A Systematic Study of Elastic Objects in Kernel Exploitation

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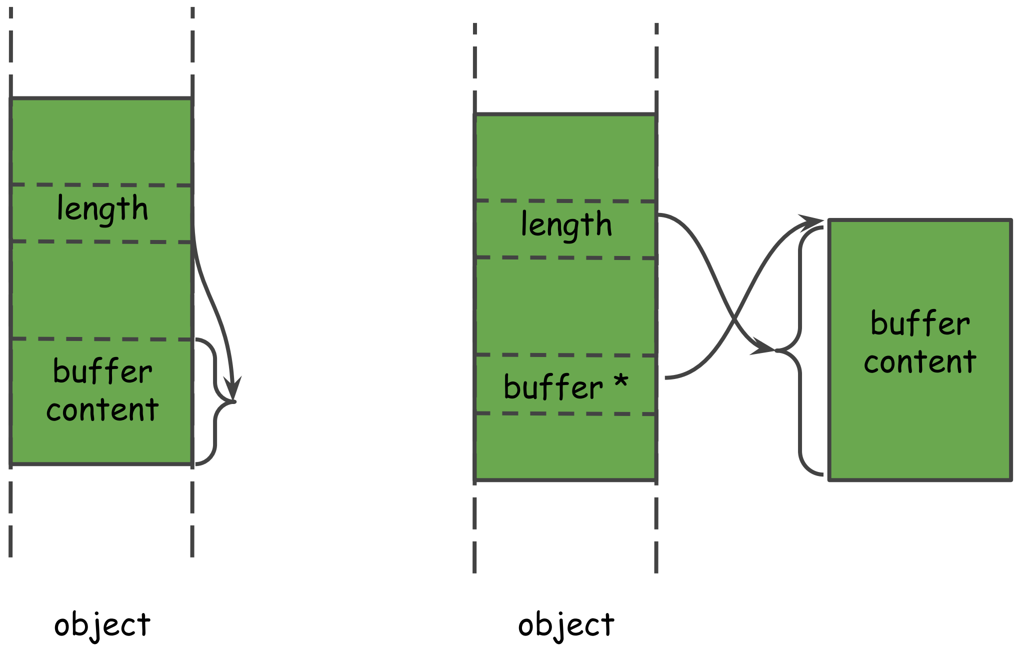
Kernel Wars

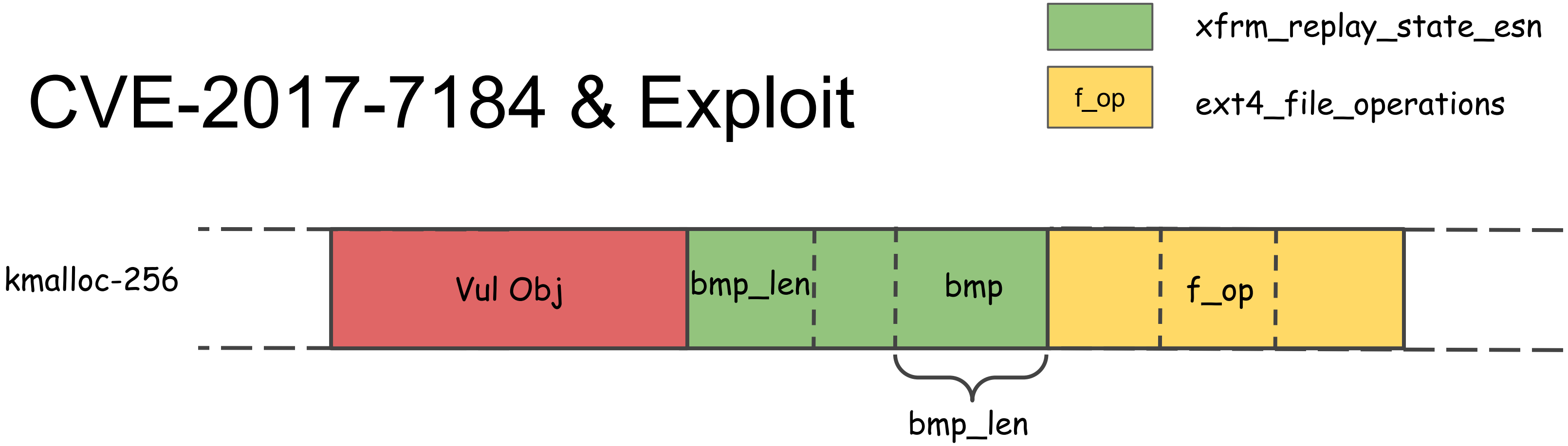
- A lot of exploit mitigations (e.g. KASLR, stack canary, heap cookies…)
- A lot of exploitation methods to circumvent kernel mitigations
- One of commonly known methods is to utilize elastic kernel objects to bypass mitigations

Elastic Objects

- Contain a length field
- The length field indicates the size of an elastic kernel buffer



CVE-2017-7184 & Exploit



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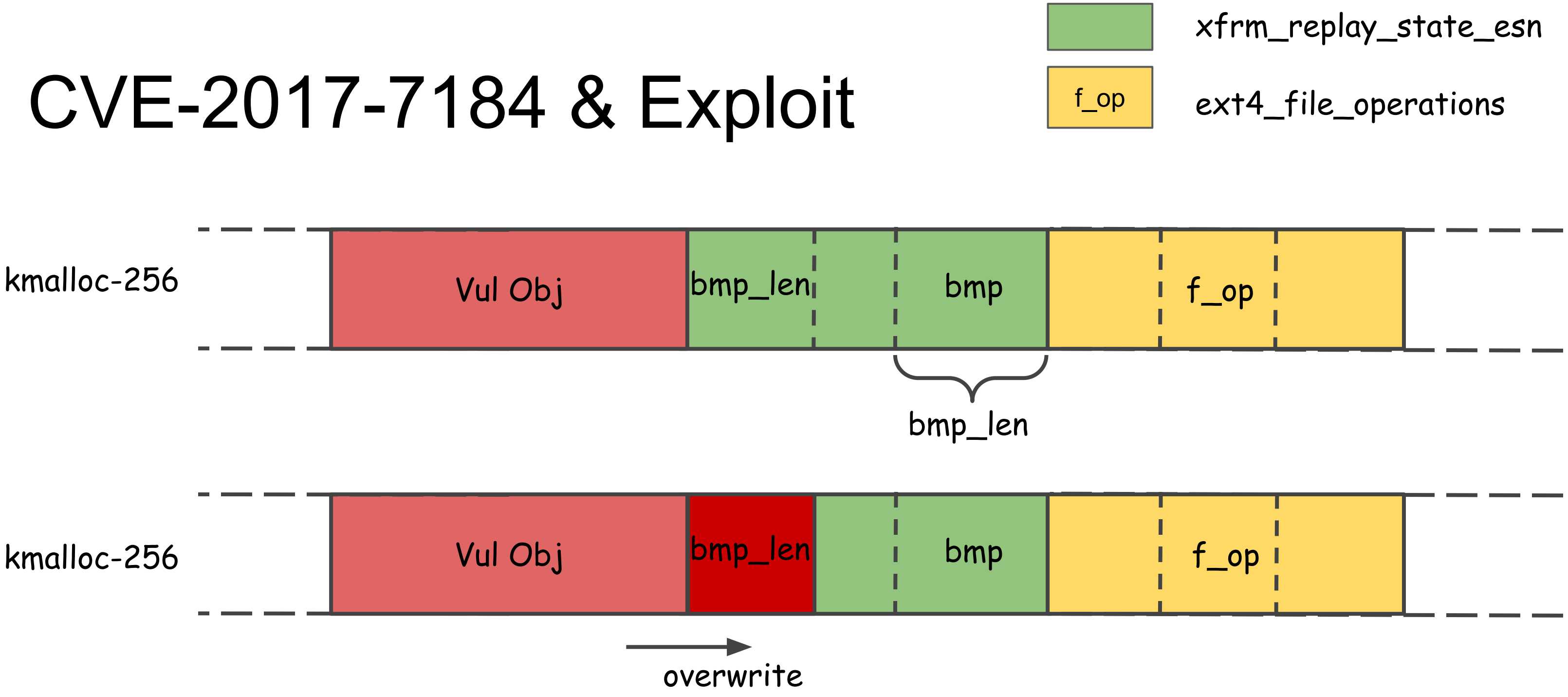

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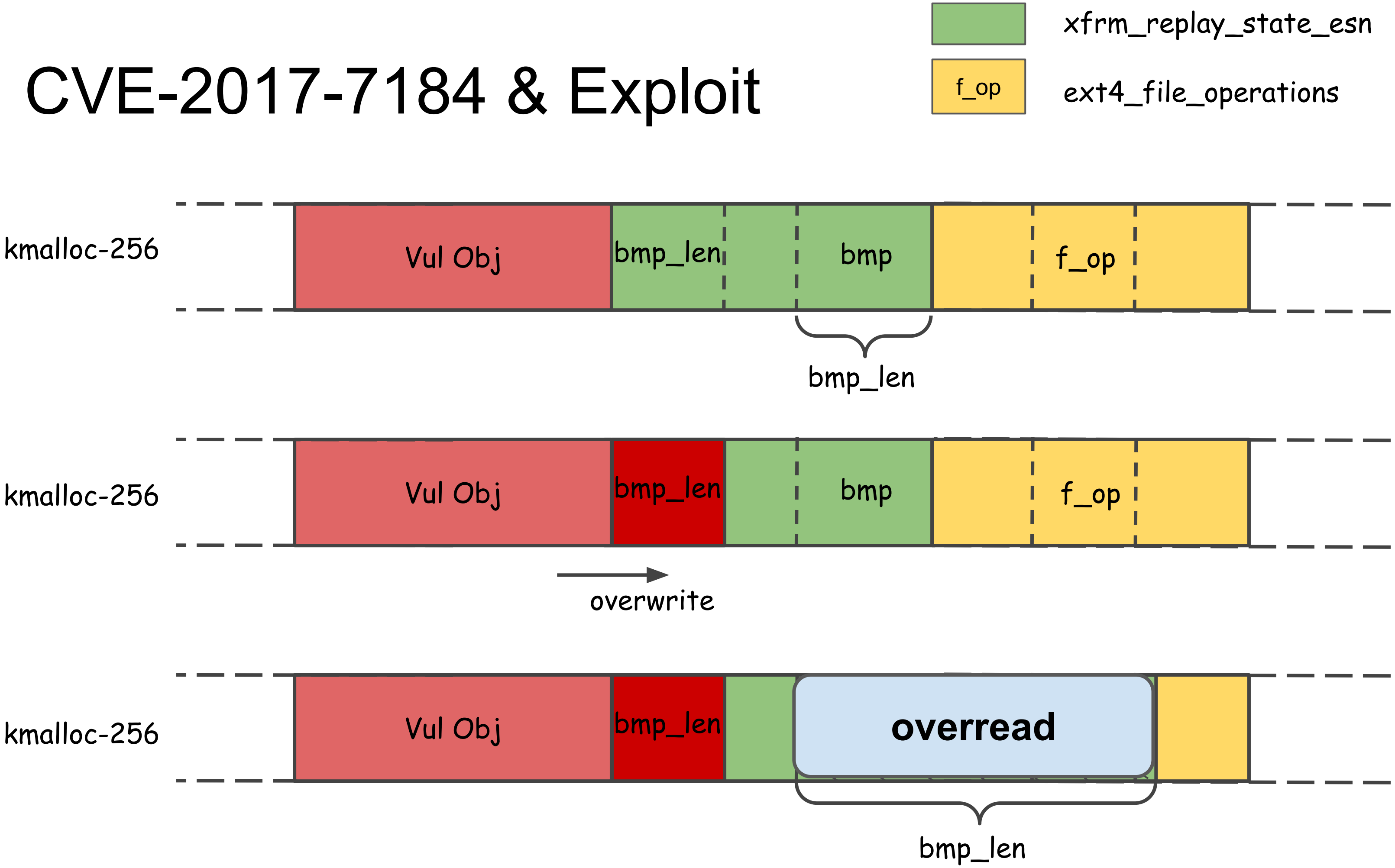
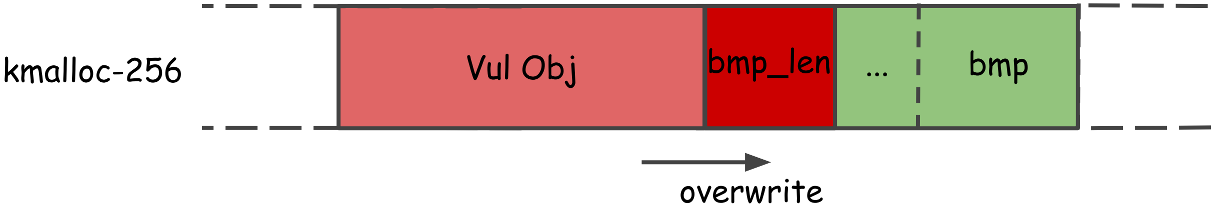


Conditions of Elastic Object Attack

- The same cache

- The length field can be enlarged by the vulnerability



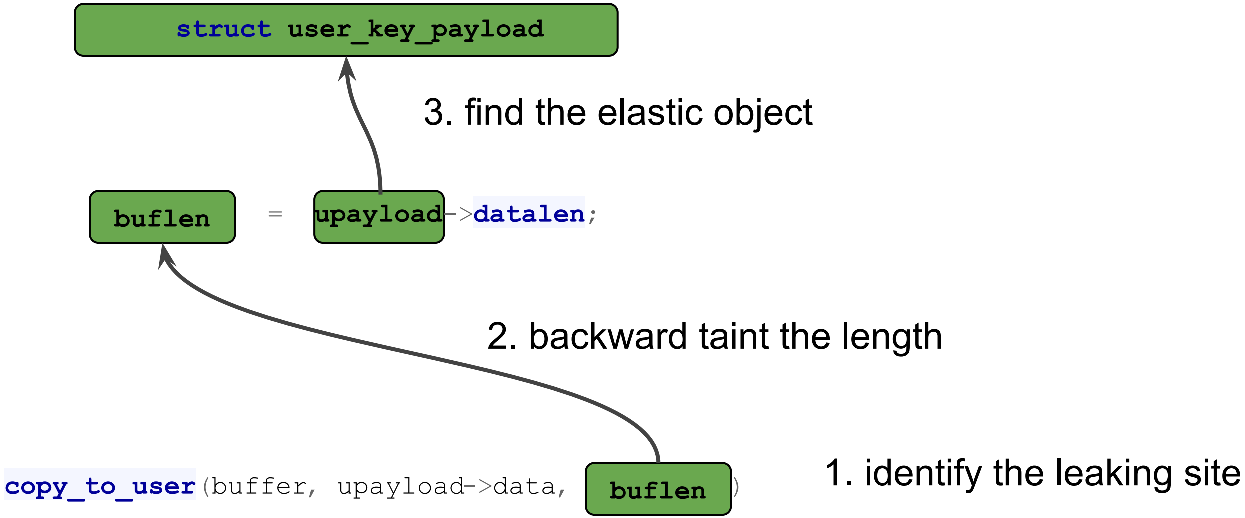
- Existing a channel to leak the elastic buffer to the userland

Severity and Generality of Elastic Object Attack

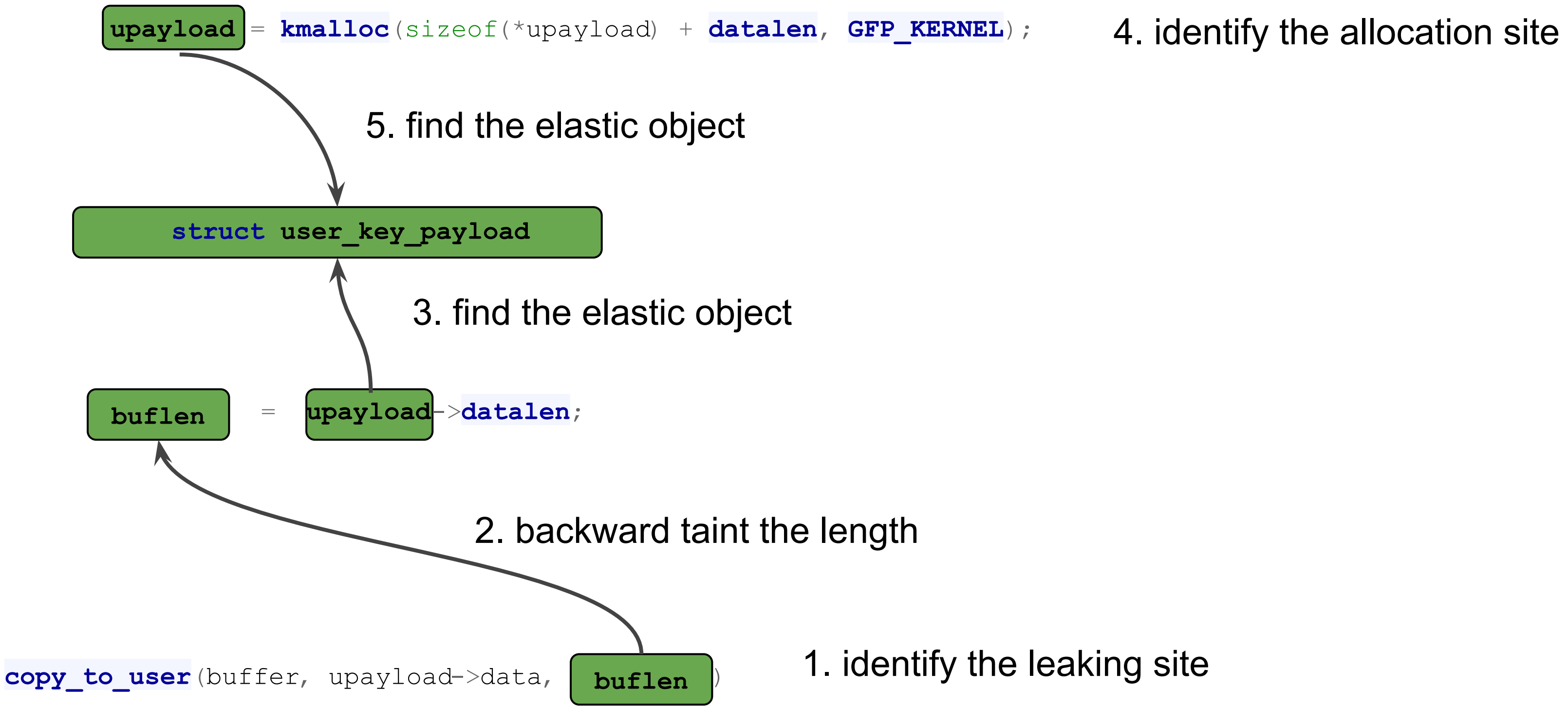
- Severity is obvious
  - Leaking kernel information from an overwrite primitive
- Generality is unknown
  - Pervasive object
  - Exploiting different vulnerabilities

Do we have the need to build defense?

Static Analysis



Static Analysis



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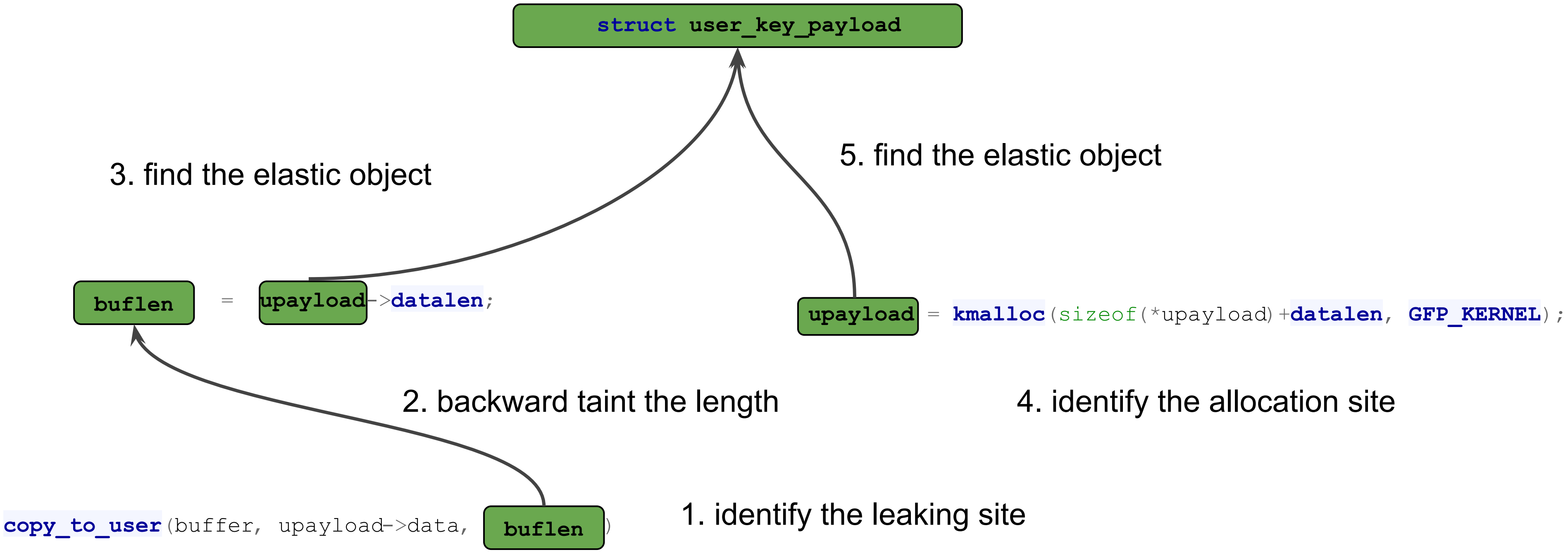


Experiment Setup and Results

- Select 3 commonly used open-sourced OSes
- Identify **38** structures in Linux, **16** structures in XNU, and **20** structures in FreeBSD

Experiment Setup and Results

- Select 3 commonly used open-sourced OSes
- Identify **38** structures in Linux, **16** structures in XNU, and **20** structures in FreeBSD
- Cover most of general caches/zones
- 18/74 structures are general cache/zone-flexible kernel structures

Effectiveness in Bypassing Mitigation

- 27/40 vulnerabilities are able to bypass not only KASLR but also heap cookies
- 12/40 vulnerabilities are able to uncover stack canary
- 8/40 vulnerabilities are able to exhibit the capability of performing arbitrary kernel read.

Elastic objects could nearly always facilitate a kernel vulnerability to bypass exploitation mitigation

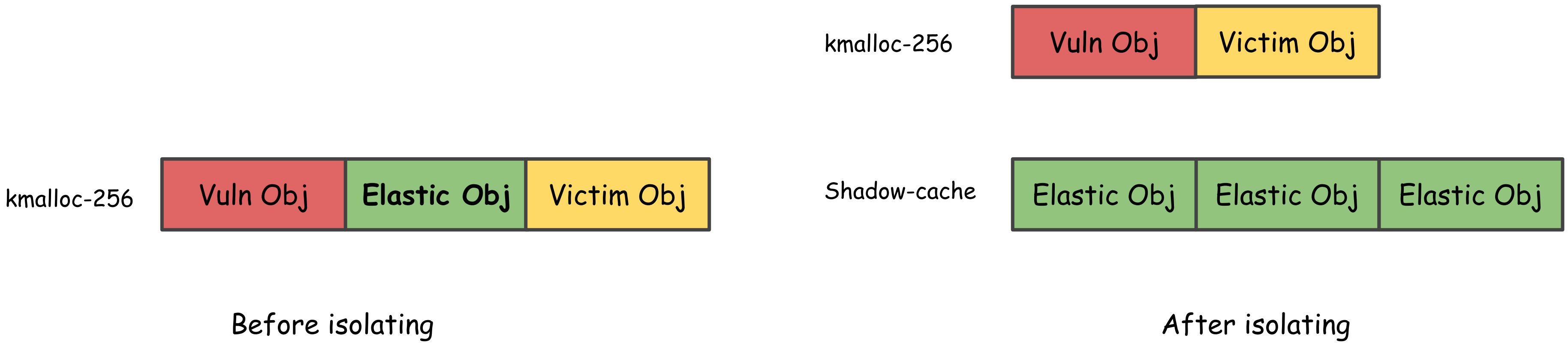
Defense

- Key idea: Isolating elastic objects into individual shadow caches/zones

Before isolating

Defense

- Key idea: Isolating elastic objects into individual shadow caches/zones



Defense Evaluation

- Performance overhead
  - The average performance drop is 0.19% on LMBench, Phoronix and our customized benchmark
- Security improvement
  - 29/31 vulnerabilities find no suitable elastic object
  - CVE-2017-7184, CVE-2017-17053: vulnerable objects are also elastic objects

Summary

- A systematic approach to finding out the elastic kernel objects
- An evaluation of the effectiveness of utilizing elastic kernel objects on 40 kernel vulnerabilities across three OSes
- A new defense mechanism to mitigate the threat of elastic kernel objects
- An evaluation of the defense mechanism in terms of performance overhead and security improvement

Thank You !

Code & Data

https://github.com/chenyueqi/w2l

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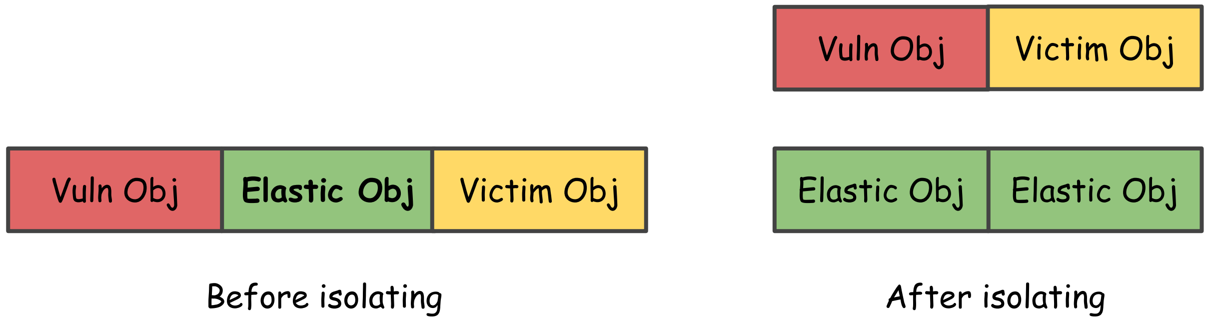
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