TU Graz
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KernelSnitch

Side-Channel Attacks on Kernel Data Structures

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NDSS 2025

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About

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  - Different access timings of kernel data structures

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  - Website fingerprinting with F_1 of 89.3 %
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  - Kernel heap pointer leak in under 65 s
- Opensource our artifacts on:
  - https://github.com/IAIK/KernelSnitch

Motivation & Background

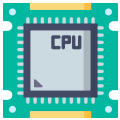
Motivation

Hardware

Application

Motivation

Hardware



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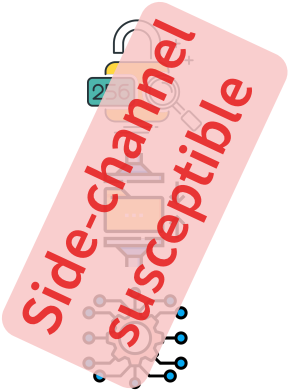

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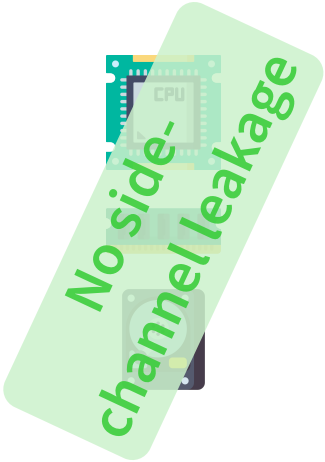

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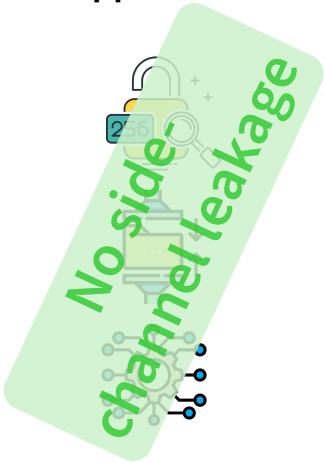

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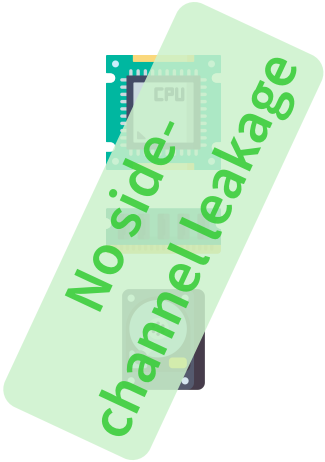

Operating System

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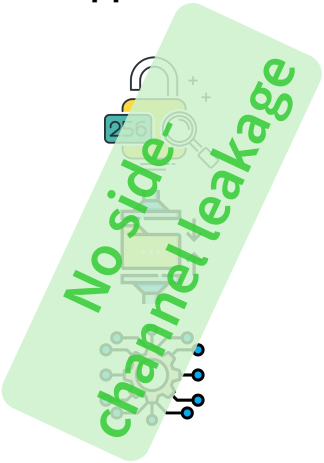

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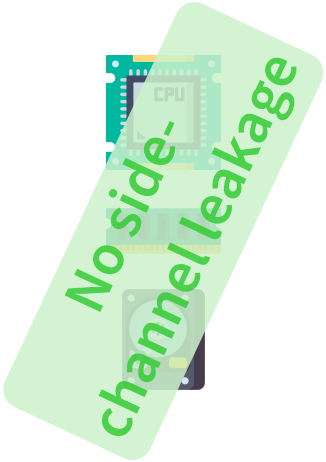
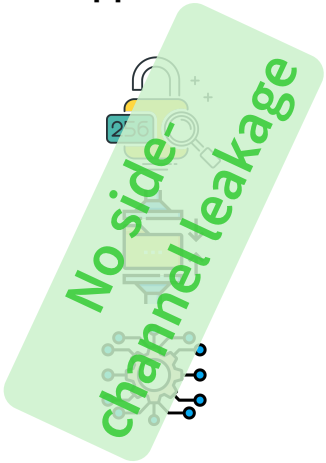


Operating System

Research sparse

Application



Linked Lists

Empty list

List with
2 elements

List with
5 elements

Linked Lists

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Fast access

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Medium fast access

Linked Lists

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Fast access

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Slow access

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[1] This presentation only covers hash tables. For other data structures, see paper.

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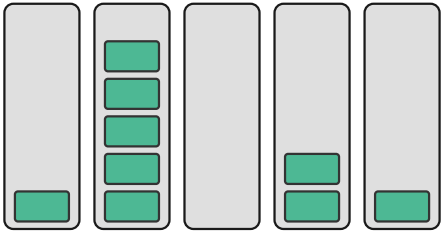

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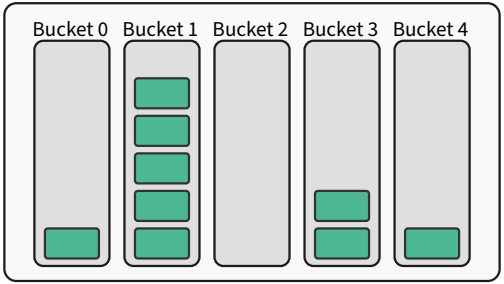

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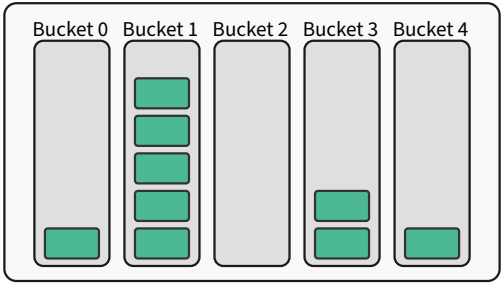

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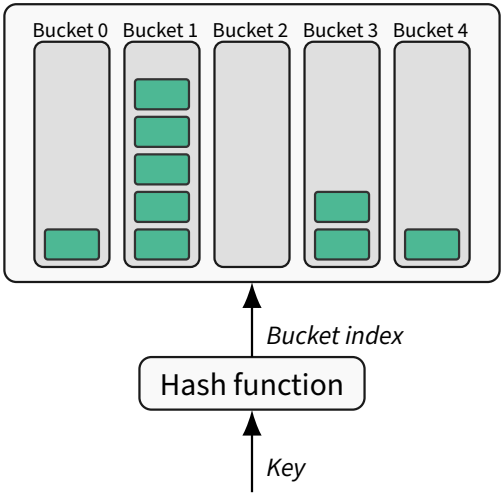

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KernelSnitch

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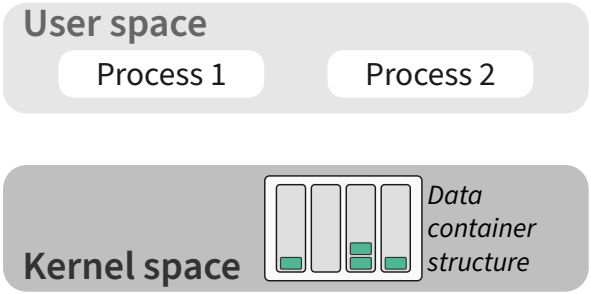

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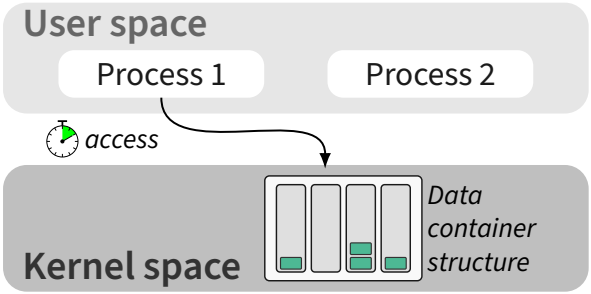

Process 1 $\rightarrow$ syscall accesses the data structure

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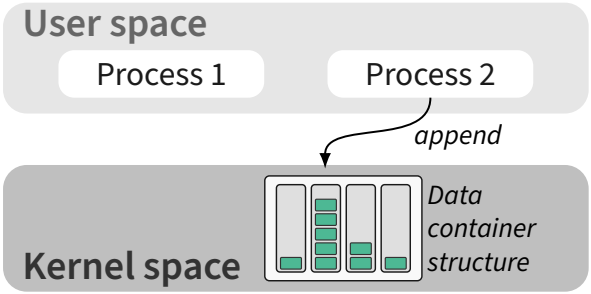

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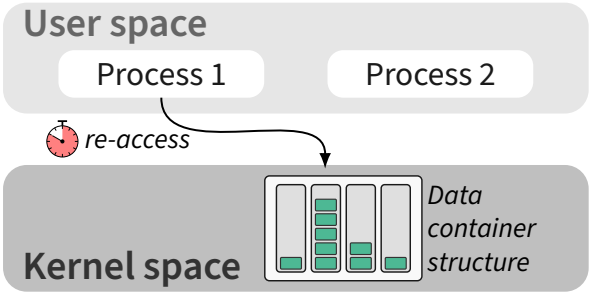

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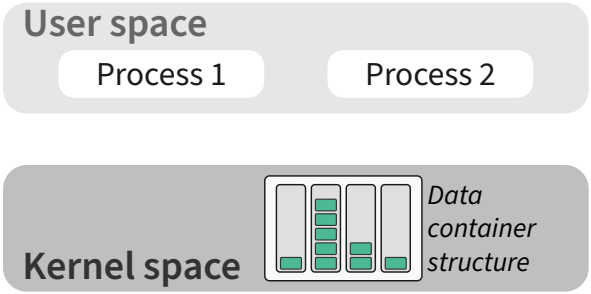

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Deduce security-critical information

Primitives

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Access primitive

Append/remove primitive

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- Such as:

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Timing Differences Histogram

Access randomly selected buckets[2]

- Repeat 4096 accesses
- Buckets between 0 and 5 timers

[2] Applied information leakage amplification, see paper.

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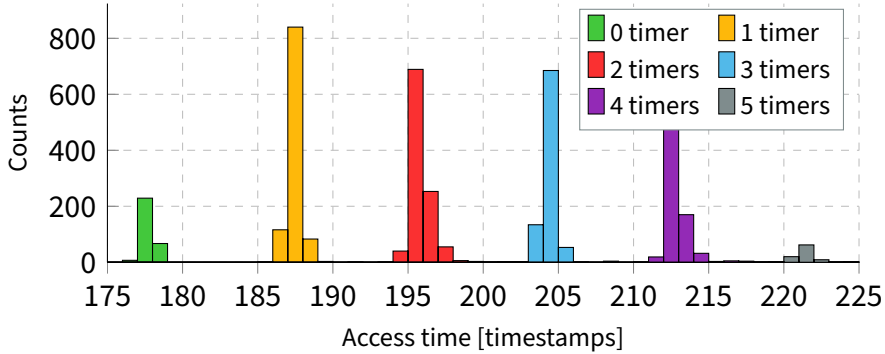

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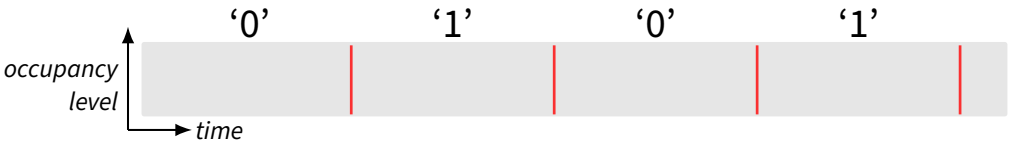
Attacks

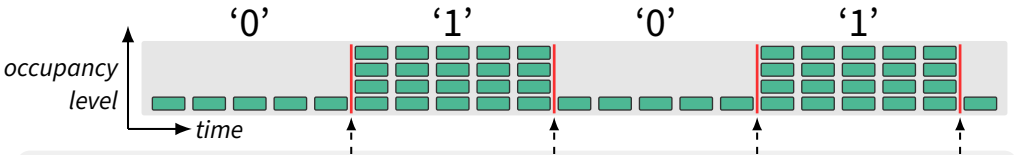
Covert Channel



Sender:

Receiver:

Covert Channel



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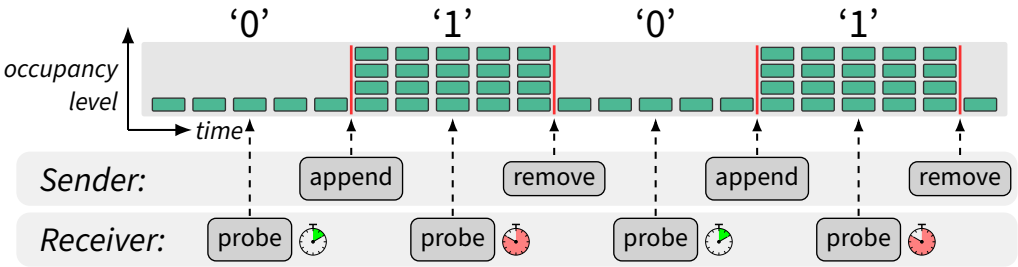

Performance of Covert Channel

Vary time slice

- Determine raw capacity and BER
- Calculate true capacity

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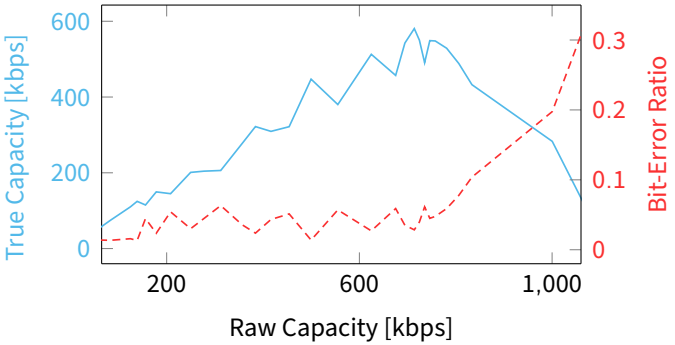
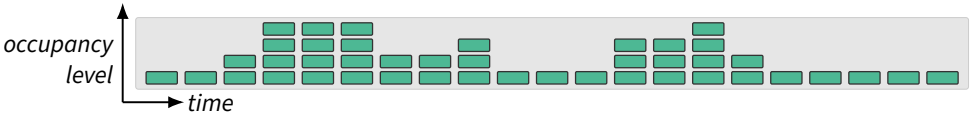
- True capacity up to 580 $\mathrm{kbit\,s^{-1}}$



Website Fingerprinting



Browser:

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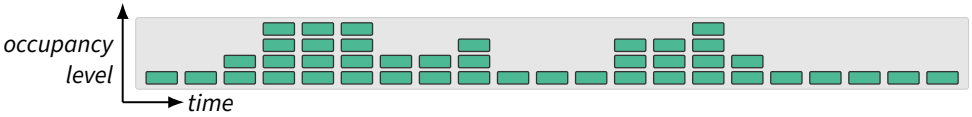

Browser: Appends/removes when accessing a website ...

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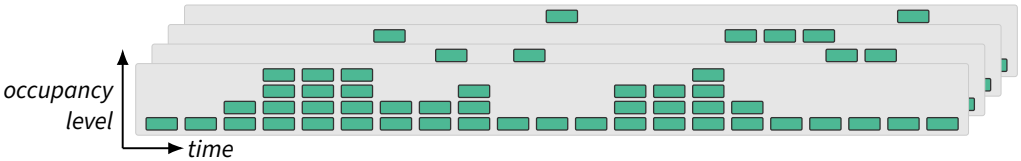

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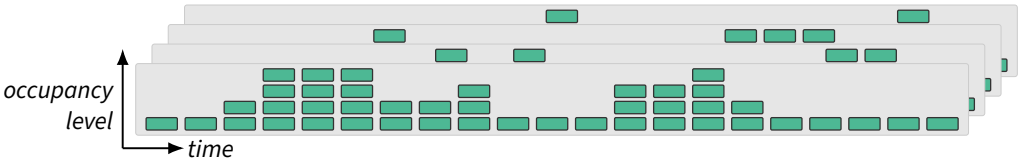
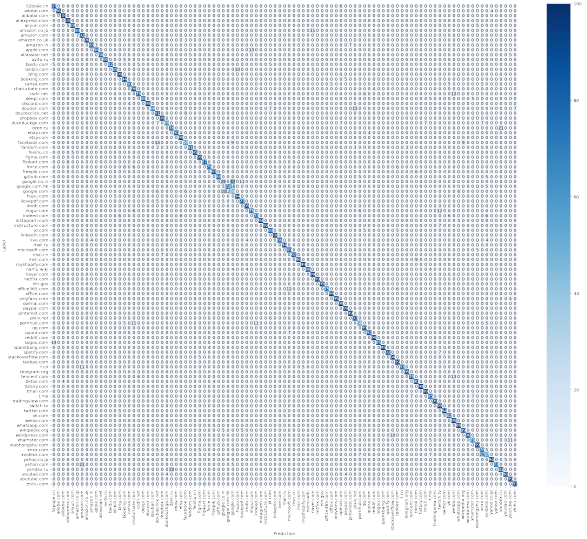


Browser:	Appends/removes when accessing a website for all buckets.
Spy:	Probes all buckets.

Confusion Matrix of Website Fingerprinting



Top 100 websites

- Use Convolutional Neural Network (CNN)
- F_1 score of 89.3 %

Kernel Heap Pointer Leak

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Bruteforce (offline phase):

- Test all possible `kaddrs`
- Match hash collisions

Kernel Heap Pointer Leak of `mm_struct`

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- Less than 65 s

Mitigations & Conclusion

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- **Still exploitable to this day!**

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- **We showed three attacks**
  - Covert channel
  - Website fingerprinting
  - Kernel heap pointer leak

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KernelSnitch

Side-Channel Attacks on Kernel Data Structures

Lukas Maar Jonas Juffinger Thomas Steinbauer Daniel Gruss Stefan Mangard

Graz University of Technology, Austria

NDSS 2025

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