Cross Miniapp Request Forgery: Root Causes, Attacks, and Vulnerability Detection

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11/08/2022

What is Super app?

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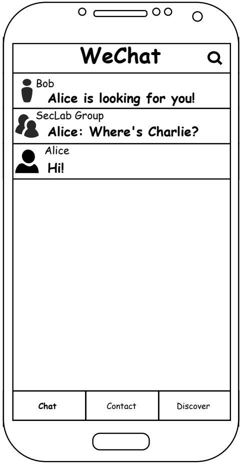
2. Miniapp, a light-weight and full-fledged app, executed inside a JavaScript engine created (or virtualized) by the super app.

What is Mini-app?



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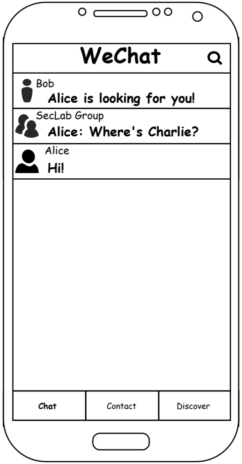
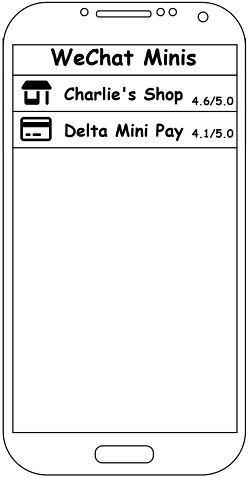


Bob
Alice is looking for you!

SecLab Group
Alice: Where's Charlie?

Alice
Hi!



Charlie's Shop	4.6/5.0
Delta Mini Pay	4.1/5.0

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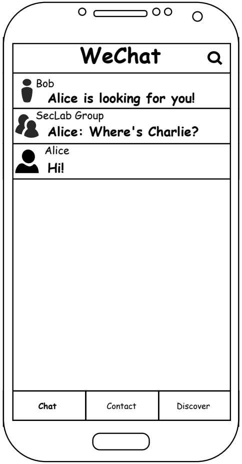
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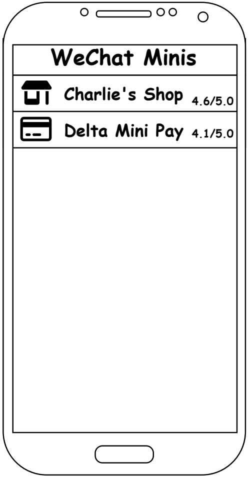
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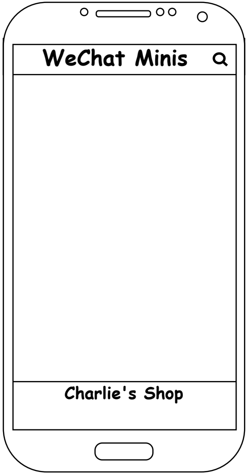
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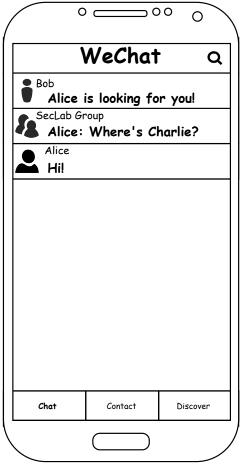

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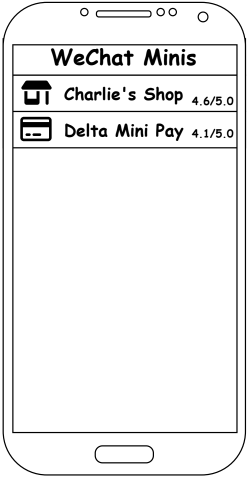

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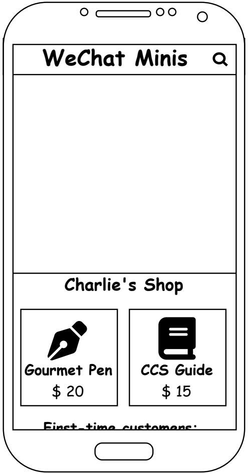


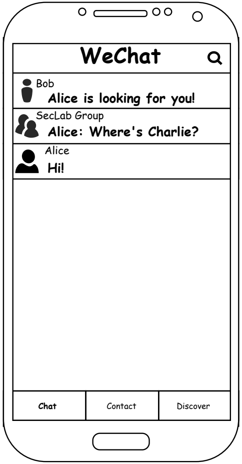
WeChat Minis

Charlie's Shop

Gourmet Pen	CCS Guide
$ 20	$ 15

First-time customers:

What is Mini-app?



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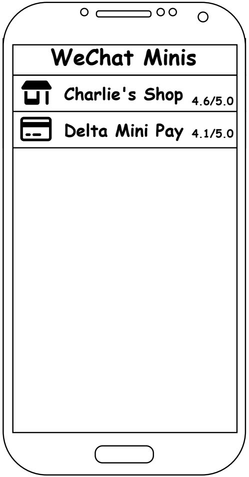

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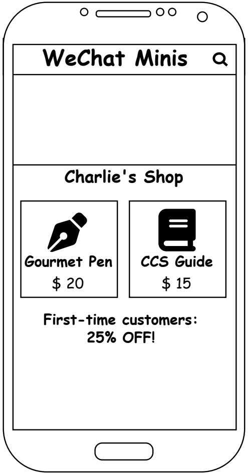

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First-time customers:
25% OFF!

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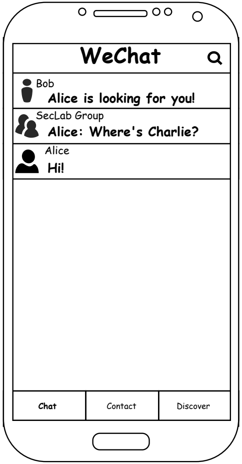

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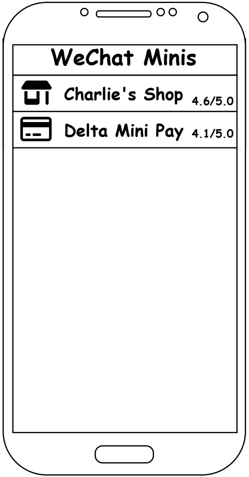

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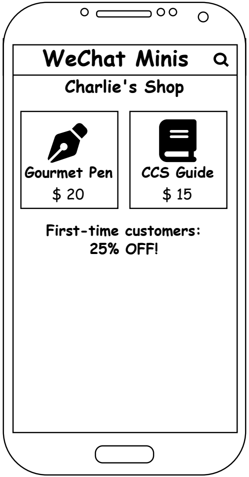

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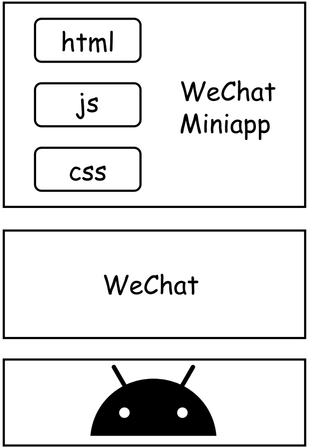
Summary: Miniapp



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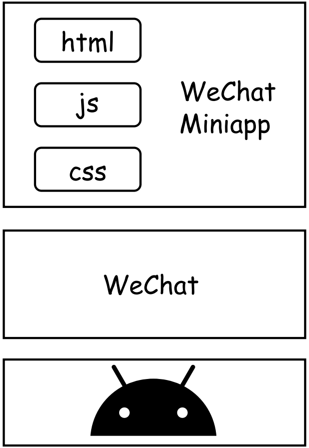

- Miniapp: third-party apps *inside* super app
- Super app:
  - Provide Execution Environment

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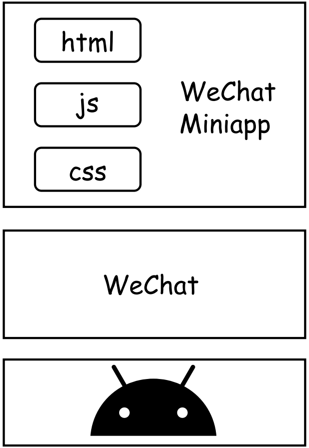

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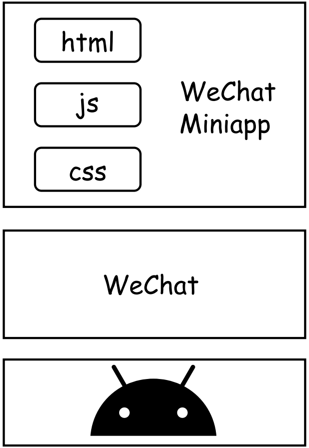

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  - Handle Cross-miniapp Messages

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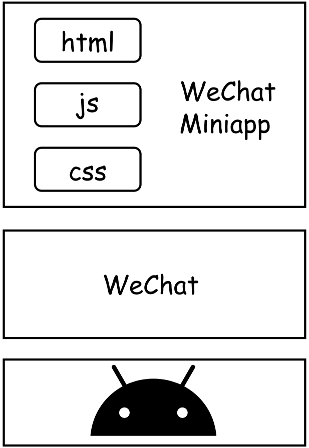

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  - Provide Execution Environment
  - Manage OS Resources
  - Handle Cross-miniapp Messages
  - ...

Collaboration between miniapps

WeChat Minis
Charlie's Shop
$15.00
Pay

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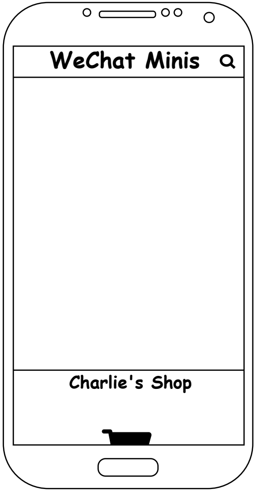

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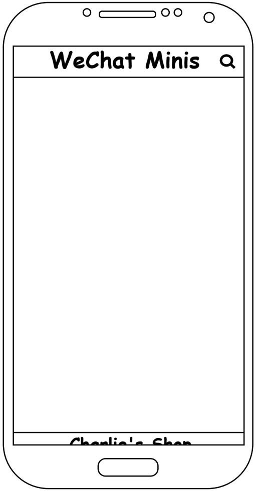

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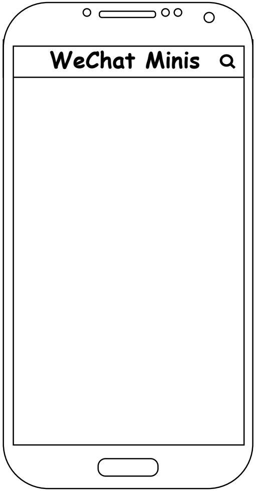

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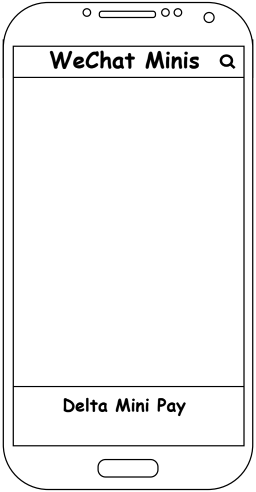

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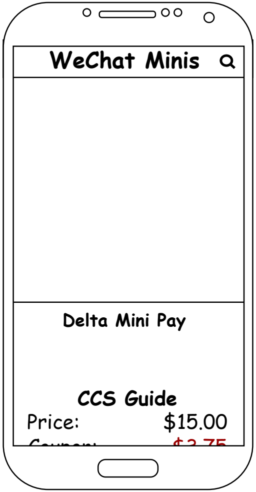
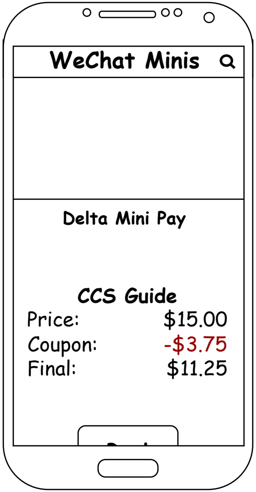


CCS Guide

Price: $15.00

Coupon: $3.75

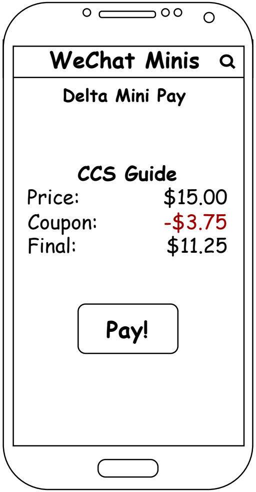
Collaboration between miniapps



CCS Guide

Price:	$15.00
Coupon:	-$3.75
Final:	$11.25

Collaboration between miniapps



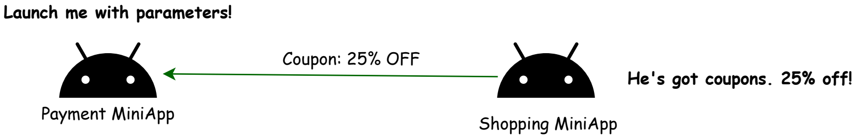
Price:	$15.00
Coupon:	-$3.75
Final:	$11.25

Real-world Case

```
// sender (shopping miniapp) ID: wxd7c977843ebe7a64
    submitOrder: function(){
    price = self.getPrice();
    tt.navigateToMiniProgram({
      appId: "wx2d495bf4b2abdecef",
      path: "paymentpage",
      extraData: {
        Price: price
        orderID: orderid,
      }
    });
  }
  onLaunch(o){
    var e=this;
    o.referrerInfo && (e.globalData.paymentState
      = o.referrerInfo.extraData.paymentState) &&
      (e.globalData.couponCode
      = o.referrerInfo.extraData.couponCode)
    if(e.globalData.paymentState == "Success")
    {
        shiptheProducts() //ship the products
    }
    saveCouponCode(e.globalData.couponCode)
  }
```

```
// receiver (payment miniapp) ID: wx2d495bf4b2abdecef
  var e=getApp();
  onLaunch(o){
    o.referrerInfo && (e.globalData.price
      = o.referrerInfo.extraData.Price) &&
      (e.globalData.appId
      = o.referrerInfo.appId)
    e.globalData.orderID = o.referrerInfo.extraData.orderID
  }
  Pay:function() {
    var price = e.globalData.Price
    wx.requestPayment({price, ...}) //pay the order
    if(e.globalData.appId == "wxd7c977843ebe7a64"){
        e.globalData.coupon = 'MYCOUPON'
    }else{
        e.globalData.coupon = null
    }
  }
  wx.navigateBackMiniProgram({
  extraData: {
  paymentState: 'Success',
  couponCode: e.globalData.coupon
}
```

Sending Cross-app Message



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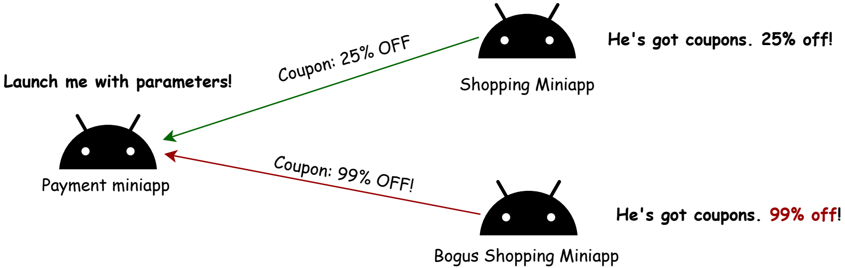

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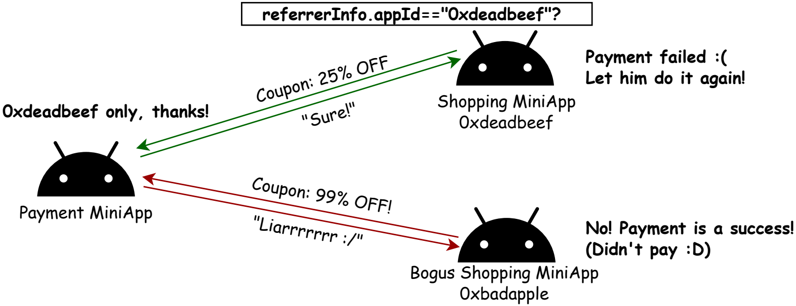
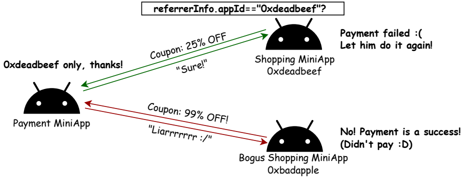
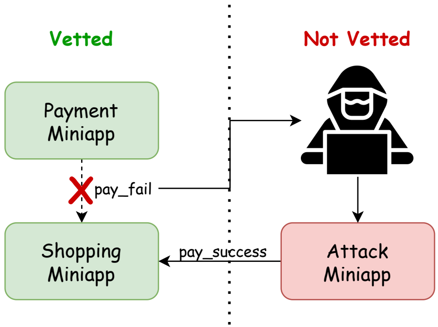


CMRF Vulnerability



- CMRF: Cross-Miniapp Request Forgery
- Consuming data without checking sender's identity can be dangerous!

Attack Threat Model



1. Victim:
   - On-market miniapp's back-end
   - Platform users' privacy
2. Assumptions:
   - Front-end code is safe
   - Back-end is trusted

Vulnerability Detection

```
// receiver (payment miniapp) ID: wx2d495bf4b2abdecef
  var e=getApp();
  onLaunch(o){
    o.referrerInfo && (e.globalData.price
      = o.referrerInfo.extraData.Price) &&
      (e.globalData.appId
      = o.referrerInfo.appId)
    e.globalData.orderID = o.referrerInfo.extraData.orderID
  }
  Pay:function() {
    var price = e.globalData.Price
    wx.requestPayment({price, ...}) //pay the order
    if(e.globalData.appId == "wxd7c977843ebe7a64"){
        e.globalData.coupon = 'MYCOUPON'
    }else{
        e.globalData.coupon = null
    }
  }
  wx.navigateBackMiniProgram({
  extraData: {
  paymentState: 'Success',
  couponCode: e.globalData.coupon
}
```

1. Dynamic analysis?
   - Over 2.5M miniapps to scan
   - Not scalable
2. Static analysis?
   - Message Usage? `referrerInfo.extraData.*`
   - ID Check? `referrerInfo.appId`

Implementation

```
// receiver (payment miniapp) ID: wx2d495bf4b2abdecef
 var e=getApp();
 onLaunch(o){
  o.referrerInfo && (e.globalData.price
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```

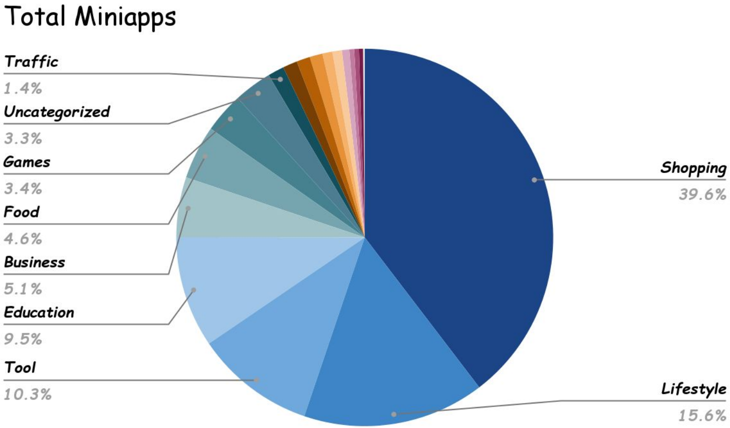
❶ Challenges
- ▶ Packages are obfuscated
- ▶ Handle Variable Aliases
- ▶ Cross-Function Invocations

❷ Data-flow Analysis
- ▶ DoubleX [1]

Data Collection

1. WeChat
   - 2,571,490 Miniapps from WeChat with MiniCrawler [2]
   - 6.29 TB space
2. Baidu
   - 148,512 miniapps
   - 81 GB space

Miniapp Stats (WeChat)



Affected Miniapps (WeChat)

	WECHAT					
Category	No Use		Checked		Vulnerable	
	# app	%total	# app	%	# app	%
Business	131,078	5.1	81	8.07	923	91.93
E-learning	10,271	0.4	4	5.19	73	94.81
Education	240,077	9.34	184	3.72	4,756	96.28
Entertainment	29,442	1.14	140	33.02	284	66.98
Finance	3,509	0.14	6	6.67	84	93.33
Food	114,675	4.46	332	8.07	3,780	91.93
Games	88,056	3.42	10	2.09	469	97.91
Government	31,432	1.22	33	9.02	333	90.98
Health	27,716	1.08	37	5.44	643	94.56
Job	21,773	0.85	16	7.02	212	92.98
Lifestyle	394,493	15.34	269	4.23	6,092	95.77
Photo	9,039	0.35	3	4.41	65	95.59
Shopping	989,498	38.48	743	2.56	28,304	97.44
Social	20,671	0.8	6	2.99	195	97.01
Sports	15,980	0.62	69	22.48	238	77.52
Tool	261,467	10.17	122	3.72	3,161	96.28
Traffic	35,412	1.38	53	9.28	518	90.72
Travelling	10,524	0.41	5	3.62	133	96.38
Uncategorized	83,983	3.27	0	0.0	18	100.0
Total	2,519,096	97.96	2,113	4.03	50,281	95.97

Case Study

Category	Variable Name	Vulnerable w/o Check	Vulnerable w/ Incomplete Check	Total
Payment Info	for_pay_back	355	0	355
	payStatus	313	2	315
	pay	178	9	187
	isPay	118	0	118
	isLecturePay	115	0	115
Order Info	orderId	132	11	143
	orderInfo	80	0	80
	order_id	42	0	42
	jtOrderId	36	3	39
	hpj_jsapi_order_id	21	0	21
Phone Number	mobile	6,627	7	6,634
	phone	53	0	53
	userPhone	8	0	8
	phoneNumber	6	1	7
	partnerMobile	2	0	2
Promotion Info	cardId	25	0	25
	user_coupon_id	2	0	2
	couponCode	1	0	1
	coupon_id	1	0	1
	coupon_no	1	0	1
Device Info	deviceID	2	0	2
	uuid	2	0	2
	deviceId	1	0	1
	devicenum	1	0	1
	UUID	1	0	1

Case Study: Shopping-for-free

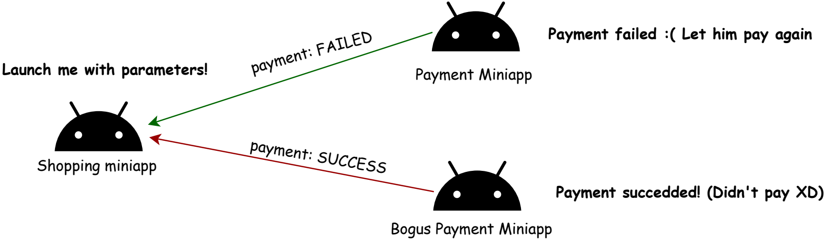

Launch me with parameters!
Shopping miniapp
payment: FAILED
Payment Miniapp
Payment failed :(Let him pay again
payment: SUCCESS
Bogus Payment Miniapp
Payment succedded! (Didn't pay XD)

Figure: Xixiu Group Purchase Backend (WeChat)

Case Study: Device Manipulation

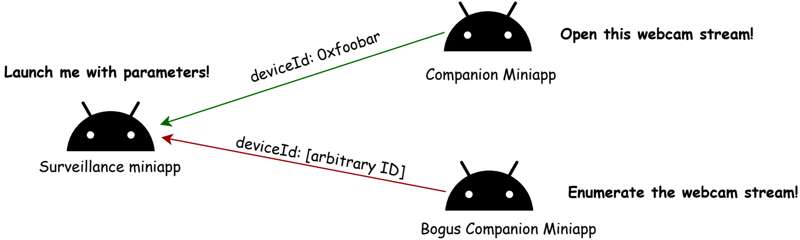


Figure: Suyuan Webcam (WeChat)

Case Study: Promotion Abuse

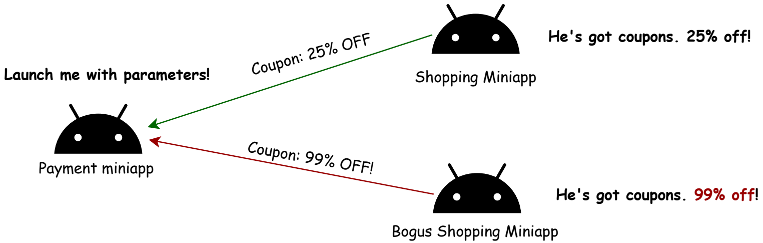
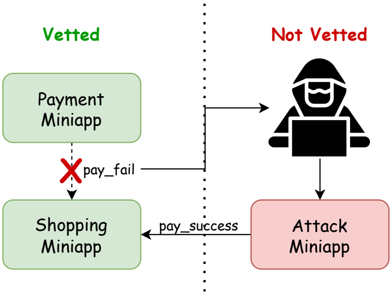


Figure: Aurora Vision (Baidu)

Takeaway



1. **Root Cause**: failure to check miniapp identity before consuming data is dangerous.
2. **The Attack**: CMRF attack can both cause financial loss to vendors and privacy leakage to users.
3. **Detection**: we detected that over 95.97% WeChat and 99.8% Baidu miniapps consuming cross-miniapp data are vulnerable.
4. **Responsible disclosure**: we informed Tencent (Oct 2021) and Baidu (Apr 2022) and received acknowledgements from both.

https://github.com/OSUSecLab/CMRFScanner

Thank You

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References I

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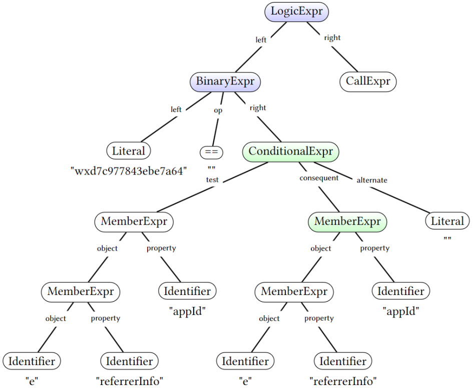
Doublex: Statically detecting vulnerable data flows in browser extensions at scale.
In *Proceedings of the 2021 ACM SIGSAC Conference on Computer and Communications Security*, pages 1789–1804, 2021.

Yue Zhang, Bayan Turkistani, Allen Yuqing Yang, Chaoshun Zuo, and Zhiqiang Lin.
A measurement study of wechat mini-apps.
In *Proceedings of the 2021 ACM SIGMETRICS/International Conference on Measurement and Modeling of Computer Systems*, 2021.

Identifying ID Checks

```
//code fragment of a vulnerable miniapp
"wxd7c977843ebe7a64"==(
  e.referrerInfo.appId?e.referrerInfo.appId:"")
  && checkPayStatus(param).then(function(a){...})

}
```



Applicability

Super App	Vendors	AppID	Sending Request APIs	Location	Audio	Bluetooth	Camera	Multi-Media	Sport	UserInfo	Address	Invoice	File	Data Cache	Payment	AccountInfo	Coupon	PhoneNumber	Network
QQ	Tencent	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WeChat	Tencent	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WeCom	Tencent	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Baidu	Baidu	AppKey	`navigateToSmartProgram`, `navigateBackSmartProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
Taobao	Alibaba	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
Alipay	Alibaba	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓
Tiktok	Bytedance	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓				✓	✓
JINRI Toutiao	Bytedance	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓				✓	✓
Watermelon Video	Bytedance	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓				✓	✓
Pipixia	Bytedance	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓				✓	✓
Toutiao Lite	Bytedance	appId	`navigateToMiniProgram`, `navigateBackMiniProgram`	✓	✓		✓	✓		✓	✓	✓	✓	✓				✓	✓