OAuth User Profile Attack

How to Sign into One Billion Mobile App Accounts Effortlessly

Ronghai Yang, *Prof. Wing Cheong Lau and Tianyu Liu*

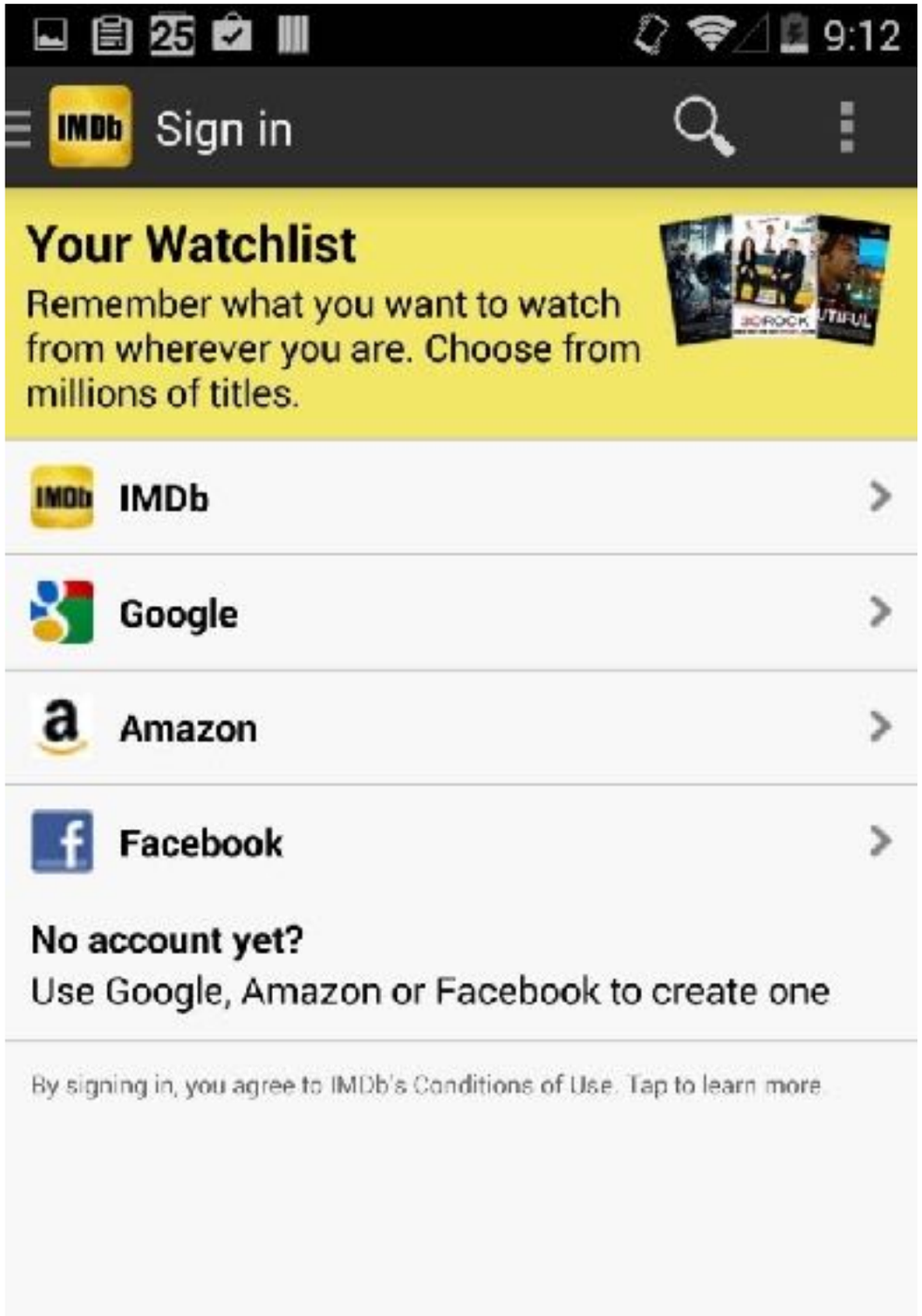
The Chinese University of Hong Kong

Nov 4, 2016

Outline

- Background of OAuth2.0
  - ✤ Unwell-defined protocol for mobile platforms
- User Profile Vulnerability
- Exploit
  - ✤ Challenges & Tricks
  - ✤ Case study
- Corresponding Remedies

What is OAuth2.0?

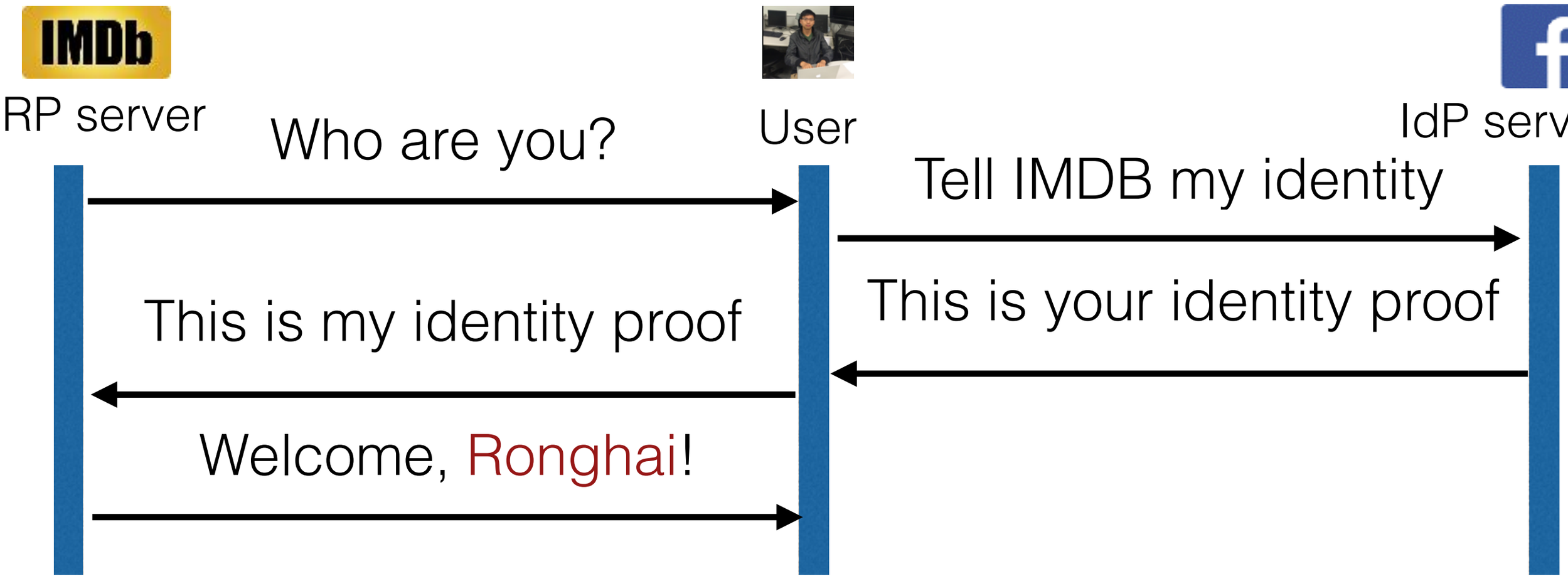


Three Parties in OAuth2.0

User | Identity Provider (IdP) | Relying Party (RP)

Goal: The user can log into the RP via the IdP

Basic Interactions among User, RP and IdP



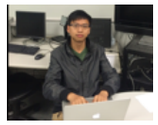
- Such an identity proof is “access token (AT)” in OAuth2.0.
- OAuth2.0 supports two types of mode: authorization code flow & **implicit flow**

OAuth2.0 Protocol Flow for Mobile: Implicit Flow

RP server

User device

IdP server



RP App

auth req

IdP App

Sign in

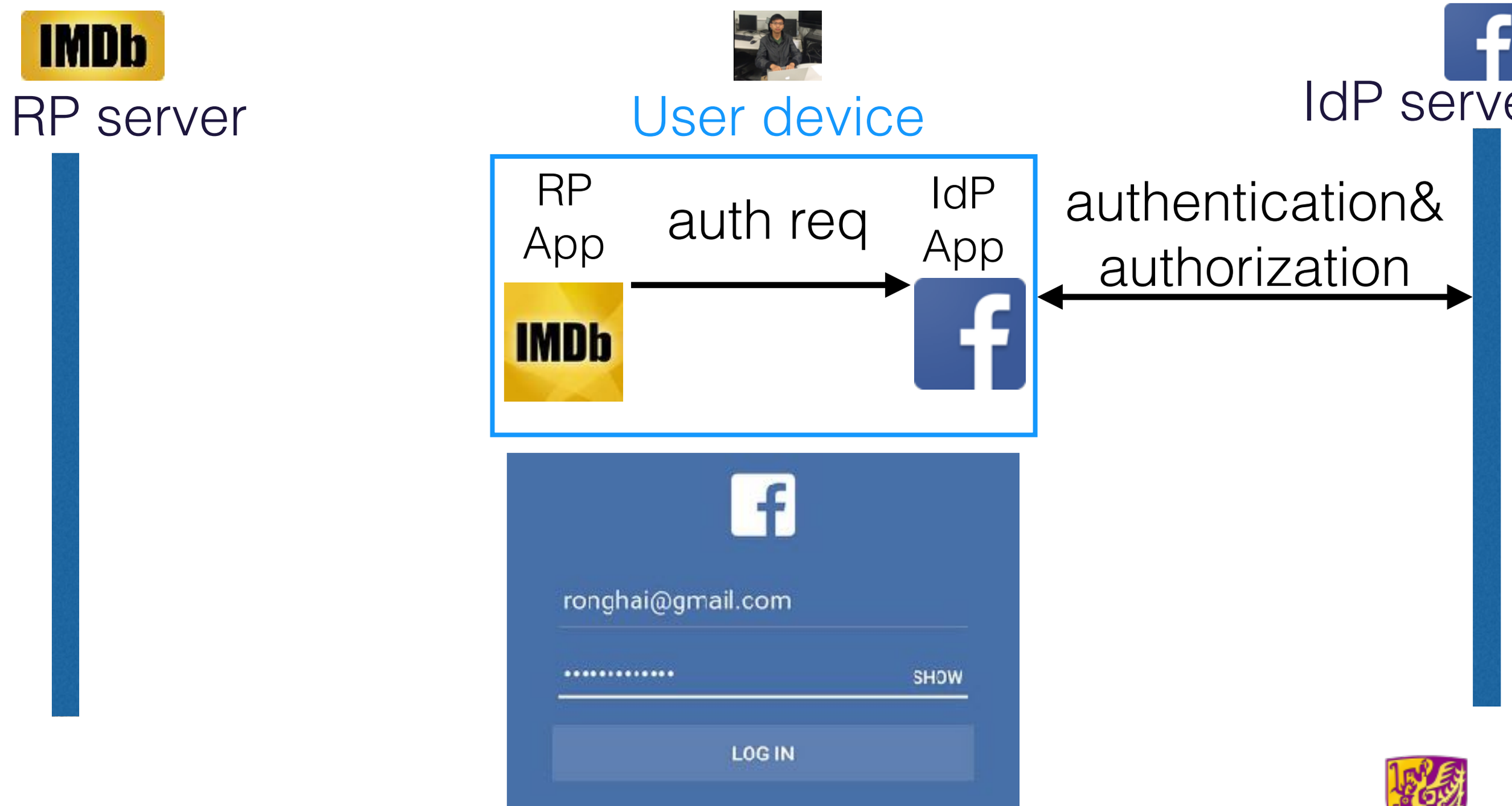
Use an existing account

IMDb

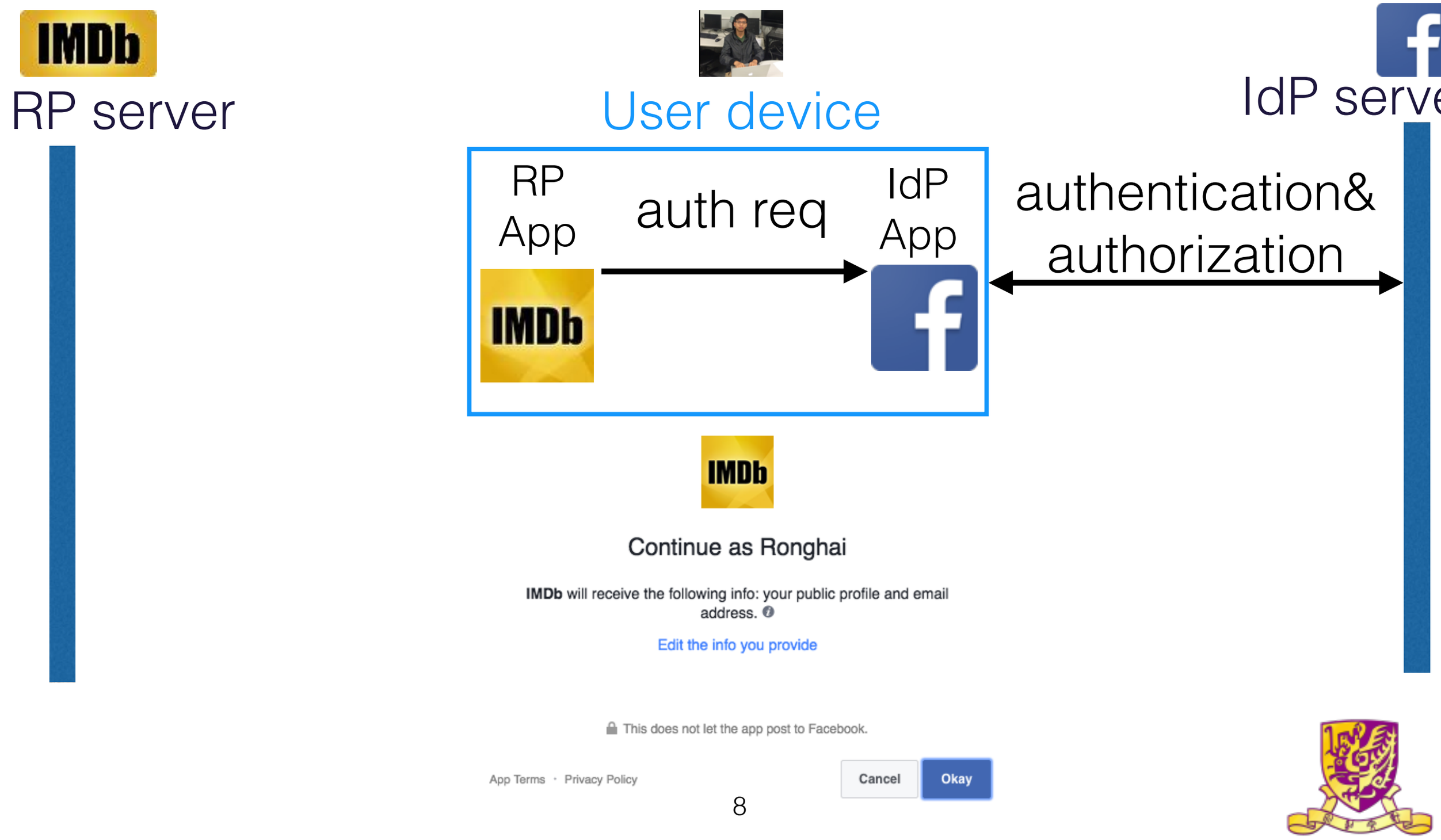
Facebook

Google

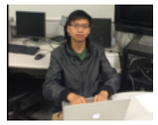
OAuth2.0 Protocol Flow for Mobile: Implicit Flow

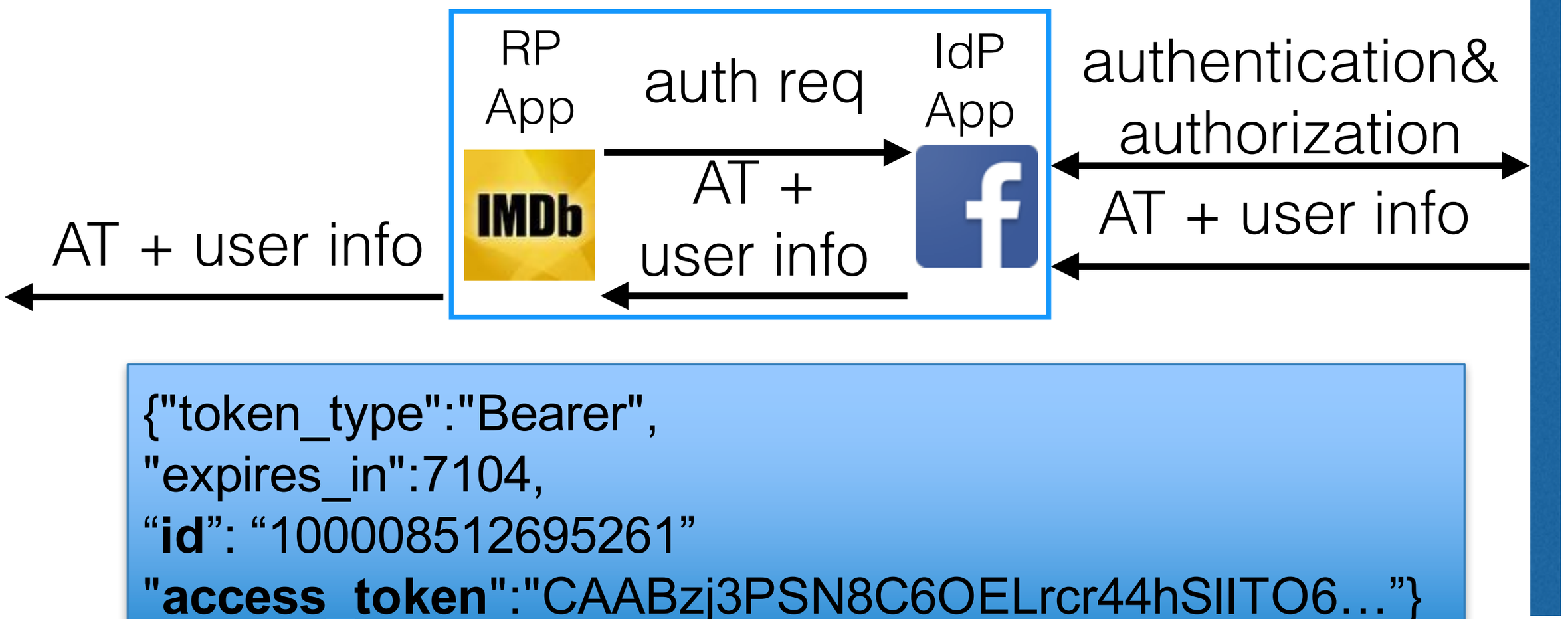


OAuth2.0 Protocol Flow for Mobile: Implicit Flow



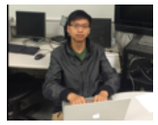
OAuth2.0 Protocol Flow for Mobile: Implicit Flow






```
{"token_type":"Bearer",
"expires_in":7104,
“id”: “100008512695261”
"access_token":"CAABzj3PSN8C6OELrcr44hSIITO6…”}
```

OAuth2.0 Protocol Flow for Mobile: Implicit Flow



RP server

User device

IdP server

RP App

IMDb

auth req

AT + user info

IdP App

authentication& authorization

AT + user info

AT + user info

API request for user info: access token

https://graph.facebook.com/me?
access_token=CAABzj3PSNiUBAF9MQrrNHwoZ...

OAuth2.0 Protocol Flow for Mobile: Implicit Flow

RP server

IdP server

{
"id": "100008512695261",
"birthday": "02/01/1991",
"email": ”ronghai@gmail.com",
"first_name": ”Ronghai",
"gender": "male",
"last_name": ”Yang",
"link": "https://www.facebook.com/profile.php?id=100..1",
“name”: ”Ronghai Yang",
}

cation&
zation

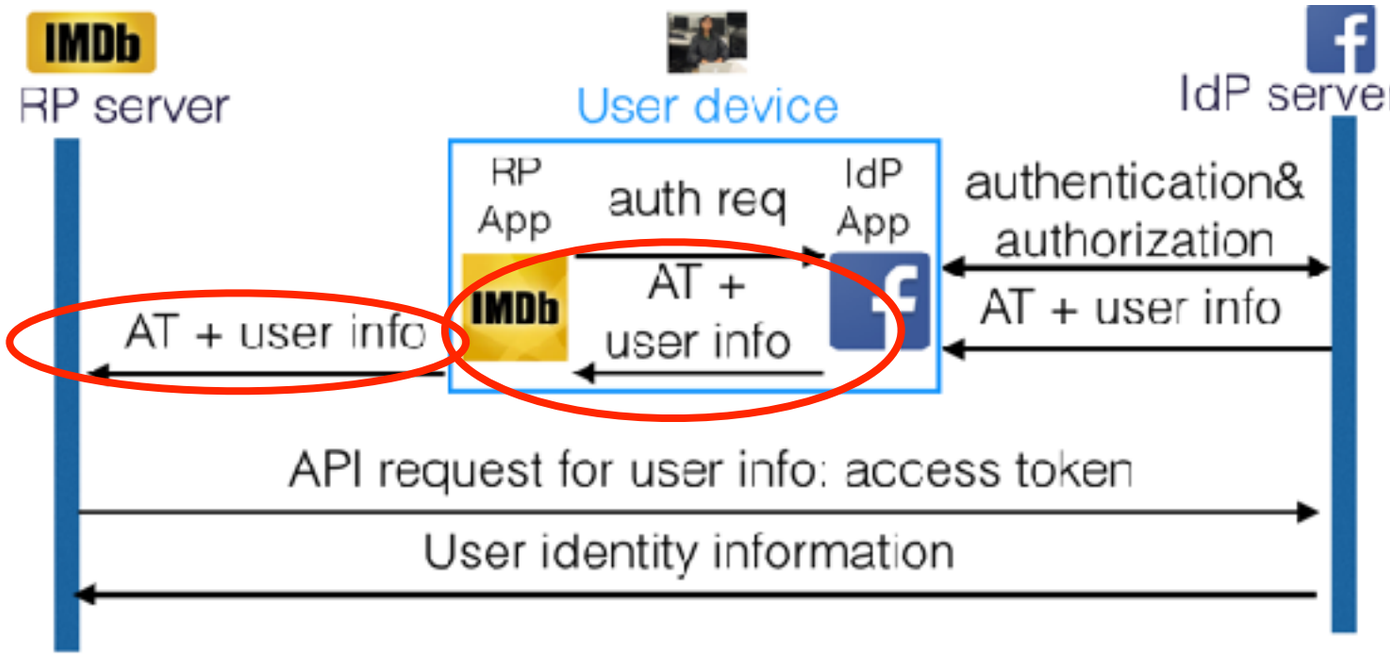
er info

AT + U

User profile information

Unwell-defined Portions of Protocol Call-flow

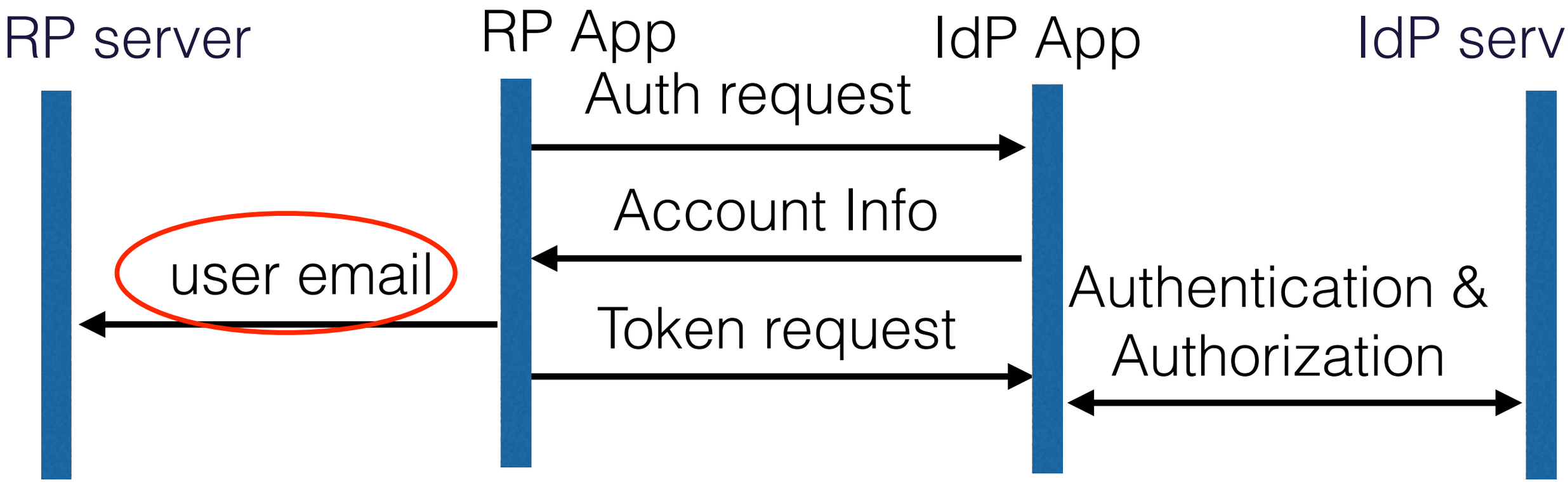
- Neither RFC nor IdPs provides the complete call-flow
  - ✤ How to communicate between RP app and IdP app: the browser splits into two apps
  - ✤ How to process identity proof: server-to-server verification



Common Mistake 1
Android Account Manager

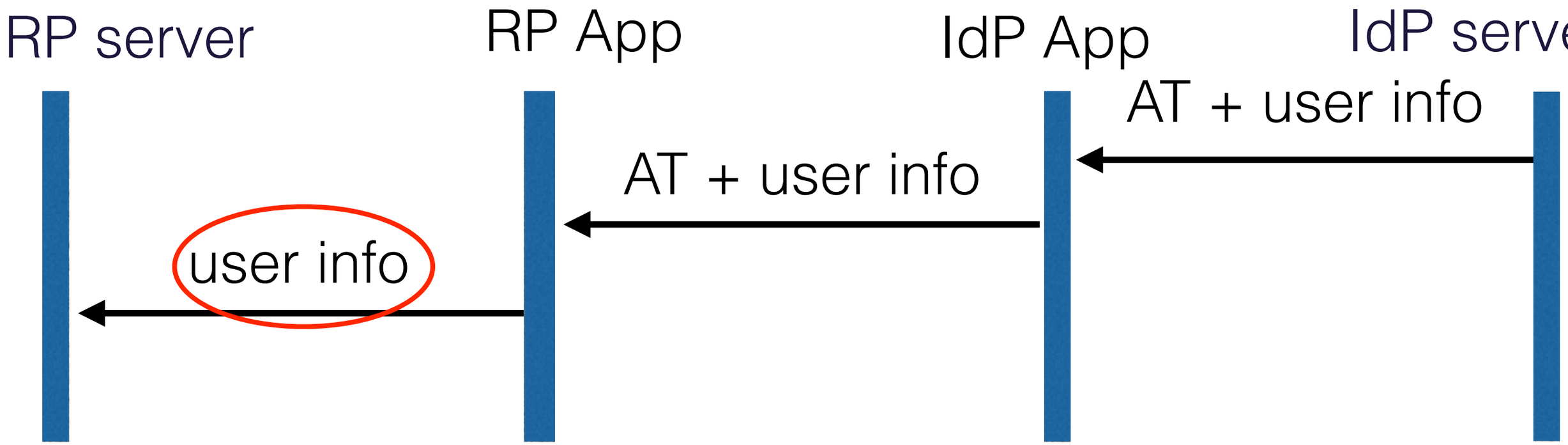
- Centralized database to store user accounts
- INSERT INTO “accounts” VALUES (1,’ronghai@gmail.com’,’com.google’,’password’ ,NULL)
- Integrated into OAuth2.0 when using Google as the IdP

Common Mistake 1
Android Account Manager



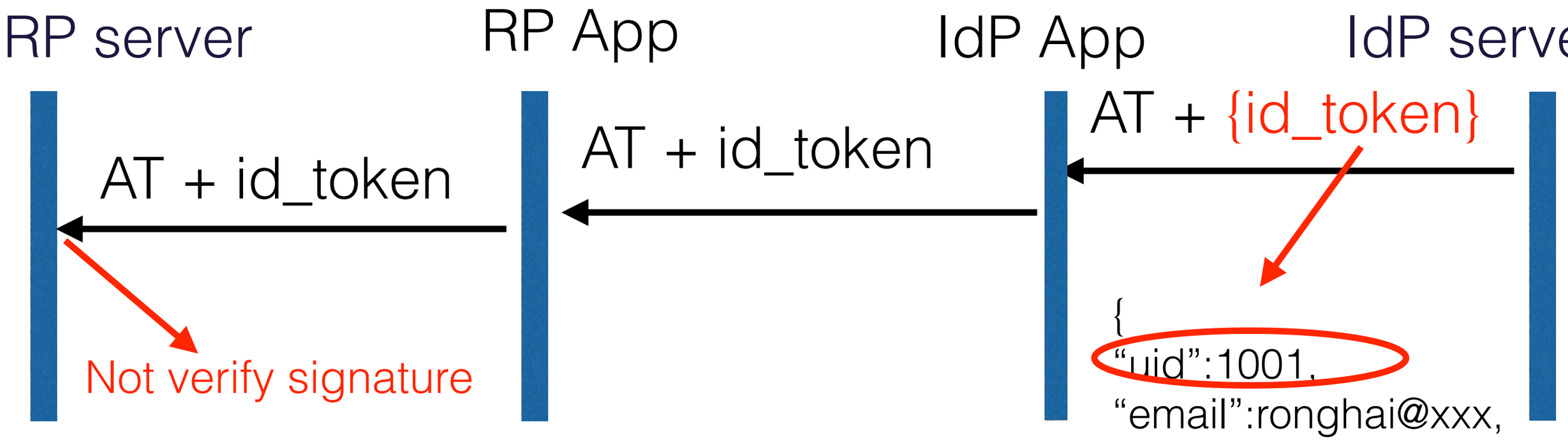
- Two steps to obtain the access token
  - ✤ Auth request: getAccounts()
  - ✤ Token request: GoogleAuthUtil.getToken()
- Step 2 is often **missing** by RP developers

Common Mistake 2
RP App Fails to Return AT



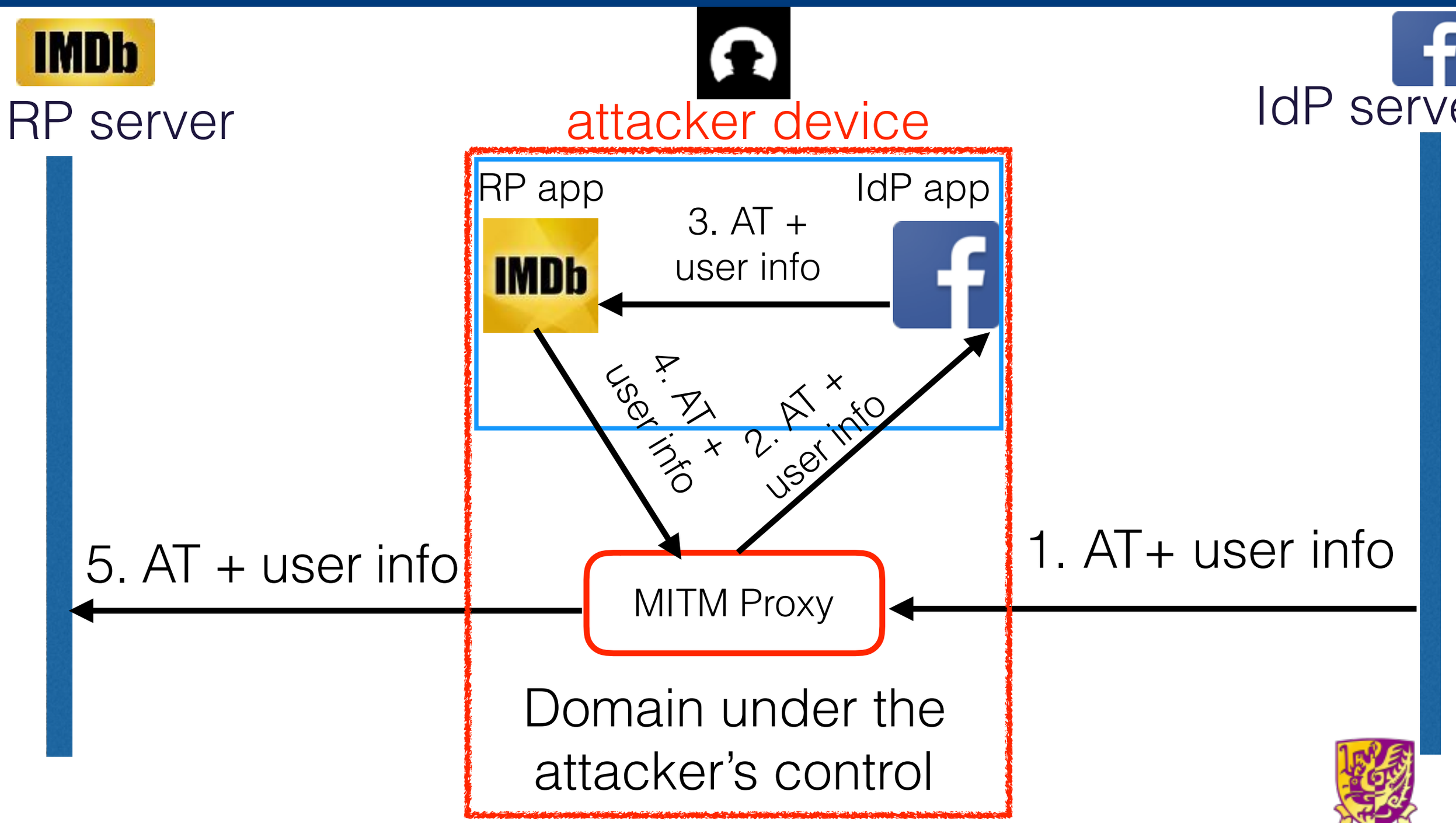
- The RP app does not return AT to the RP server
- The RP server only depends on user info to identify the user

Common Mistake 3
Fail to Verify Signature of Signed id_token (OpenID Connect)



- id_token
  - ✤ includes user profile information
  - ✤ signed by IdP server
- The signature can be incorrectly verified, *e.g.*, not verify the signature at all

The Platform to Exploit the Vulnerability



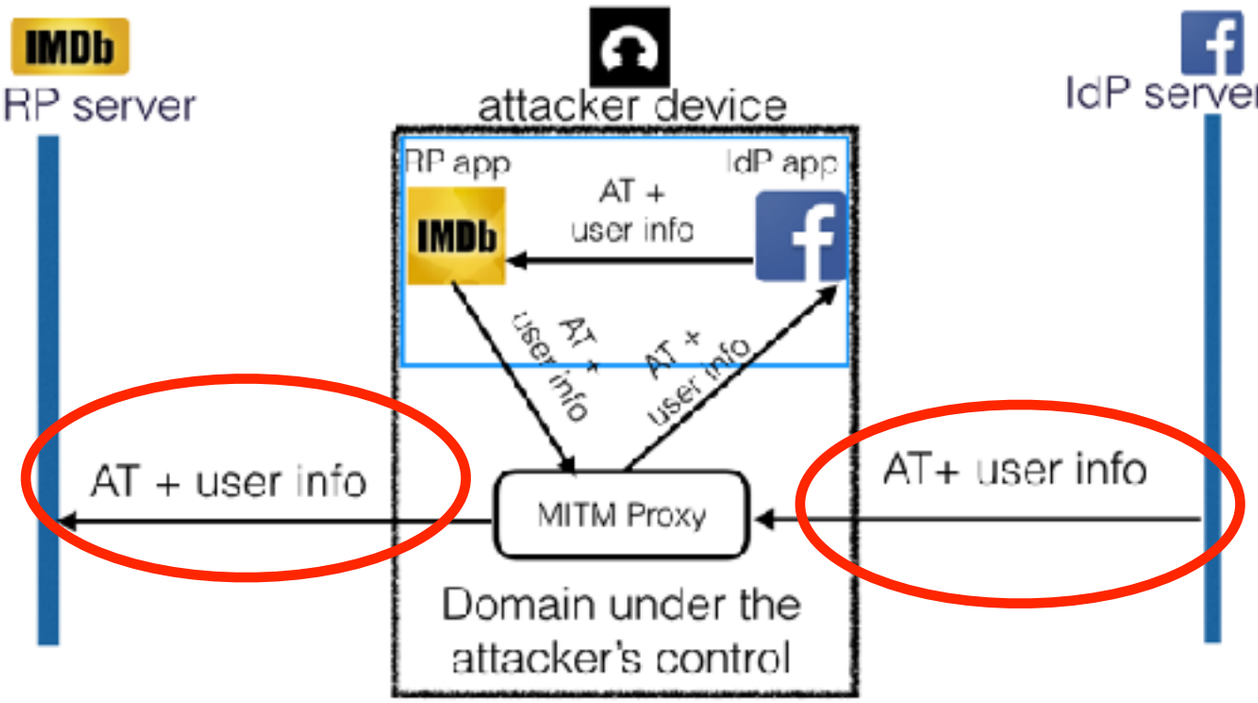
Tamper the message between RP app and RP server

- Challenges

  1. proprietary message exchanges

  2. digital signature/ encryption, in addition to HTTPS

  3. no scalable

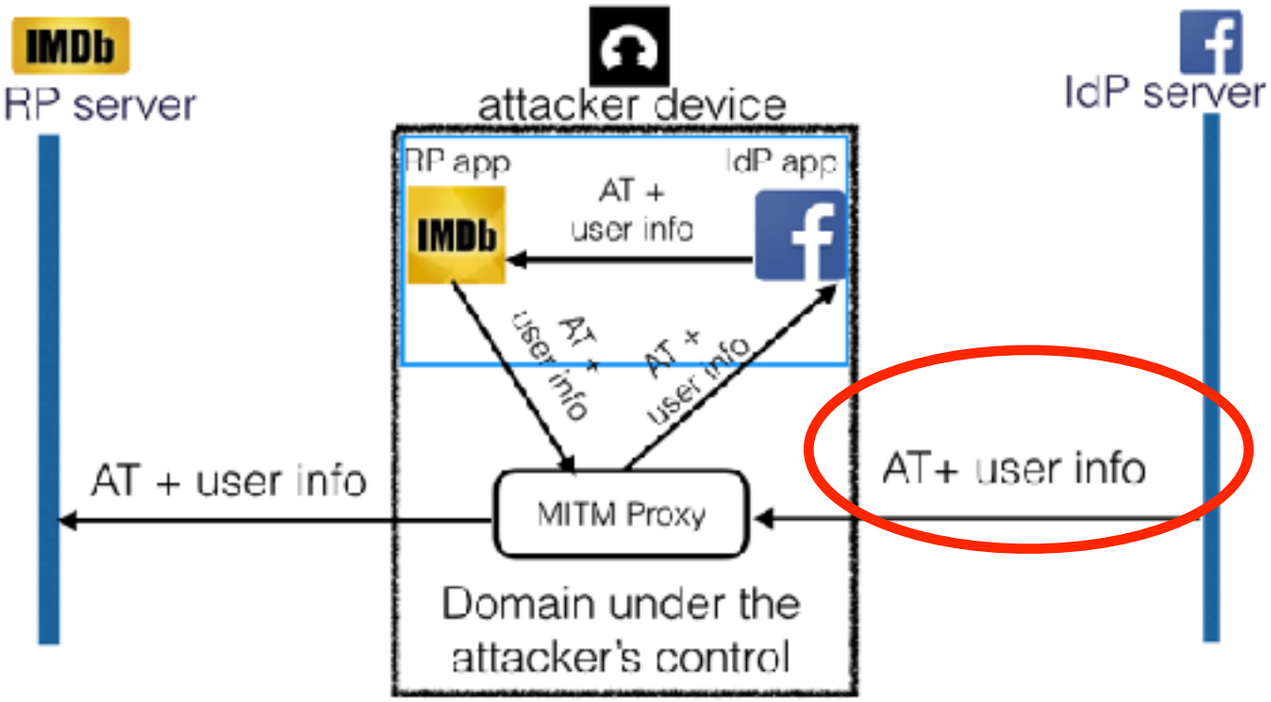


- **Tamper messages between IdP app and IdP server**

  1. messages tampered on the IdP side will be propagated to the RP side

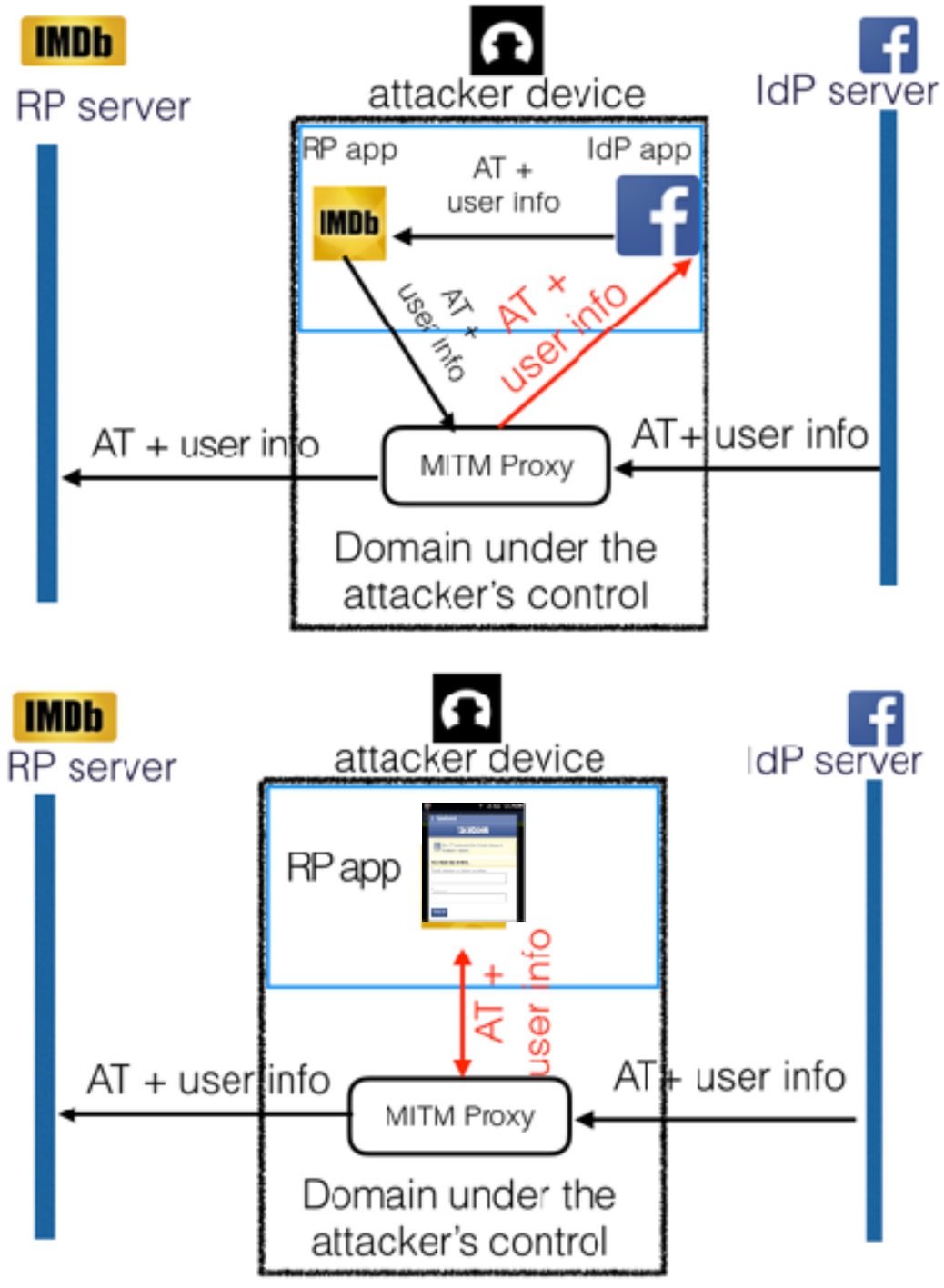
Trick 1: Naive way to tamper messages between the IdP app and IdP server

- The IdP app does not adopt any practice to avoid MITM proxy



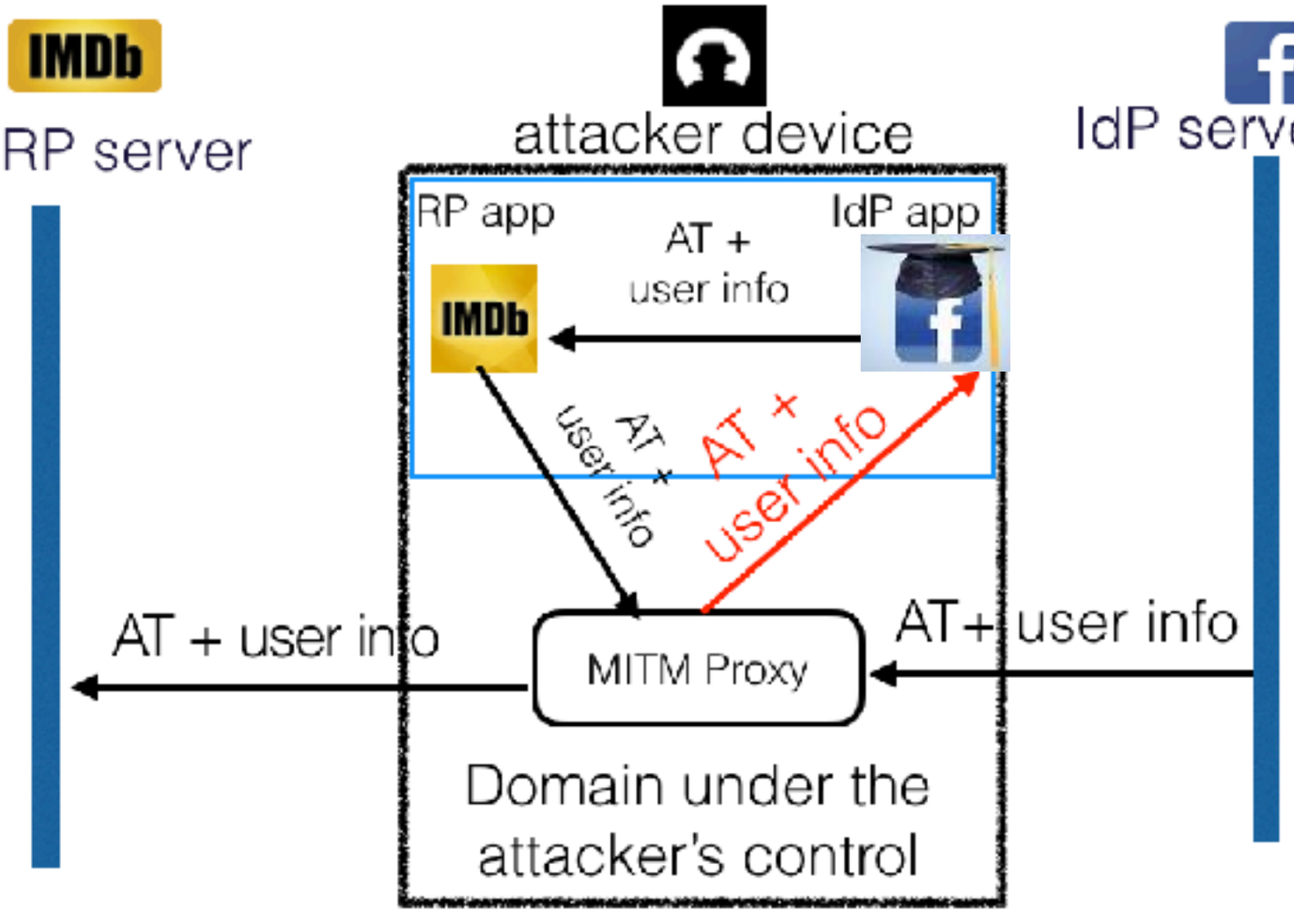
Trick 2: Use WebView to bypass certificate pinning

- Certificate pinning
  - ✤ The IdP app only accepts the certificate from the true IdP server
- Uninstall IdP app to downgrade WebView scheme



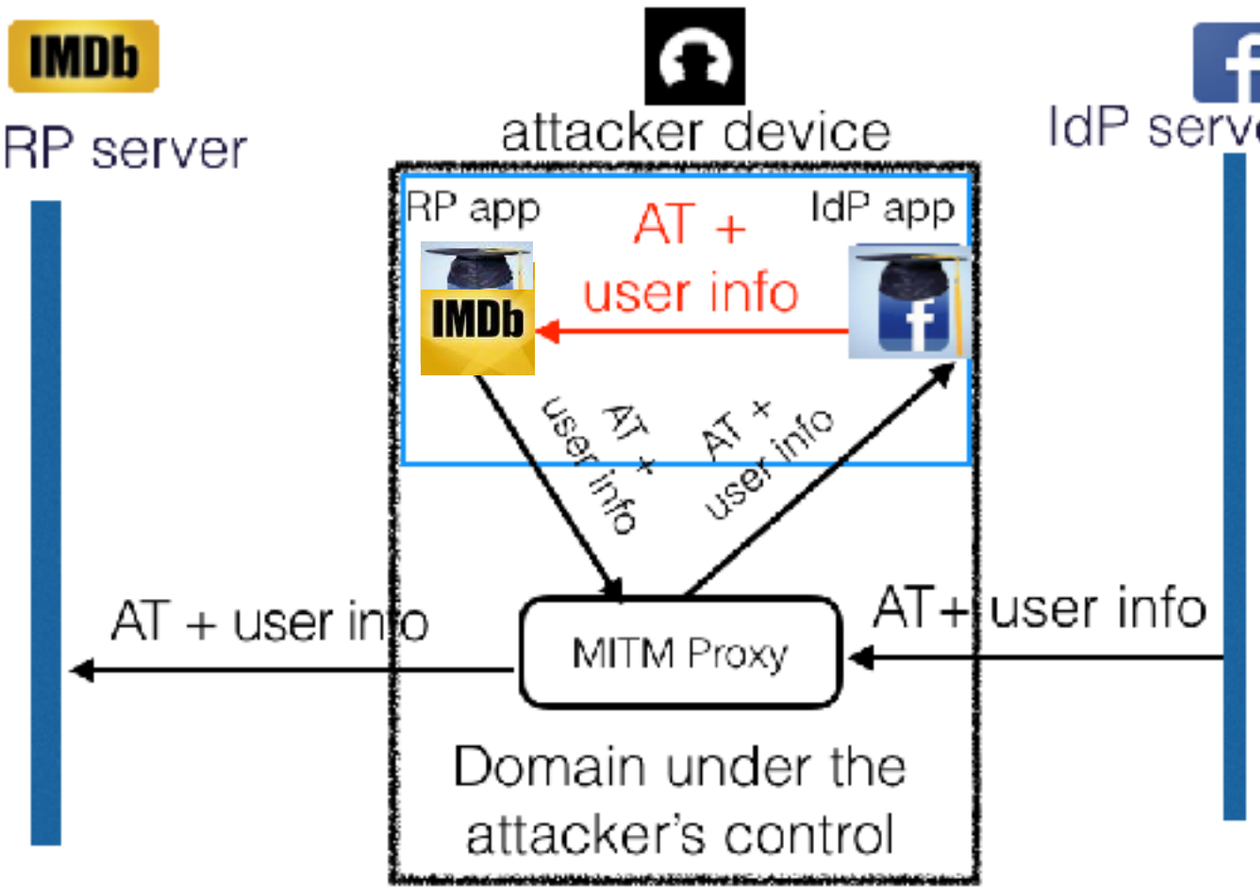
Trick 3: Modify IdP app to remove certificate pinning

- Some IdPs do NOT support WebView
- Existing tools do not work
  - ✤ SSLUnpinning
- Reverse engineering
  - ✤ Remove certificate pinning function
  - ✤ Repackage

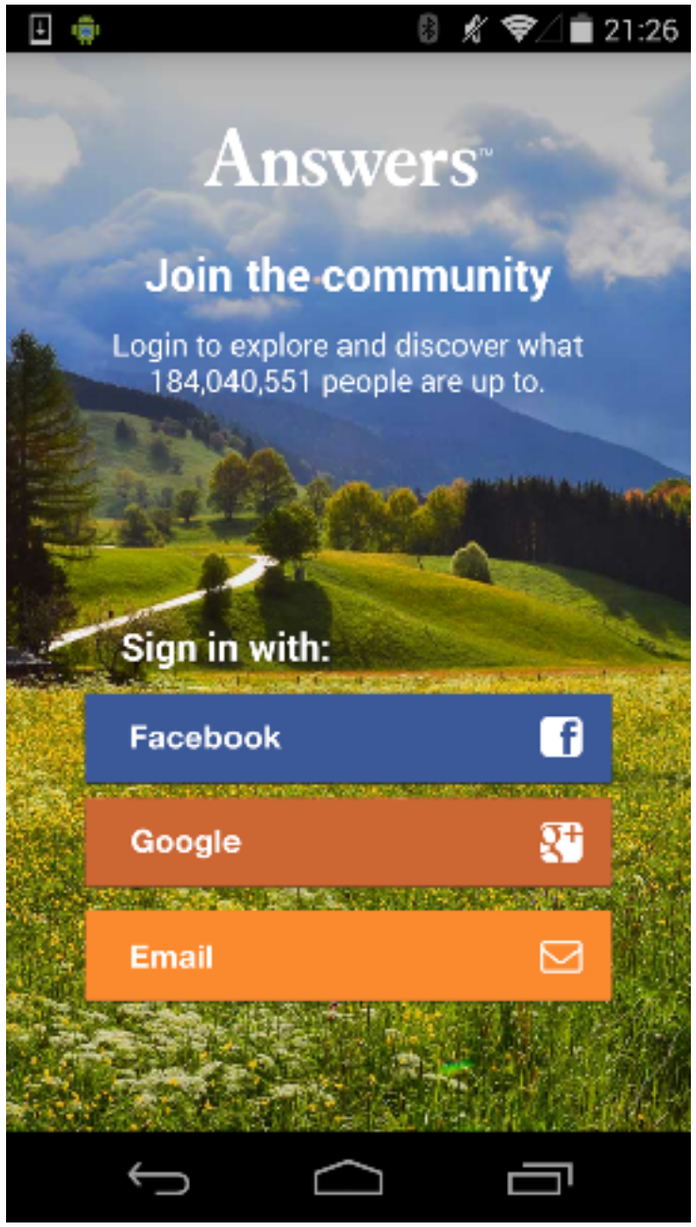


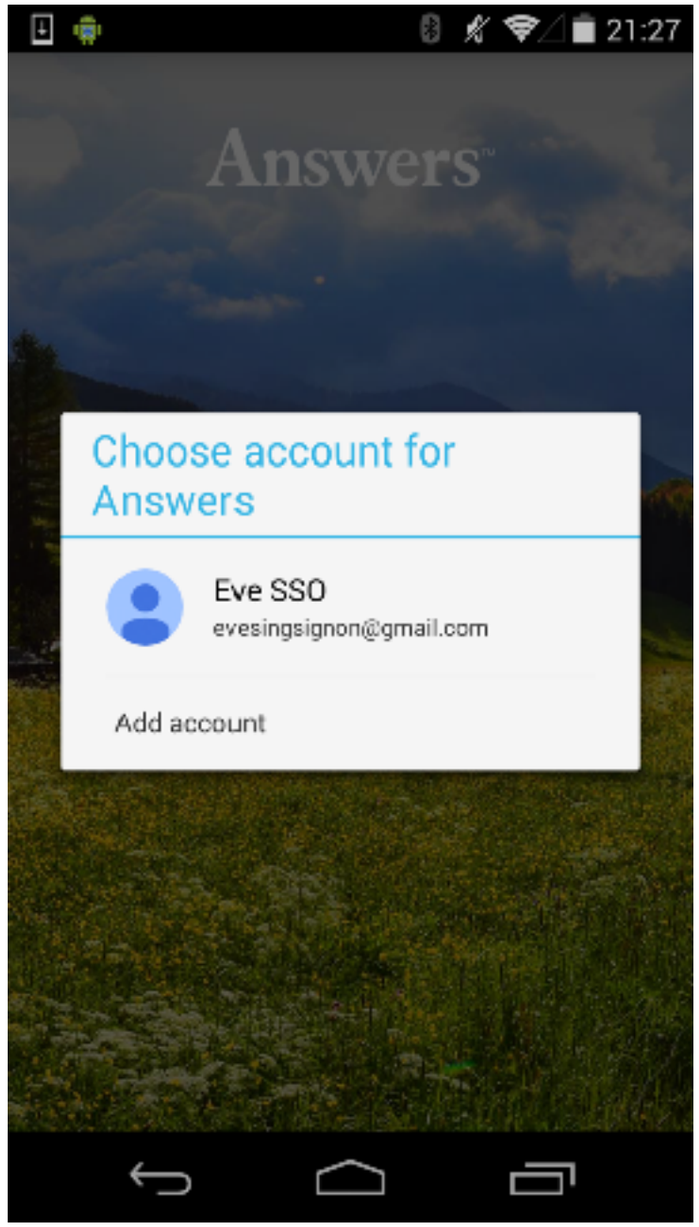
Trick 4: Modify RP app to remove the certificate comparison by SDK

- RP app checks whether IdP app is legitimate
  - ✤ The SDK hard-code the certificate of true IdP app.
  - ✤ IdP app is re-signed
- Modify RP app
  - ✤ **scalable:** modify the same function



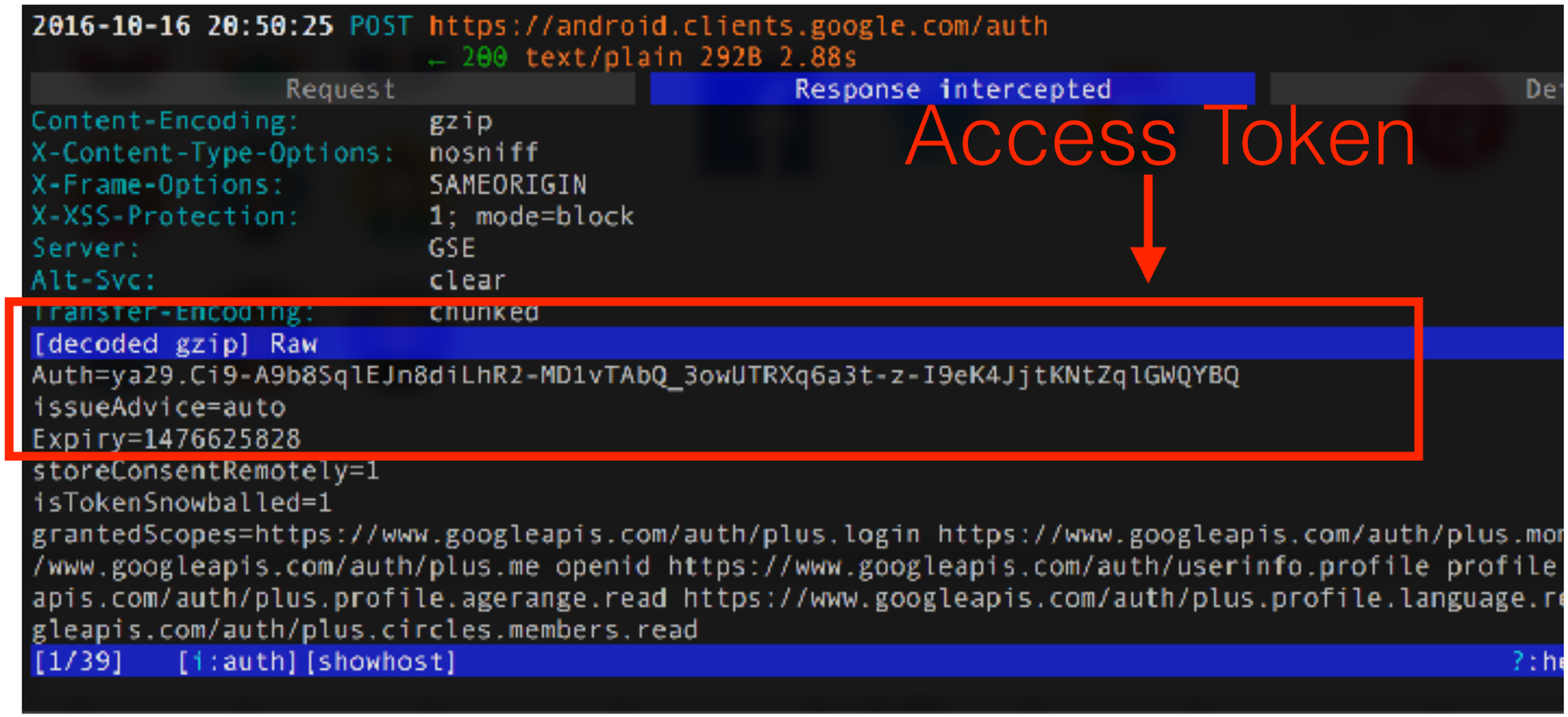
Demonstration
Attacking Answers App





Step 1: The attacker, Eve, uses her own Google account to log into Answers

Demonstration
Attacking Answers App

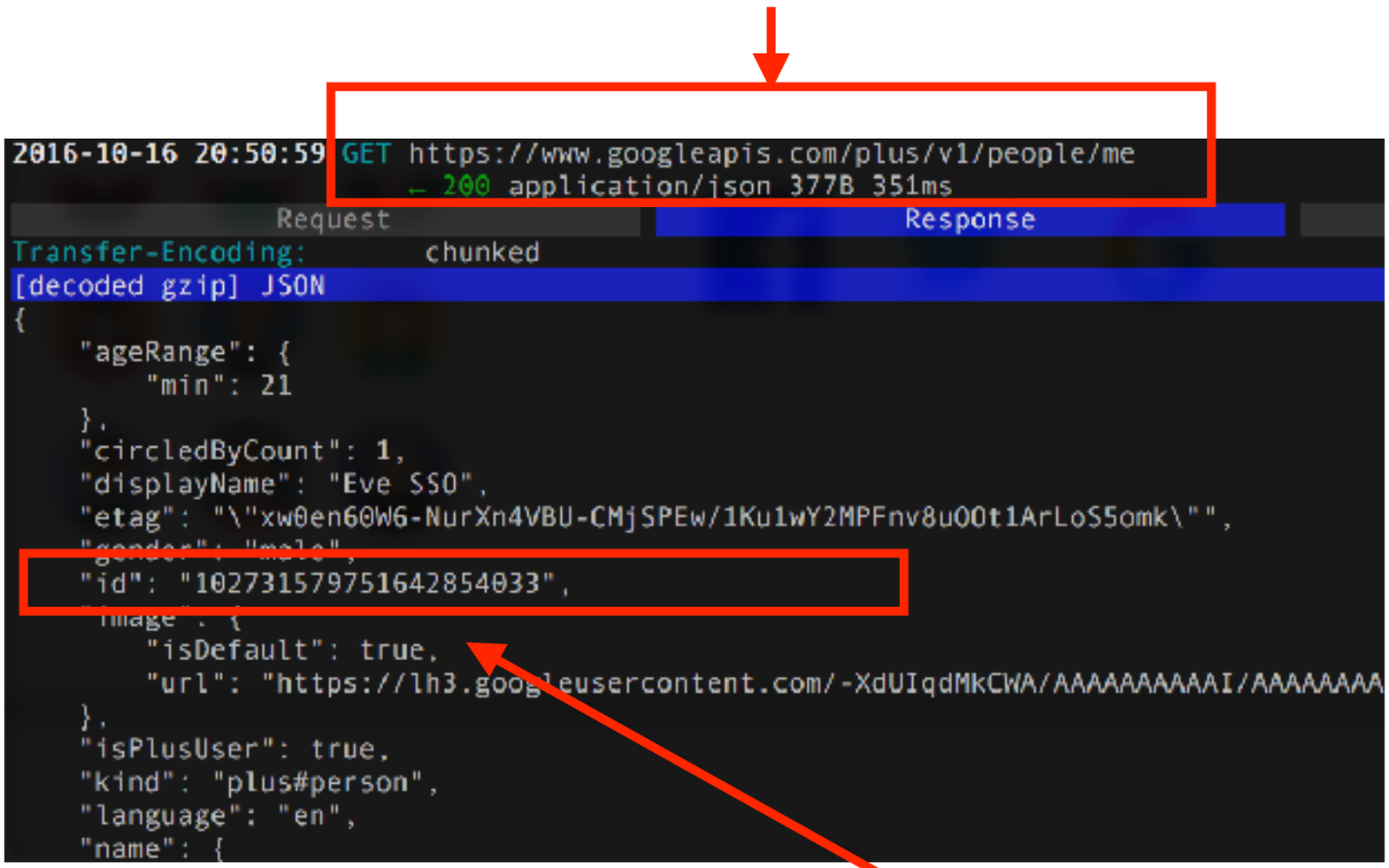


Step 2_a: The attacker setups MITMProxy

- The access token is bound to the attacker's Google account

Demonstration
Attacking Answers App

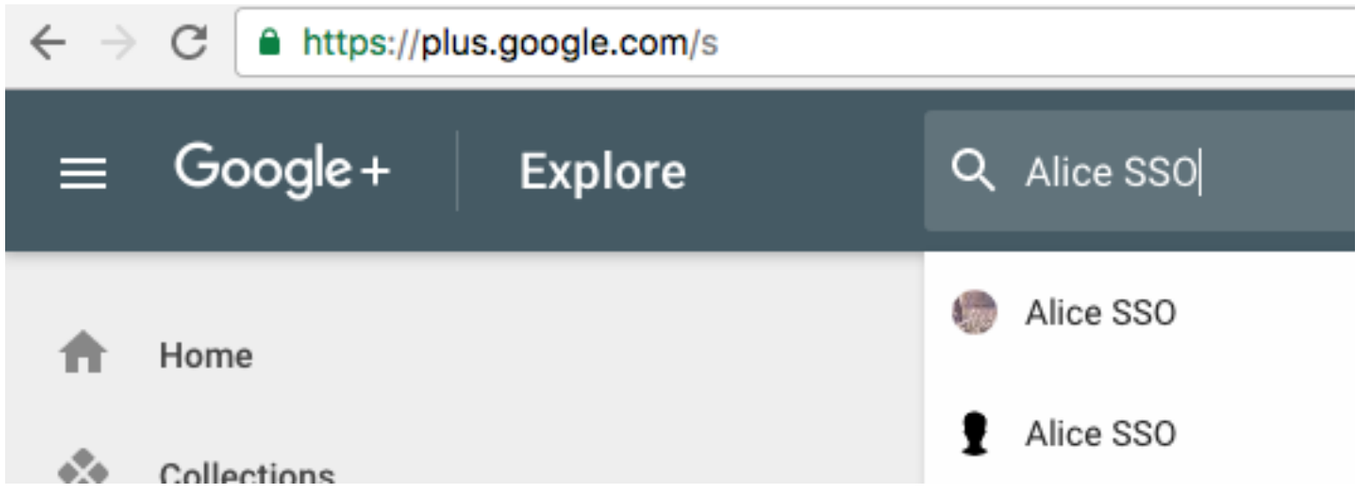
Answers app uses access token to retrieve user data



Step 2_b: The attacker intercepts the user-profile request via proxy

The unique user id of Eve in Google+

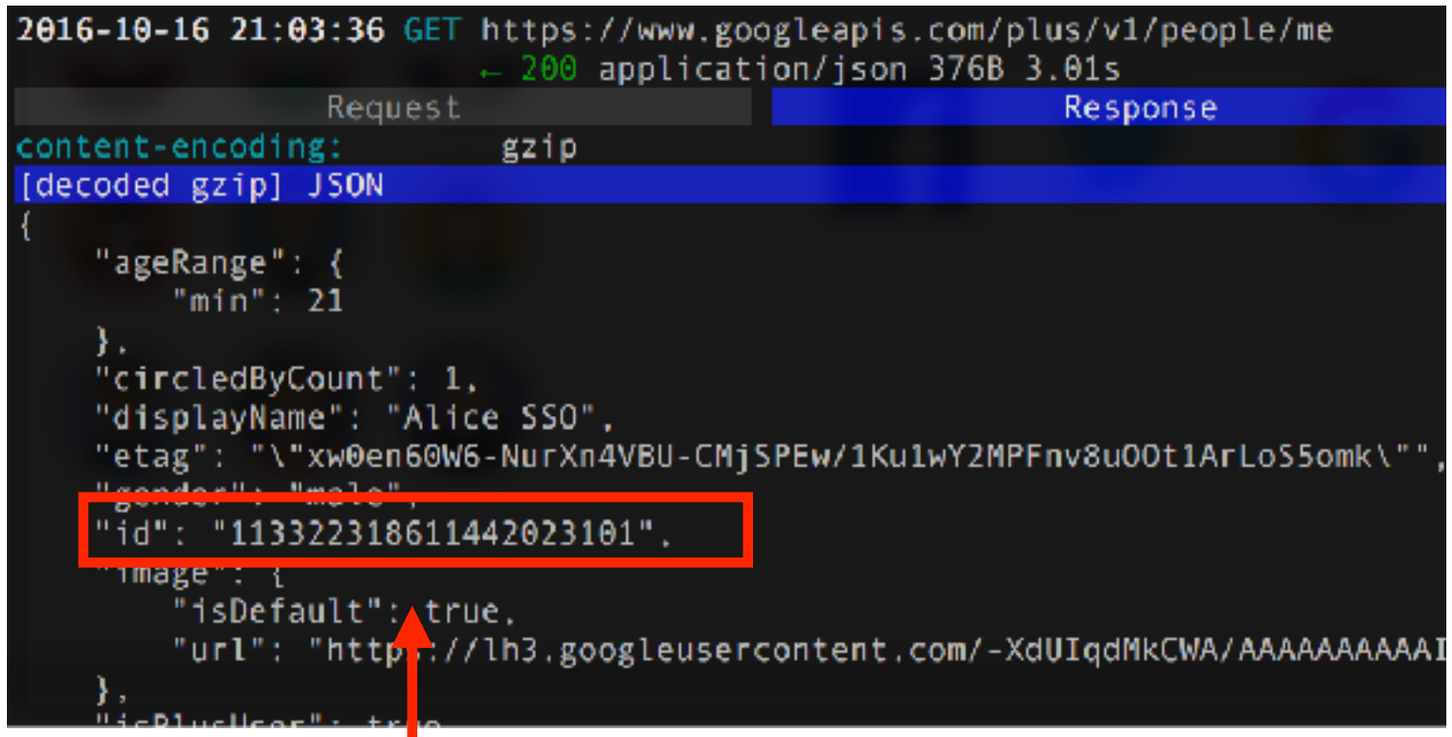
Demonstration
Attacking Answers App



Step 3_a: The attacker searches the public user profile of the victim, Alice.

Step 3_b: The attacker obtains Alice's user id via URL.

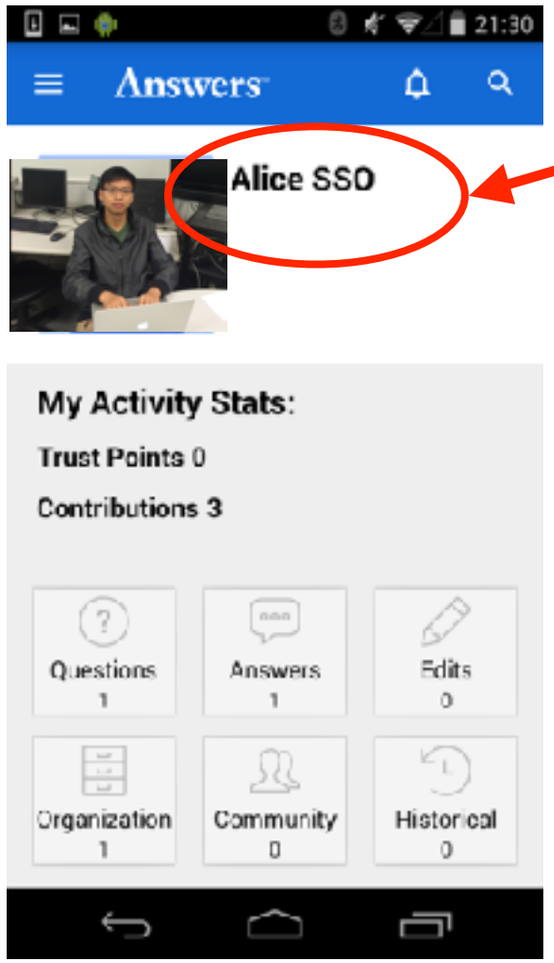
Demonstration
Attacking Answers App



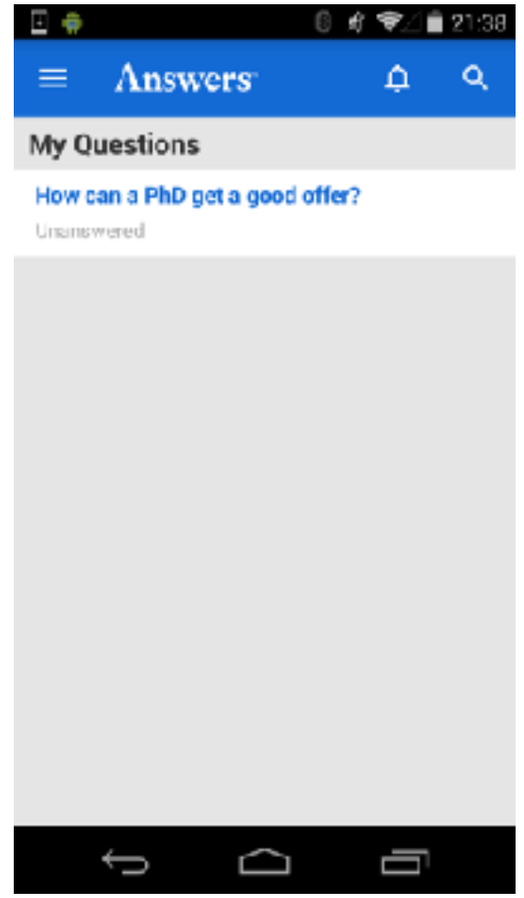
The victim's uid

Step 4: The attacker substitutes her own user id with the victim's one

Demonstration
Attacking Answers App



The attacker logins as the victim, Alice



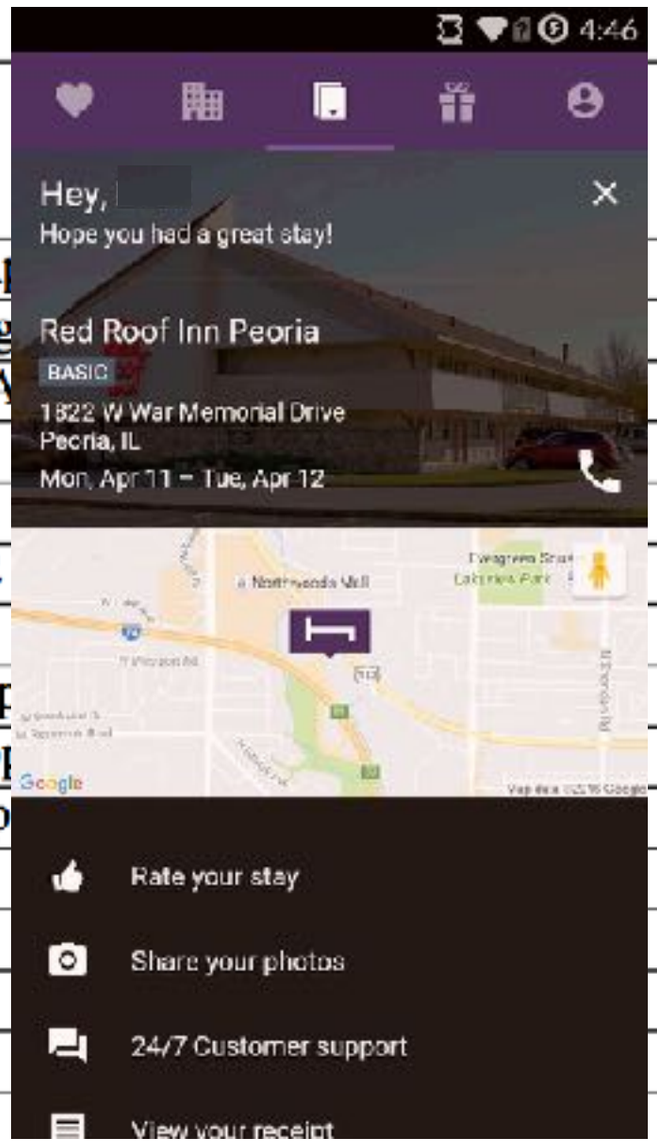
- Only require the public victim profile
- The attack can be remotely/ silently launched

Empirical Evaluation

IdPs	# of Top Apps tested (overall + per category)	# of Apps Support OAuth2.0	# of Vulnerable Apps
Facebook	400 (300+100)	59	9 (15%)
Google	400 (300+100)	40	8 (20%)
Sina	200 (100+100)	83	58 (70%)
Summary	1000	182	**75 (41%)**

- Facebook/ Google from Google Play
  - ✤ Top-300 Apps in overall category
  - ✤ Top-100 Apps in different categories
- Sina from one major Chinese app store
  - ✤ Top-100 Apps in overall and different categories

A Partial List of Vulnerable Android Mobile Apps



Type of Apps	# Do (in	Sensitive osed	Feasible Transactions by the Attacker
Travel Plan Ap	>		-
Hotel Booking	>		pay for room bookings
Private Chat A	>	/ album	send forged messages
Dating App	>	references	purchase gifts
Finance App1	>	/ expenses	-
Finance App2	>	rest	-
Call App	>	call history	call for free
Live Video Ap	>	im likes	purchase gifts
Download Ap	>	y	enjoy VIP speed
Shopping App	>		-
Browser	>		-
Video Apps	>	history	purchase videos
Music Apps	>		purchase sound-tracks
News Apps	>	story	-

A Partial List of Vulnerable Android Mobile Apps

- The total number of downloads for this incomplete list of Android apps exceeds 2.4 billion.
- Based on the SSO-user-adoption-rate of 51%, one conservative estimate is that more than one billion of different types of app accounts are susceptible.
- Such an attack is also feasible to iOS
  - ✤ iOS RP apps adopt the same protocol call-flow

Responsible Disclosure

- We reported this issue to all three IdPs on April 2016
- Receive their acknowledgements in different ways
  - ✤ Maximum bounty reward from Sina
  - ✤ Sina sent a notification letter to all its third-party app developers
- Based on our incomplete sampling very recently, most of RPs are still vulnerable

Suggested Remedies

1. **For IdPs:**
   - ✤ Provide more clear, and more security-focused guidelines
   - ✤ Issue private per-app user-id
     - ❖ Facebook has adopted this practice since May 2014, but due to the backward compatibility reason, old users are still vulnerable.
   - ✤ More security testing/ auditing on the RP app
     - ❖ We have developed an OAuthTester tool for large-scale testing
2. **For RPs:** Never trust client-side information
3. Follow the best practices in *draft-ietf-oauth-native-apps-05*

Thanks and Q&A

Ronghai Yang
http://personal.ie.cuhk.edu.hk/~yr013/

Wing Cheong Lau
www.ie.cuhk.edu.hk/~wclau/