The Spy in the Sandbox: Practical Cache Attacks in JavaScript and their Implications

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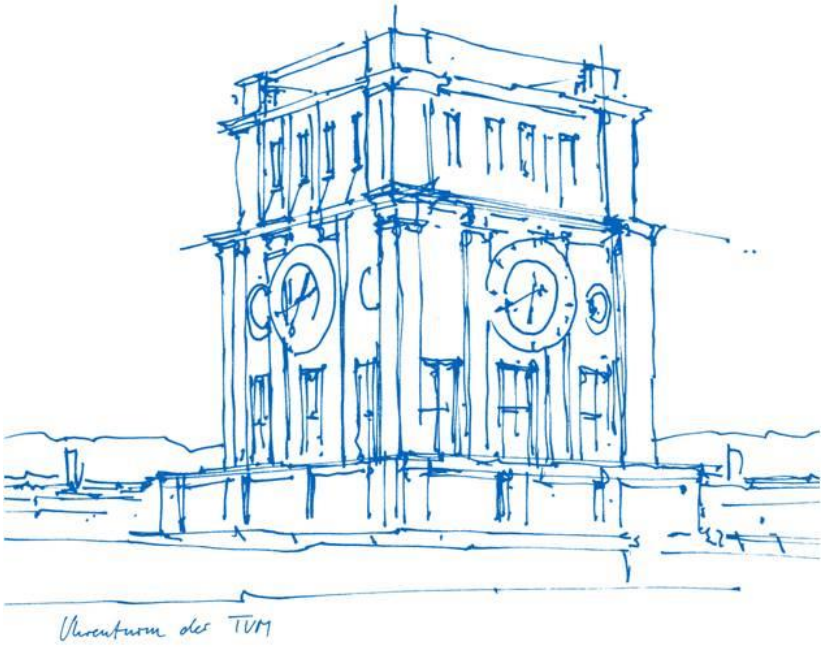
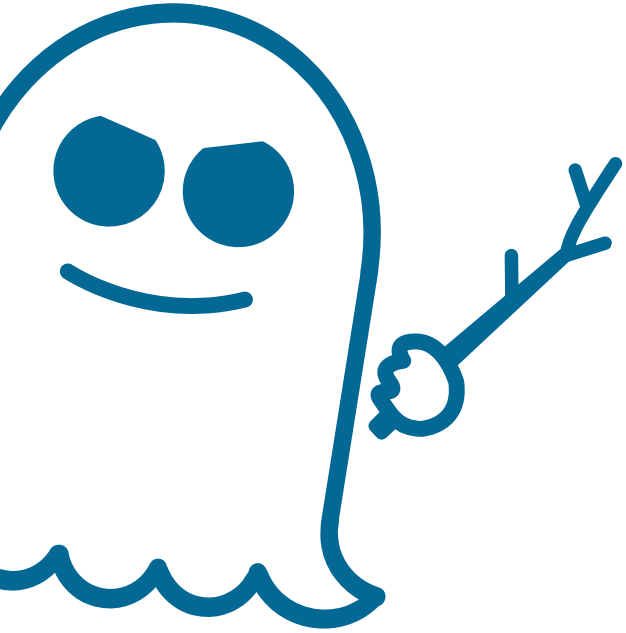


Overview

- Side Channel Attacks
- Cache Hierarchy
- Cache Attacks
- … in JavaScript
- Attacking Privacy
- Discussion

Side Channel Attacks

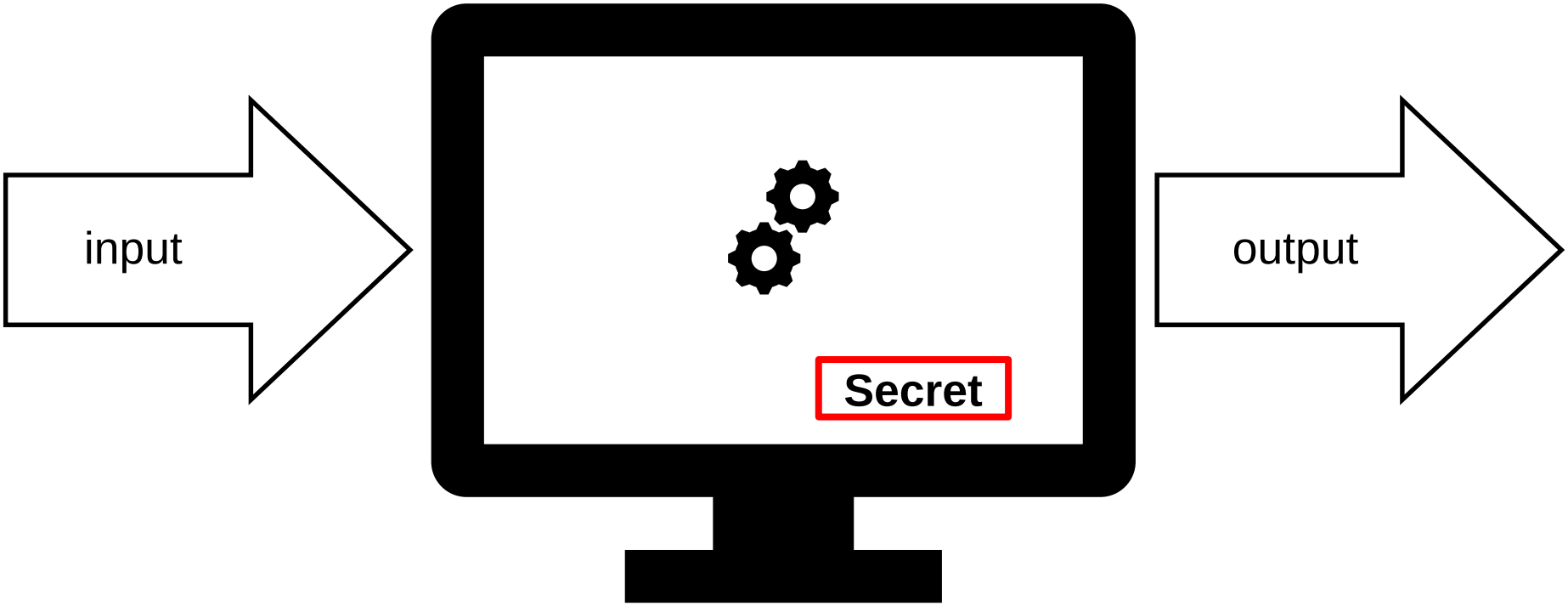


RSA

AES

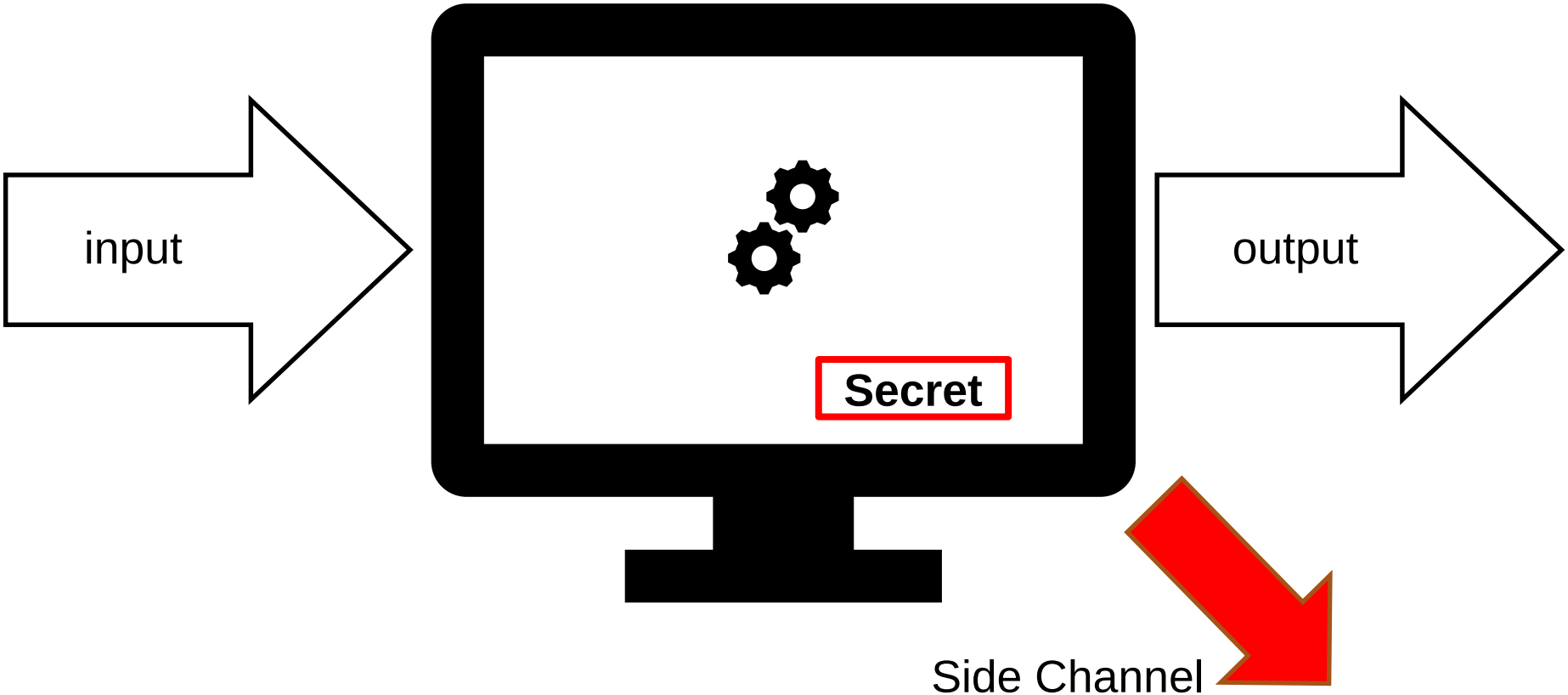
Source: https://meltdownattack.com/

Side Channel Attacks



Inspired by: https://youtu.be/hKw_vxtSNaU?t=2m52s

Side Channel Attacks



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Side Channel Attacks – Problem

Physical proximity to victim

- Install hardware device
- Run code on same machine

Possible scenarios?

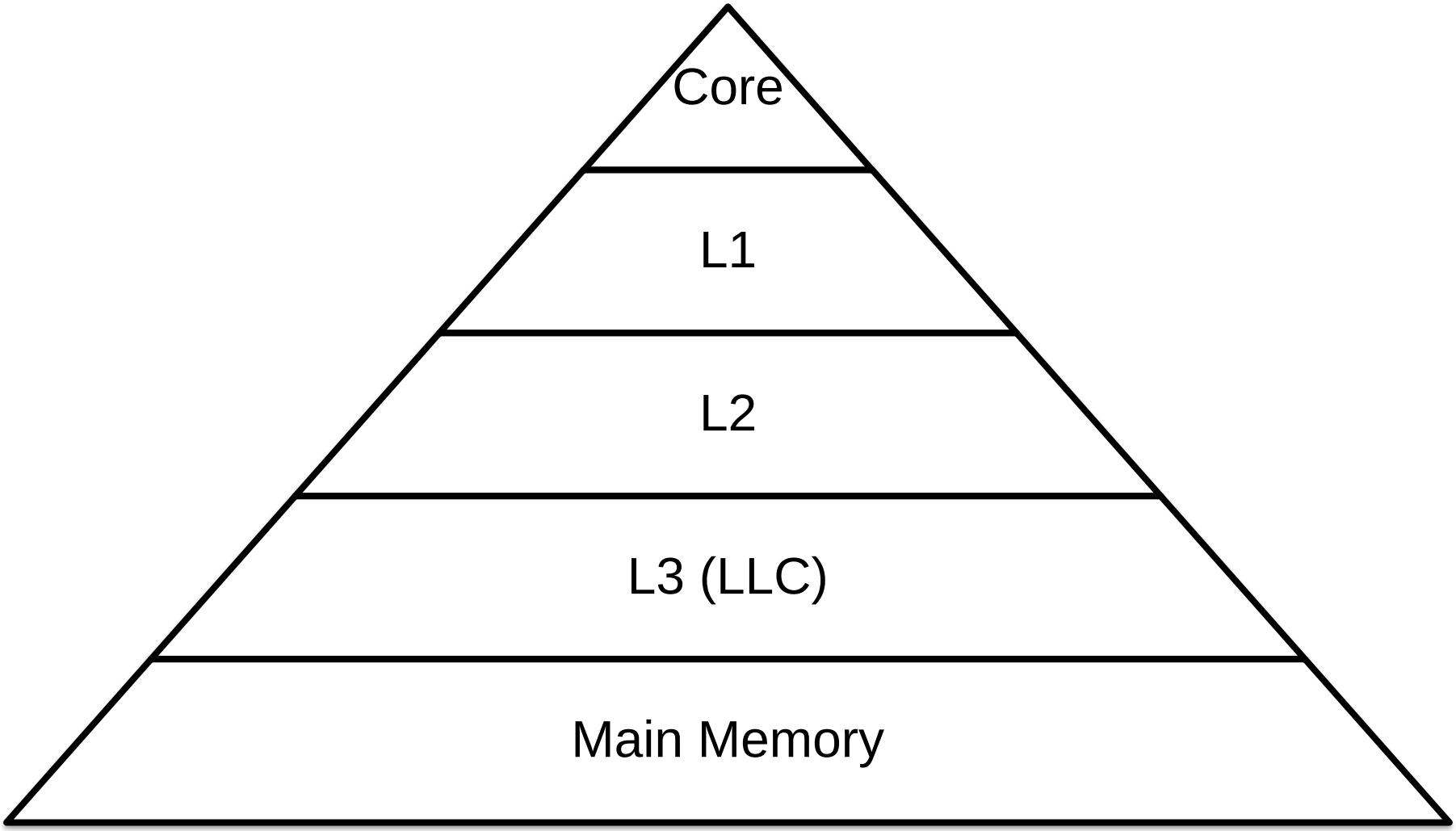
➢ Cloud computing

Side Channel Attacks – Problem

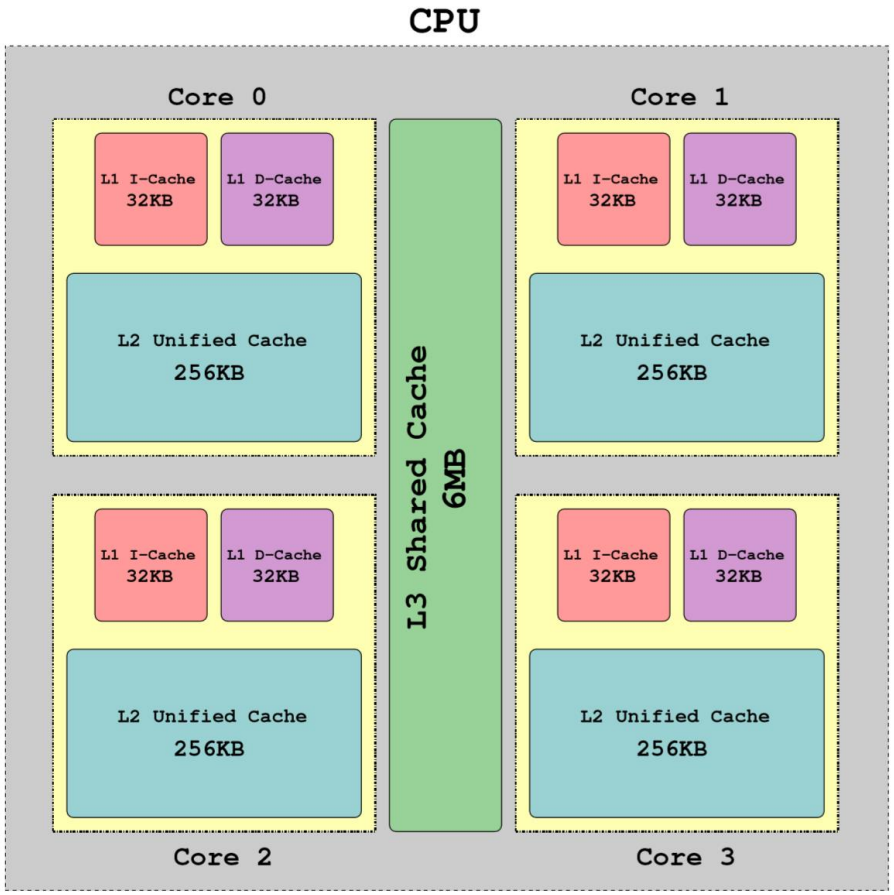
We want more!

- Reach millions of people over the Internet

Cache Hierarchy



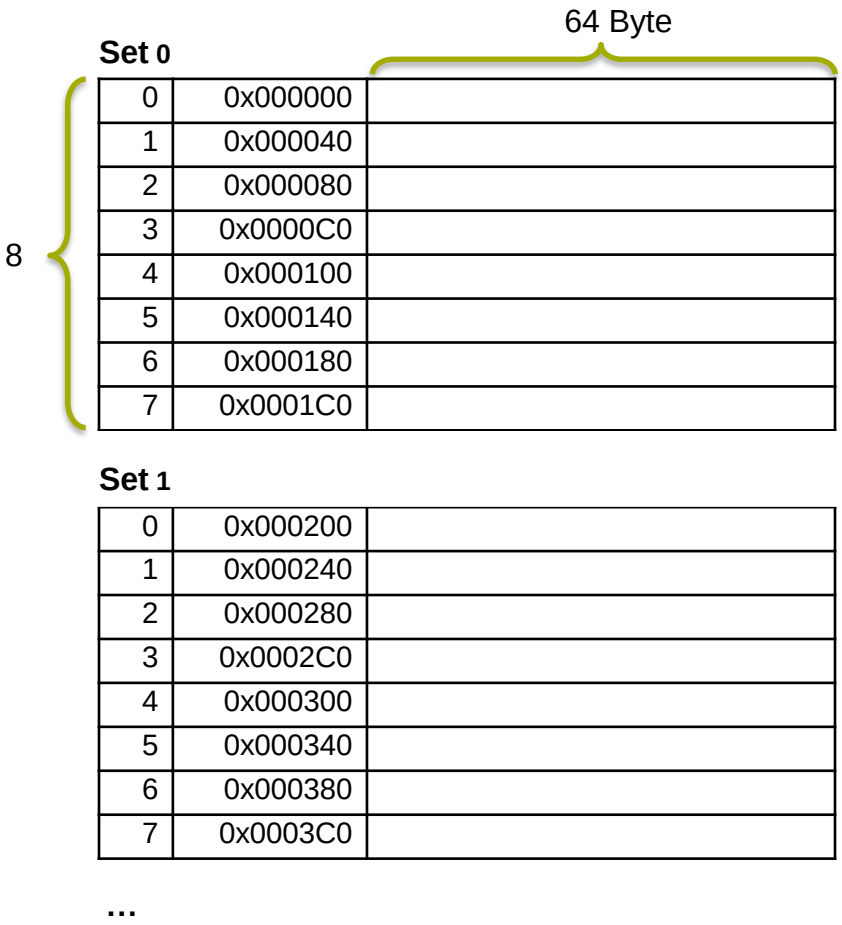
Cache Hierarchy



- Inclusive / exclusive
- Cache miss
- Cache line replacement

Source: “The Spy in the Sandbox: Practical Cache Attacks in JavaScript and their Implications”, Oren et al. 2015

Cache Hierarchy – Cache Set

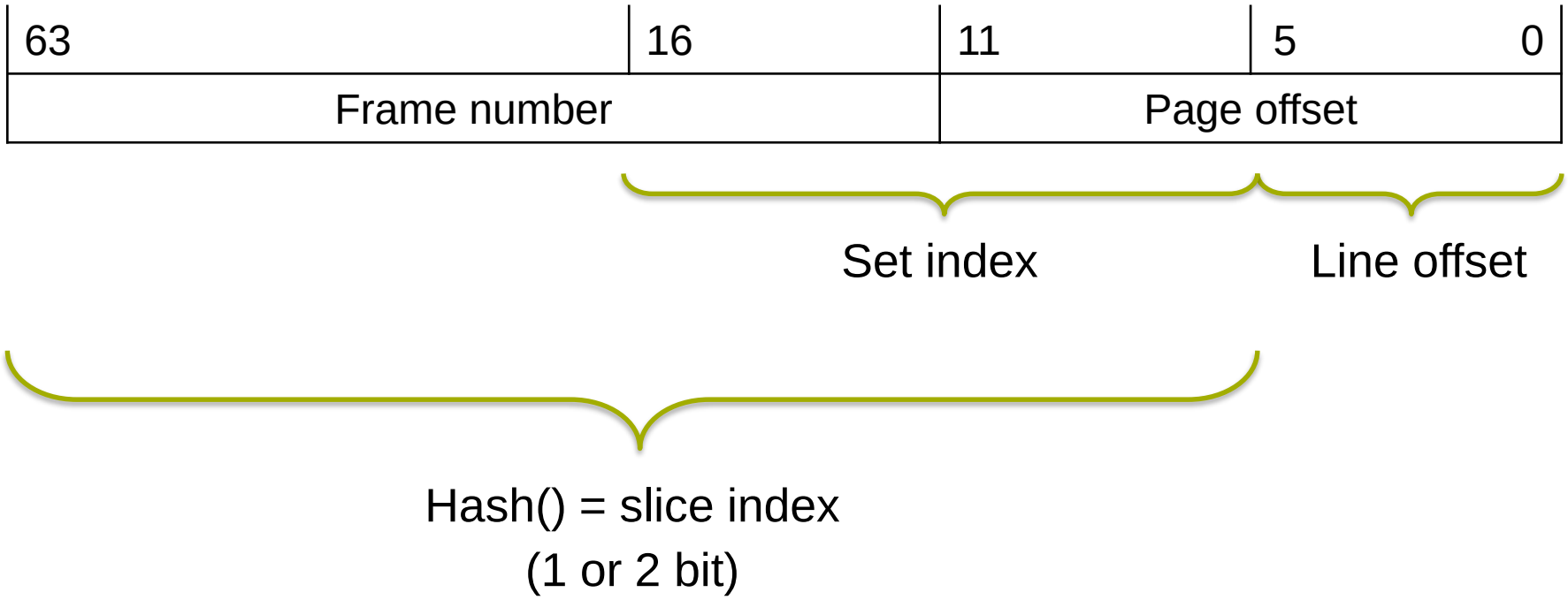


- Line 64B
- Set n-way associative
- Slice 1 per core

Question:
How do you map the addresses to a cache set?

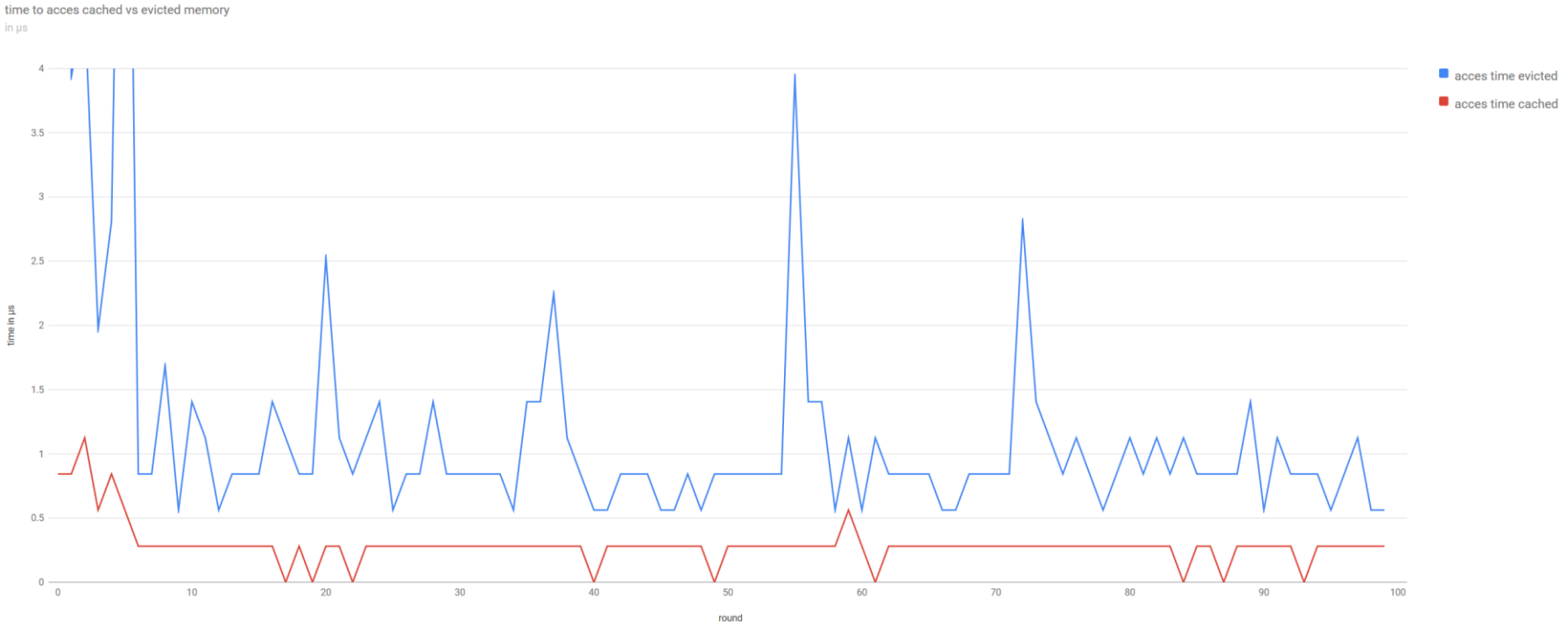
Example – Sandy Bridge

64b Physical address



Source: “Practical Timing Side Channel Attacks Against Kernel Space ASLR”, Hund et al. 2013

Cache Hierarchy



Cache Attacks

- EVICT+TIME
- FLUSH+RELOAD
- PRIME+PROBE

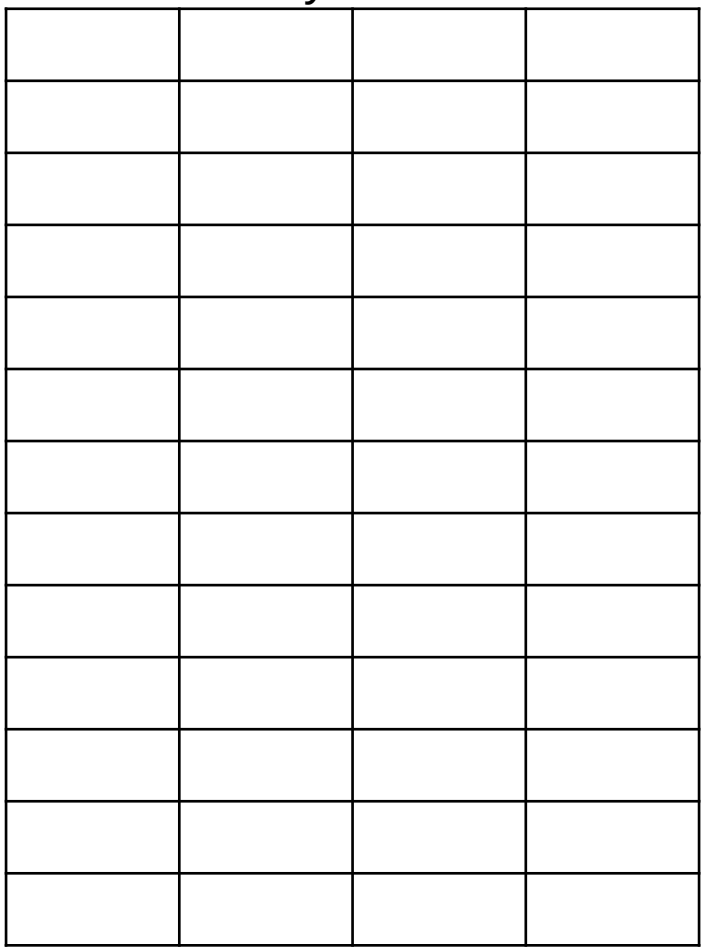
Cache Attacks – PRIME+PROBE

- Eviction set
- 4 steps
  - Create eviction set
  - Prime cache set
  - Trigger victim op
  - Probe cache set

Cache Attacks – PRIME+PROBE

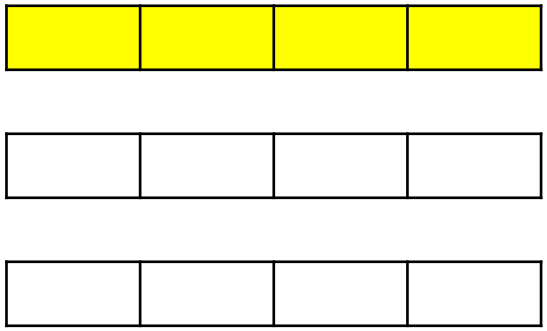
Cache Sets

Virtual Memory



Cache Attacks – PRIME+PROBE

Cache Sets



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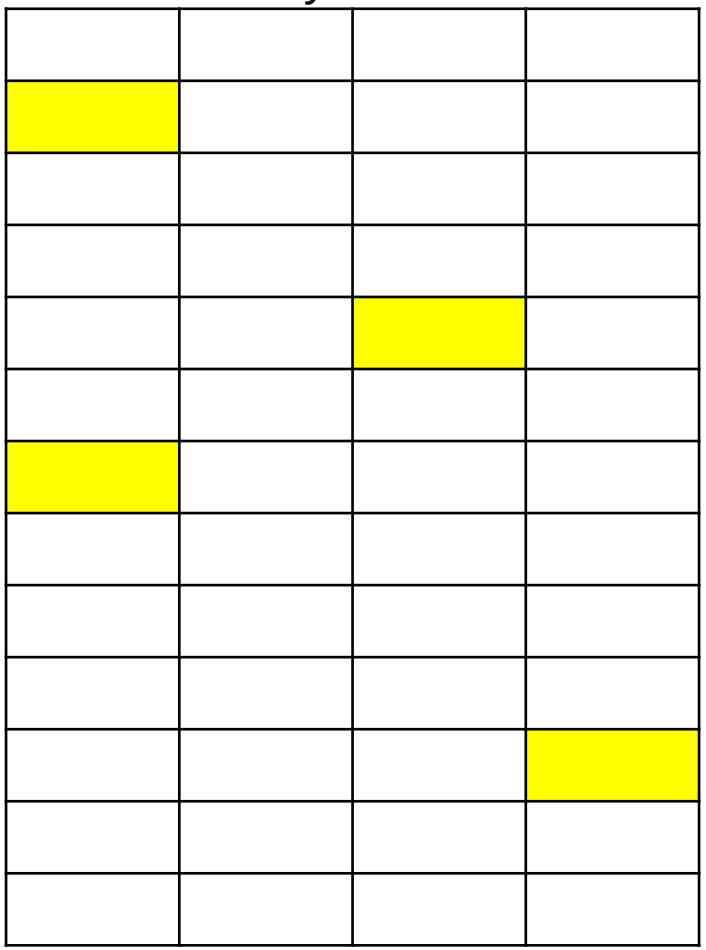
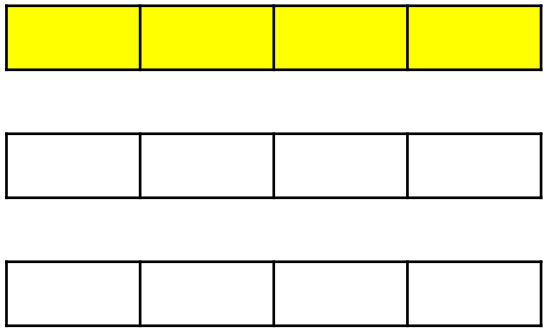


Cache Attacks – PRIME+PROBE

Cache Sets



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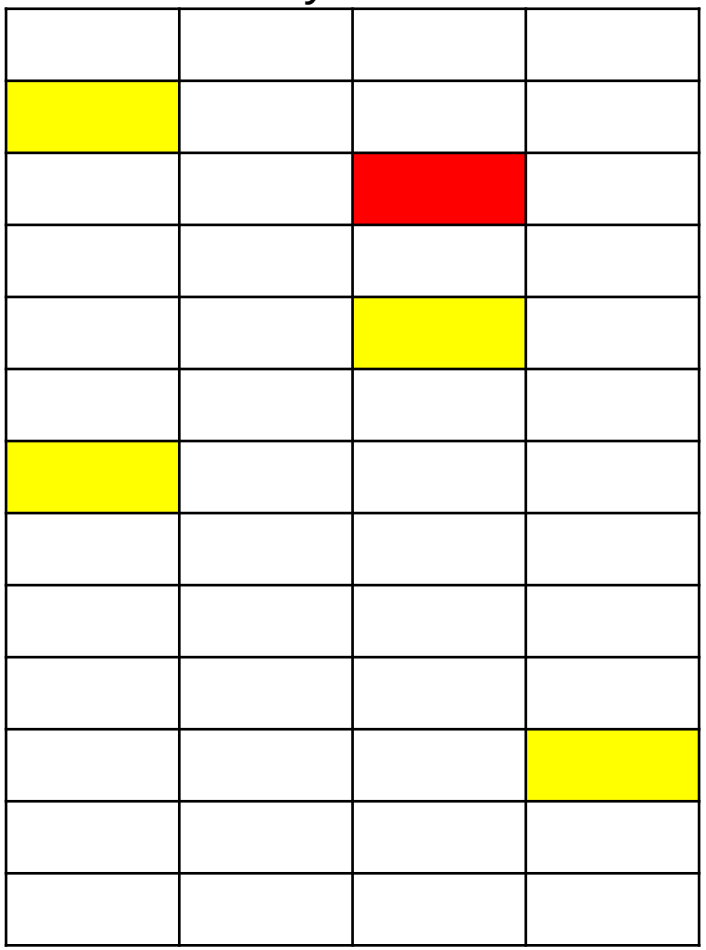
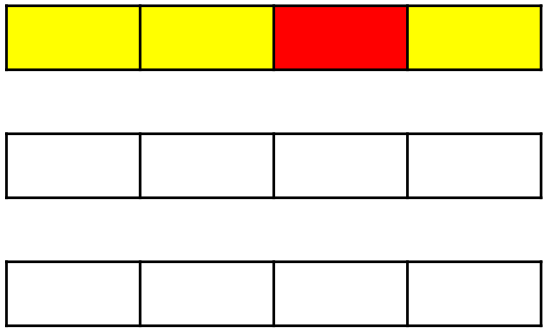
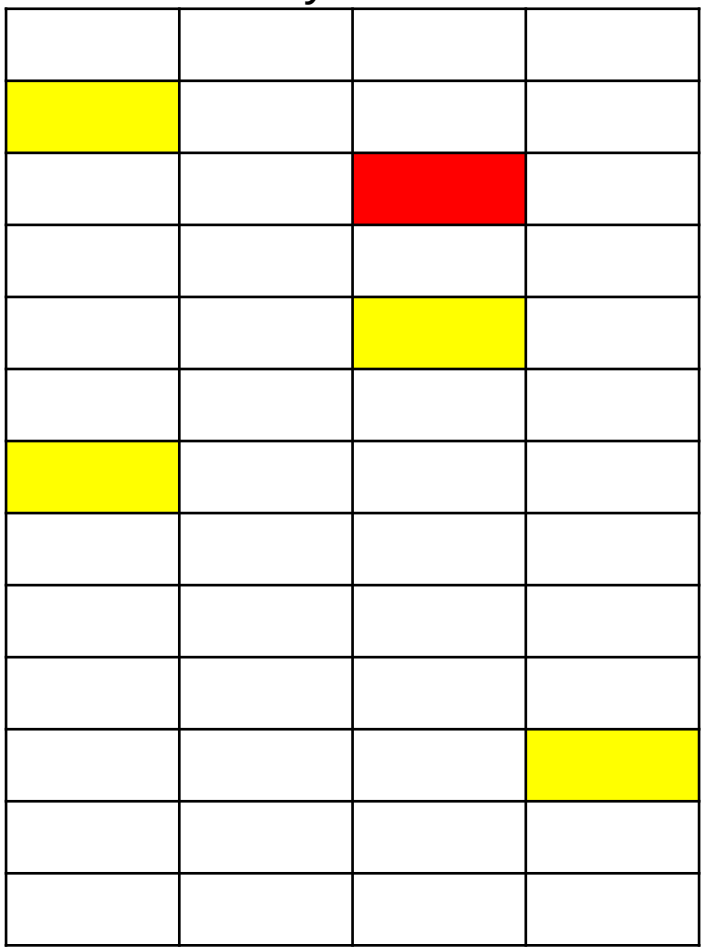


Cache Attacks – PRIME+PROBE

Cache Sets

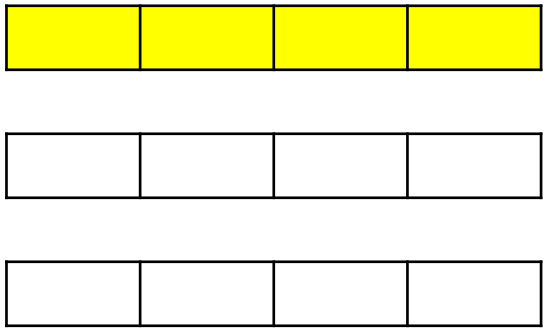


Virtual Memory

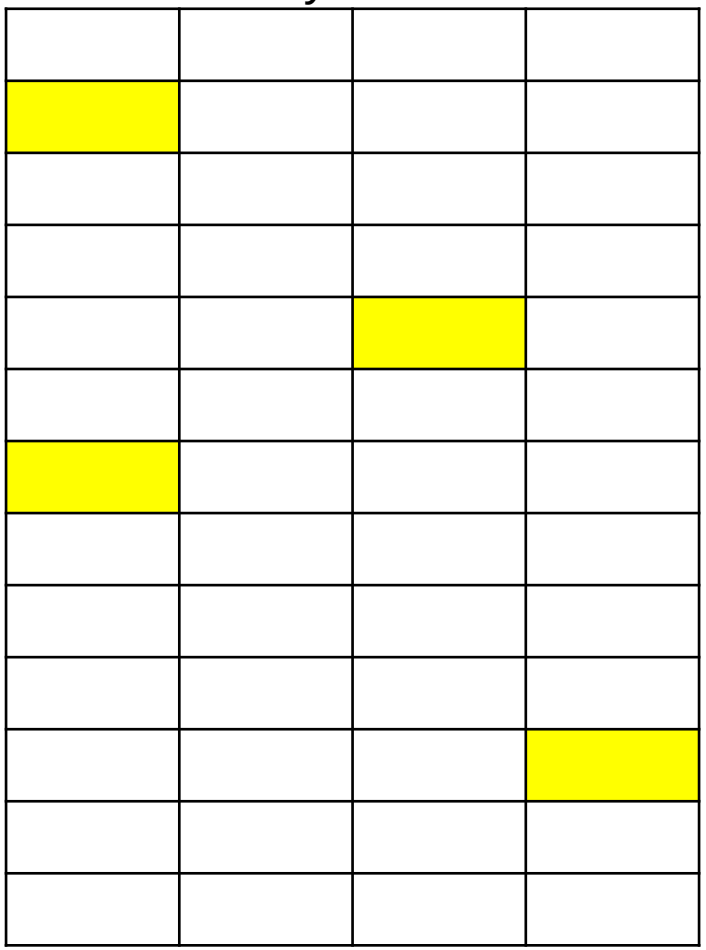


Cache Attacks – PRIME+PROBE

Cache Sets



Virtual Memory



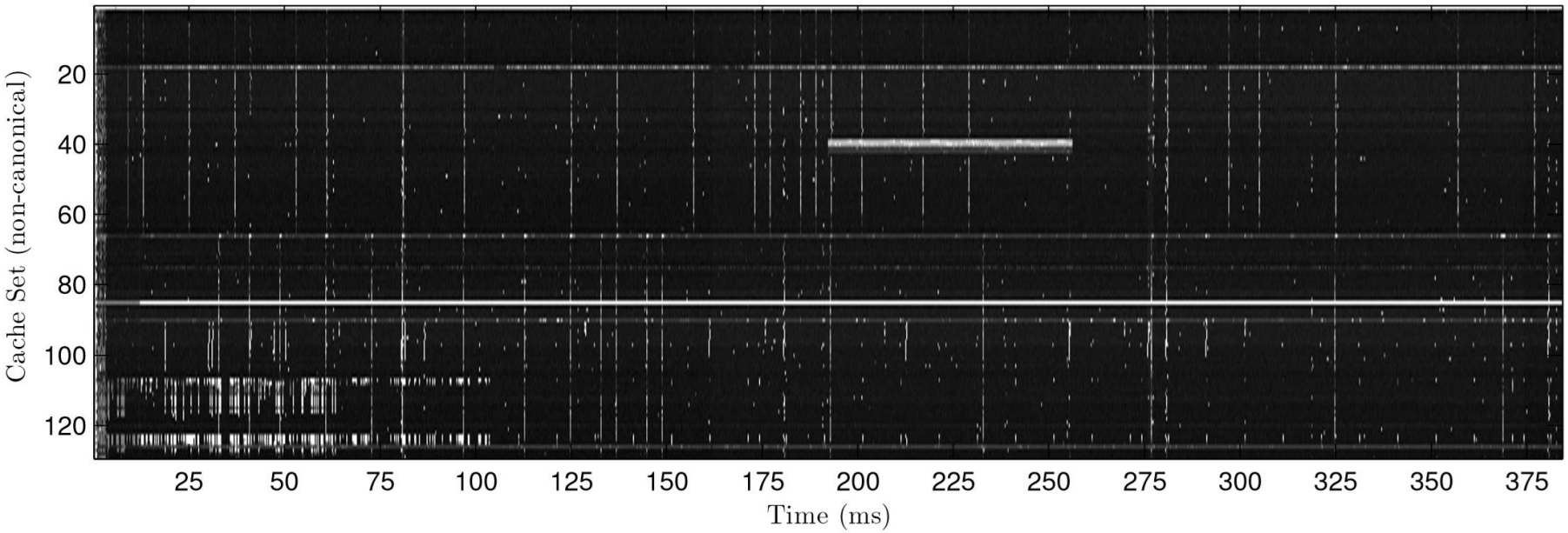
… in JavaScript

- No direct memory access
- No pointers
- No syscalls

… in JavaScript

- But:
  - High resolution Time API (nanoseconds)
  - Typed Arrays

Cache Attacks in JavaScript



Source: “The Spy in the Sandbox: Practical Cache Attacks in JavaScript and their Implications”, Oren et al. 2015

Cache Attacks in JavaScript

Bandwidth

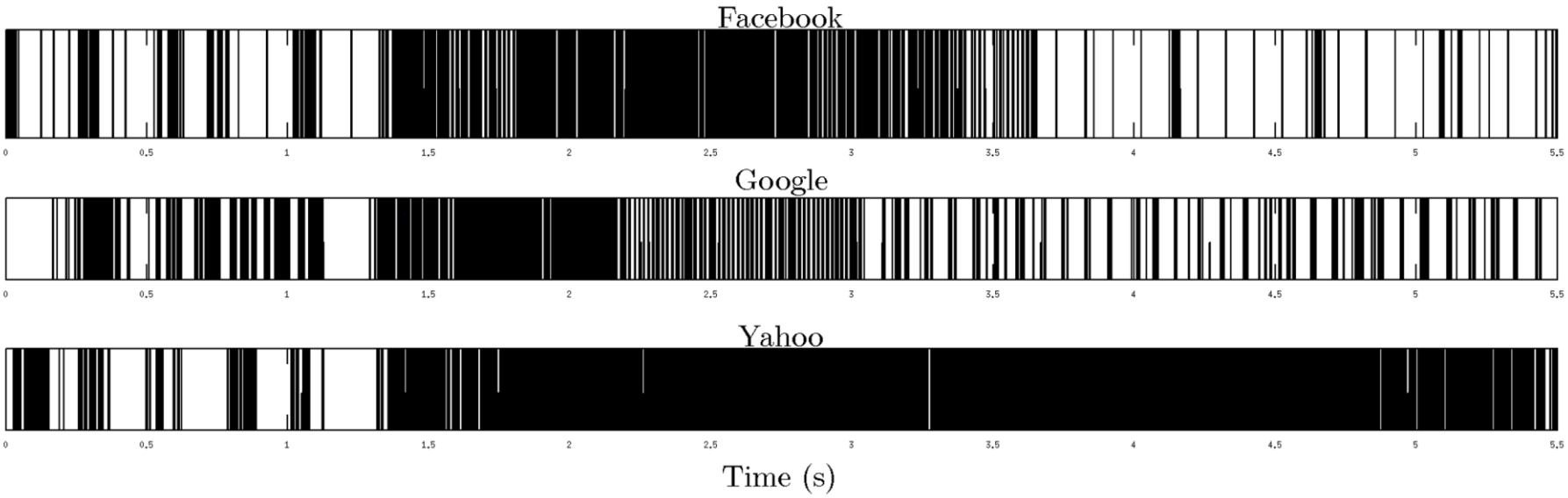
- 4KB array
- 64 cache sets -> 64 bit
- JavaScript: 320 kb/s *
- Native: 1.2 mb/s *

(*) Source: “The Spy in the Sandbox: Practical Cache Attacks in JavaScript and their Implications”, Oren et al. 2015

Attacking Privacy

- Track user browsing behavior
- Across separate browsers (even TOR)
- Use hardware related events (mouse, …)

Attacking Privacy



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Attacking Privacy

1. Find eviction sets
2. Train
3. Measure
4. Classify (mean value of Fourier Transform)

Discussion

- Accuracy:
  - 82.1% for Safari *
  - 88.6% for Tor *
- Noise

(*)Source: “The Spy in the Sandbox: Practical Cache Attacks in JavaScript and their Implications”, Oren et al. 2015

Discussion

- Who is affected?

- Countermeasures
  - Decreasing timer accuracy or restricting access
  - Fuzzing
  - Inclusive to exclusive
  - Changing cache design

Future Work

- Workaround for timer accuracy
- Save cache?

Conclusion

- Keep side channel attacks in mind
- do not leave unused browser tabs open
- disable JavaScript