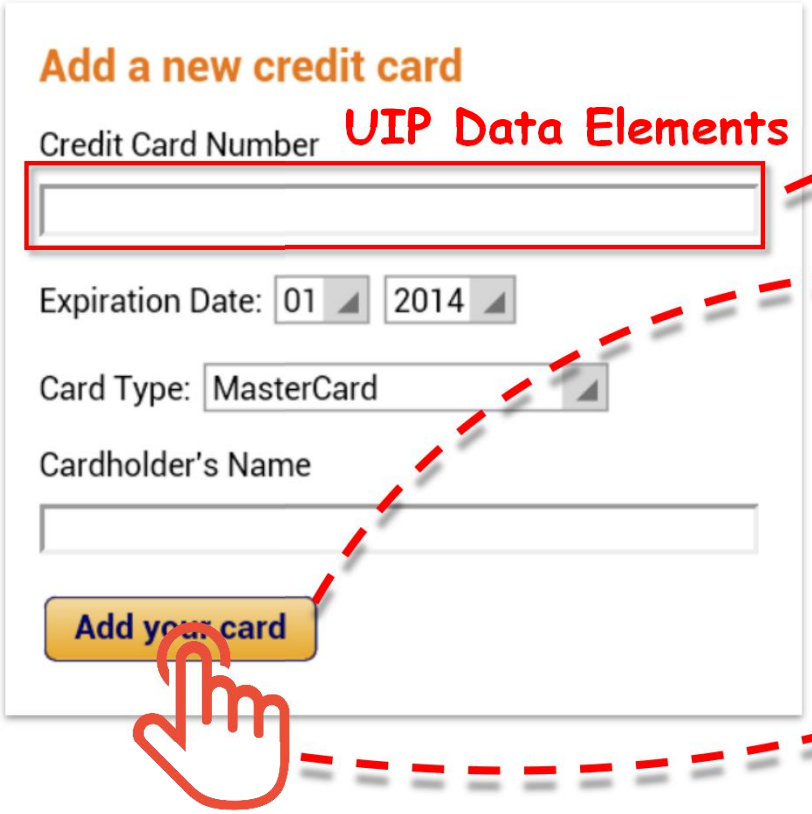
    - Manual labelled element for **Financial inputs**

Behavior Based Result Filtering

- Matching UIP data behaviors reflected in application's program code
- Filter out **static labels** which **only contain** privacy-related semantics
- Recover Input fields other than "EditText"
  - Implicit user input
    - E.g. Drop down list
  - Customized input
    - E.g. com.alipay.inputBox



Behavior Based Result Filtering



1. Locating UIP candidate & its layout

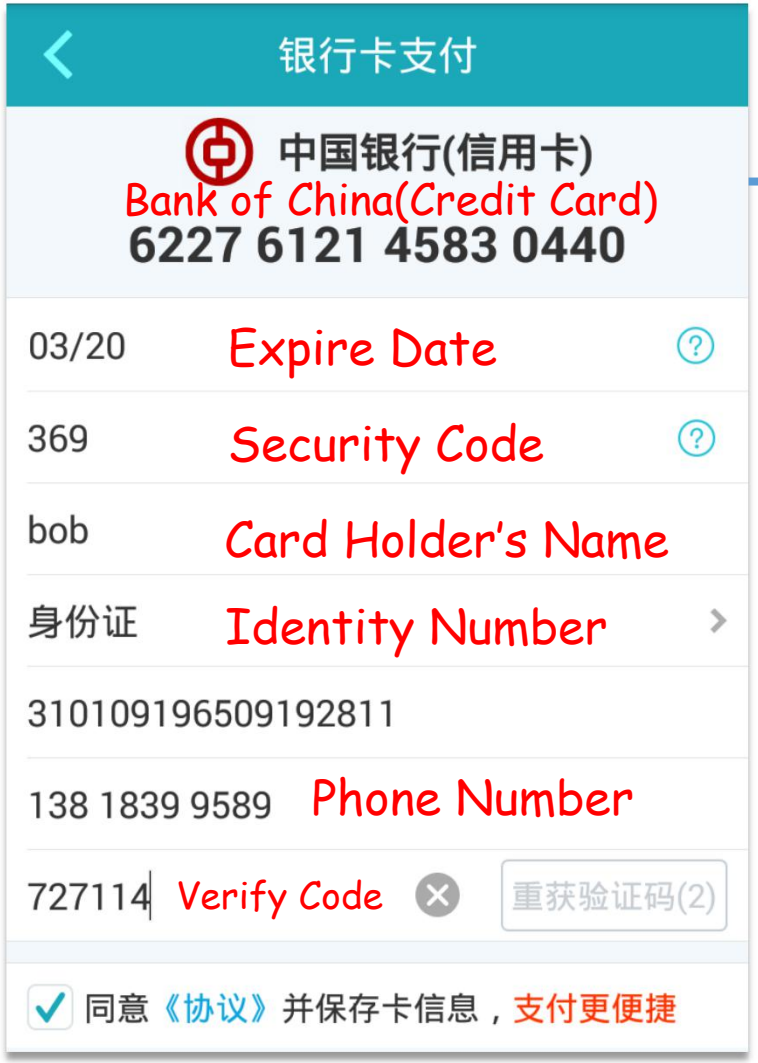
```
Activity.setContentView(R.layout.add_credit_card.xml)

Void OnCreate(Bundle bundle){
    InputBox IB = findViewById(2131231511);
    submitBtn = findViewById(2131623982);
    submitBtn.setOnClickListener(new addCardListener());
}
```

2. User-Triggered Event handling

```
addCardListener.onClick(View v) {
        ……
        creditCard = IB.getText();
        sendContent(creditCard)
        …..
}
```

Runtime Security Enhancement

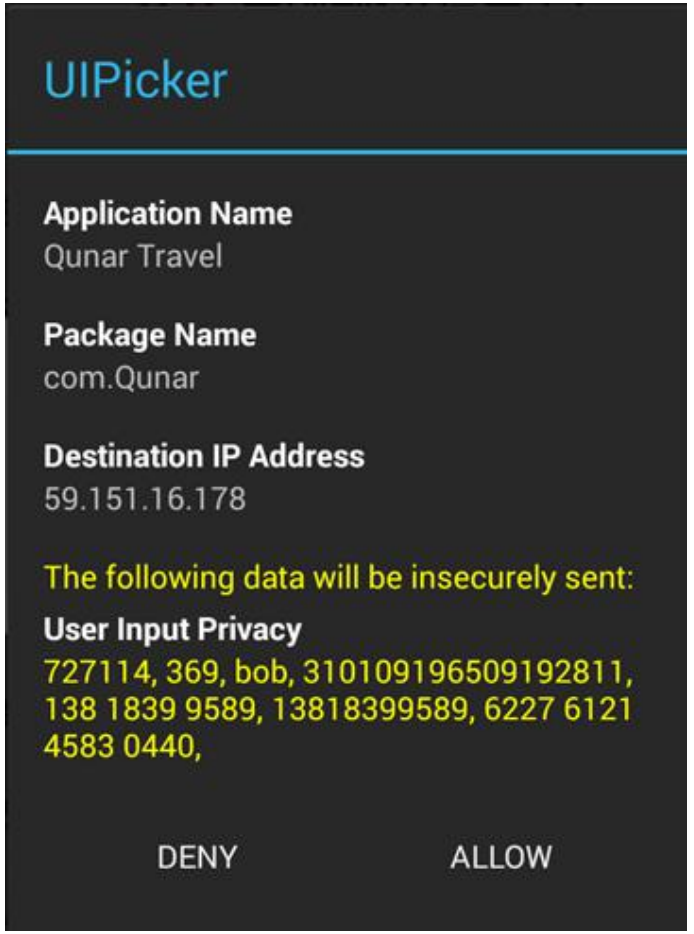


Taint Tracking based on UIPicker

TaintDroid

```
c = taint_source()
...
a = b + c
...
network_send(a)
```

WARNING



- Plain Text transmission
  - Runtime checking
- Insecure SSL implementation
  - Offline analysis with MalloDroid

UIPicker Evaluation

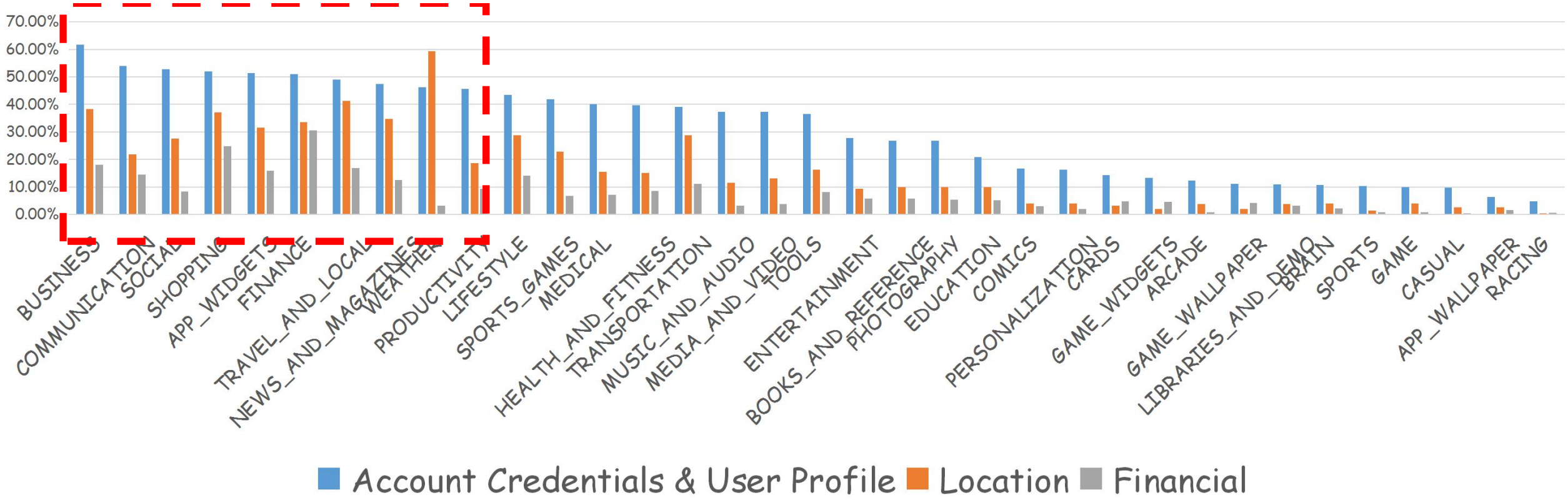
- Dataset
  - 17,425 apps crawled from Google-Play in Oct.2014
  - 35 categories, 500 apps for each

Performance

- Identification Process
  - 32 core Debian server with 64GB memory
  - Proceeded in 32 threads concurrently
  - Finished in 30.5 hours (7.6 apps per minute) for the dataset
- Run-Time Security Enhancement Mechanism
  - Only provides additional UIP data sources
  - No performance overhead compare to TaintDroid

UIP Data Distribution

- 6,179 (35.46%) contain UIP data in 17,425 Apps
- Exist in more than half of apps in 9 out of 35 categories.



UIP Data Distribution

- Categories like BUSINESS, FINANCE, SHOPPING, COMMUNICATION and SOCIAL are more likely to request Account Credentials and User Profile information
- SHOPPING category contains many location-related elements
- Both FINANCE and SHOPPING apps require many financial-related sensitive inputs

Effectiveness

- Compare with System Defined APIs (# Apps)

TelephonyManager.**getLine1Number**()
AccountManager.**getAccounts**()

LocationManager.**getLastKnownLocation**()
Location.**getLongitude**()
Location.**getLatitude**()

Category	System Defined APIs	UIPicker	Overlap
Account Credentials & User Profile	4,900	5,330	1,340
Location	15,221	2,883	2,282
Financial	-	1,318	-
Total	15,632	6,179	-

Effectiveness

- Compare with Sensitive Attributes(# Elements)

Category	InputType	UIPicker	Incremental
Account Credentials & User Profile	24,021	46,227	26,087
Location	941	14,311	13,370
Financial	-	6,353	-
Total	24,962	71,224	46,262

15x

2x

Effectiveness

- Compare with Sensitive Attributes(# Elements)

Type	# Elements	% in UIP Data
TextView	10,582	14.86%
Customized	5,075	7.13%
Spinner	1,962	2.75%
Others	784	1.10%
Total	18,403	25.84%

Precision

- Manual Validation
  - 200 random selected apps in 10 categories (20 in each)
  - False Positives: 67/1042 elements
  - False Negatives: 107 elements
  - Overall: **93.6% Precision and 90.1% Recall**

$$Precision = \frac{TP}{TP + FP} \qquad Recall = \frac{TP}{TP + FN}$$

Conclusion

- UIPicker: Identify UIP data based on novel combination of NLP, machine-learning approach, and static analysis techniques
- Runtime security enhancement based on UIPicker
- Easily be deployed for other existing mechanisms for privacy analysis/protection.

谢谢！

m_yang@fudan.edu.cn