Prime+Probe 1 – JavaScript 0

Overcoming Browser-based Side-Channel Defenses

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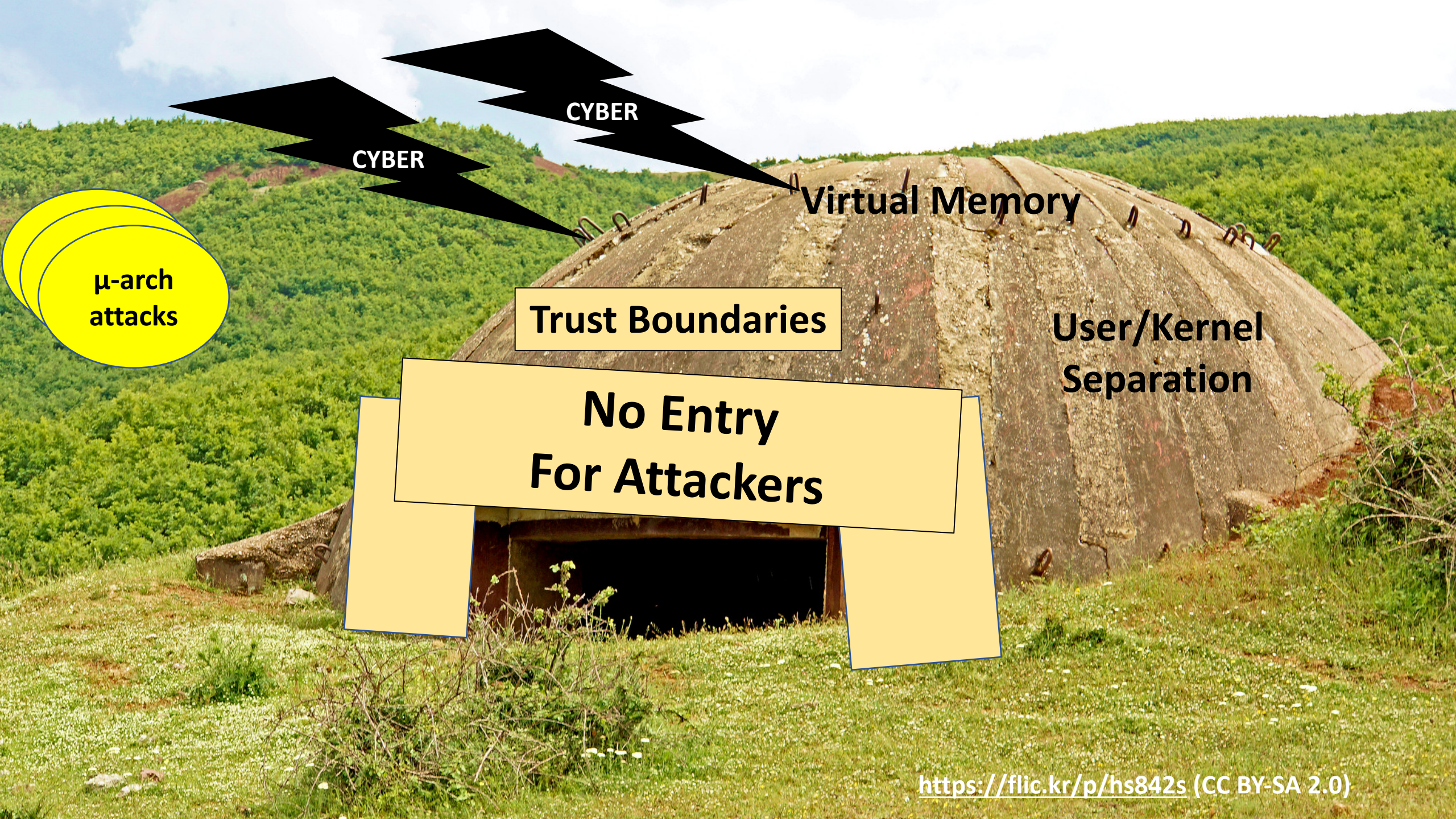

Prime+Probe

CPU

Last Level Cache

Main Memory

Prime+Probe

Ingredients:

Array buffer-memory map

Nano_second-Timer

Covert Channel

Private-Key Retrieval

The Spy in the Sandbox – Practical Cache Attacks in Javascript

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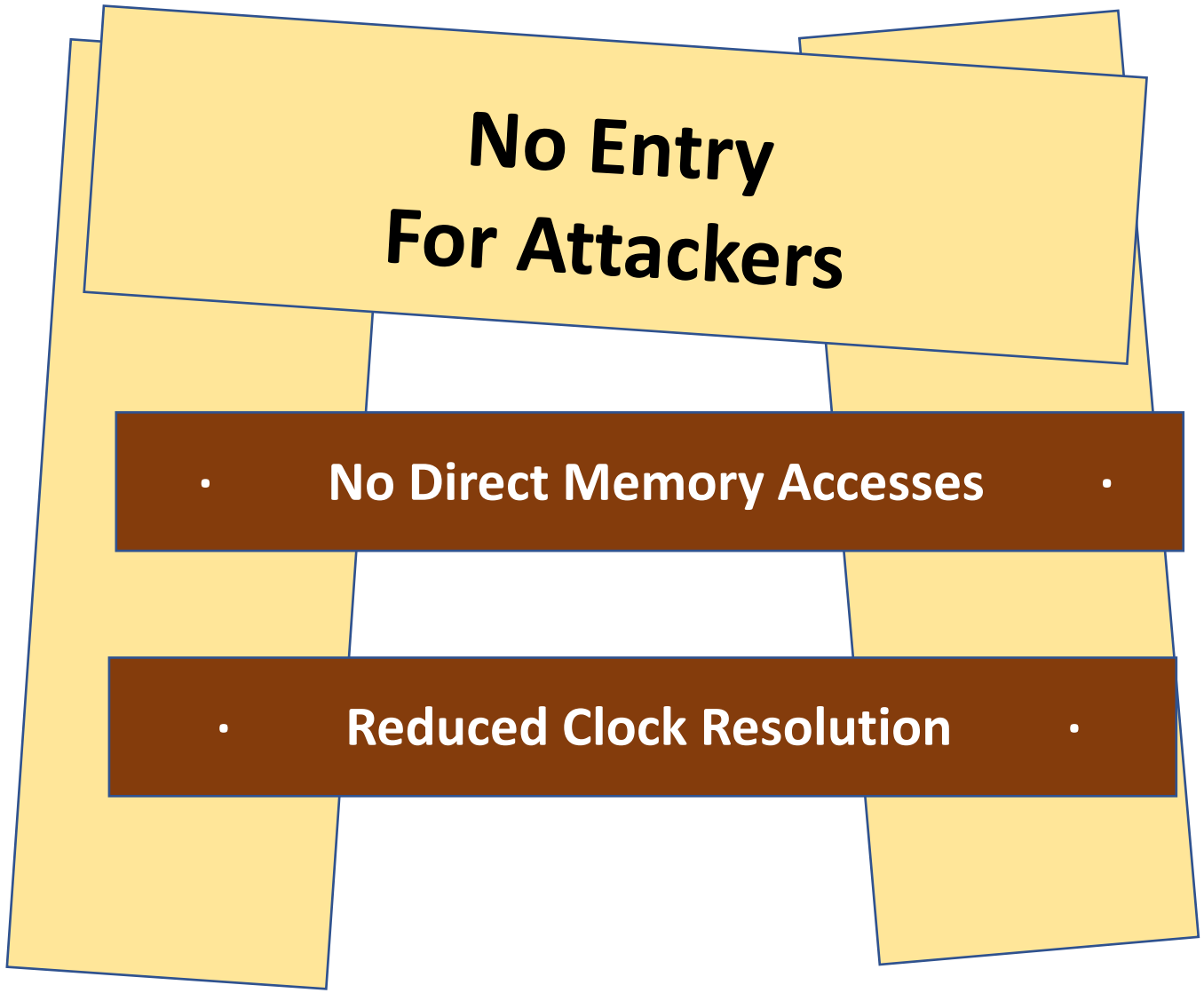
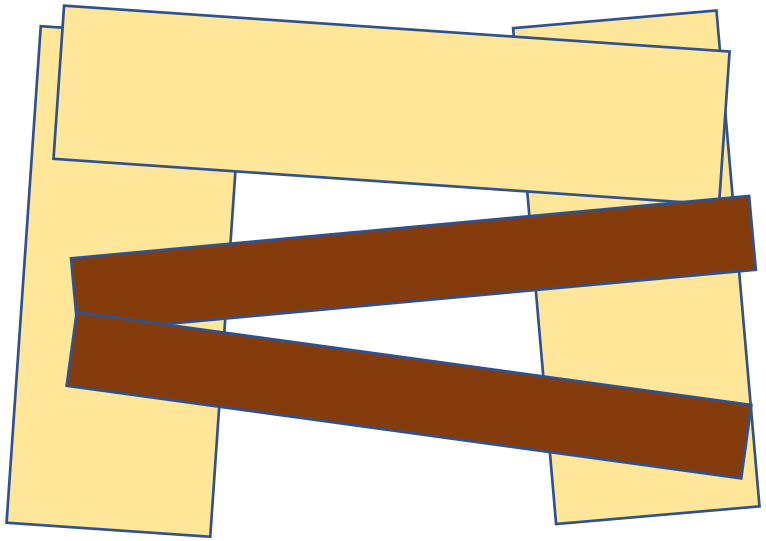

No Entry
For Attackers
No Direct Memory Accesses
Reduced Clock Resolution

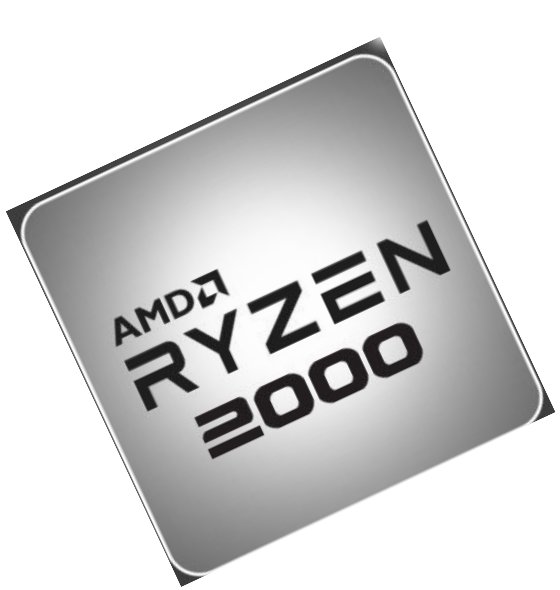
Our Research Questions

- RQ1: What are the minimal requirements for µ-architectural side-channel attacks in browsers?



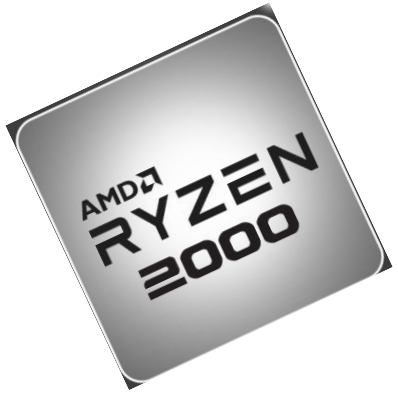
Our Research Questions

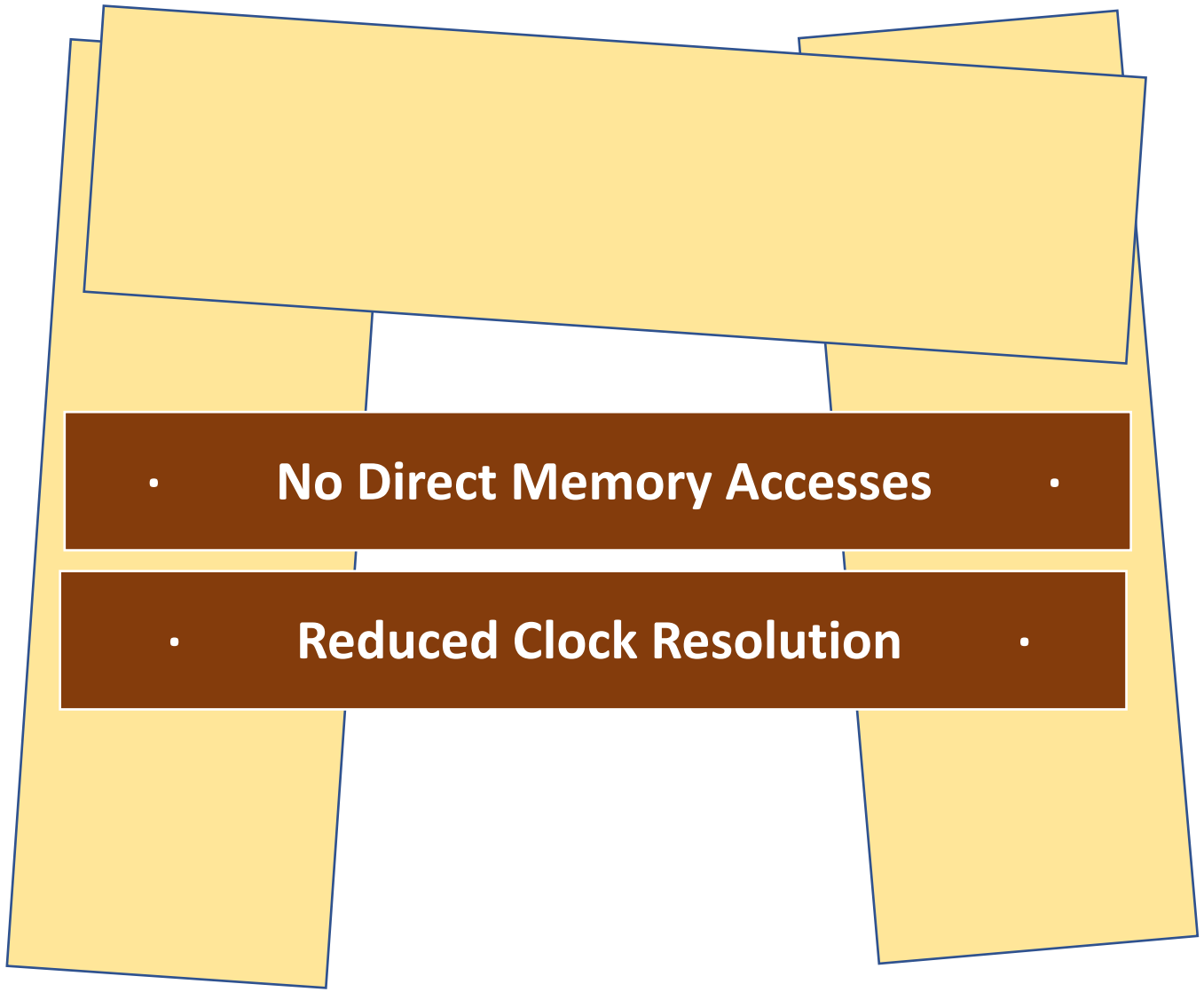
- RQ2: Can processor diversity prevent side-channel attacks?



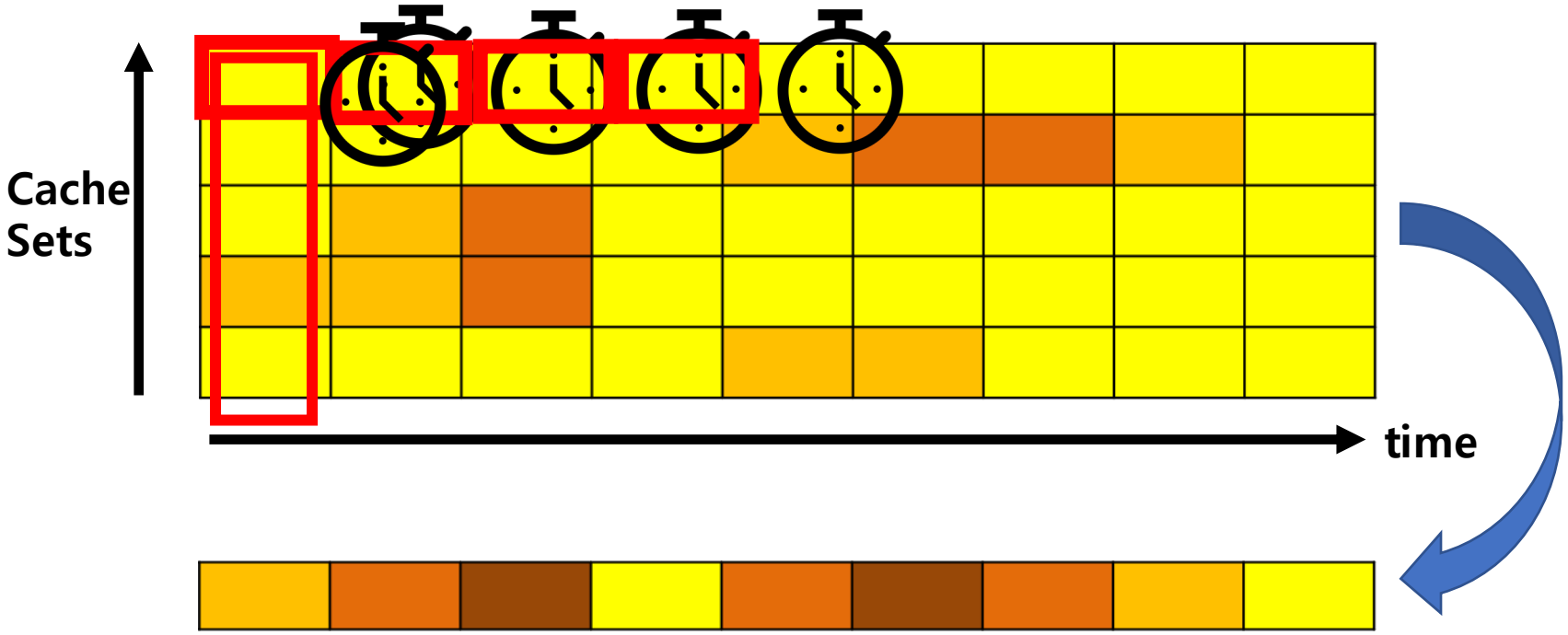
Contributions

- RQ1: End-to-end of remote cache attacks with no timers , no arrays, and no JavaScript
- RQ2: An architecturally-agnostic attack that works on ARM, AMD, Intel and Apple M1

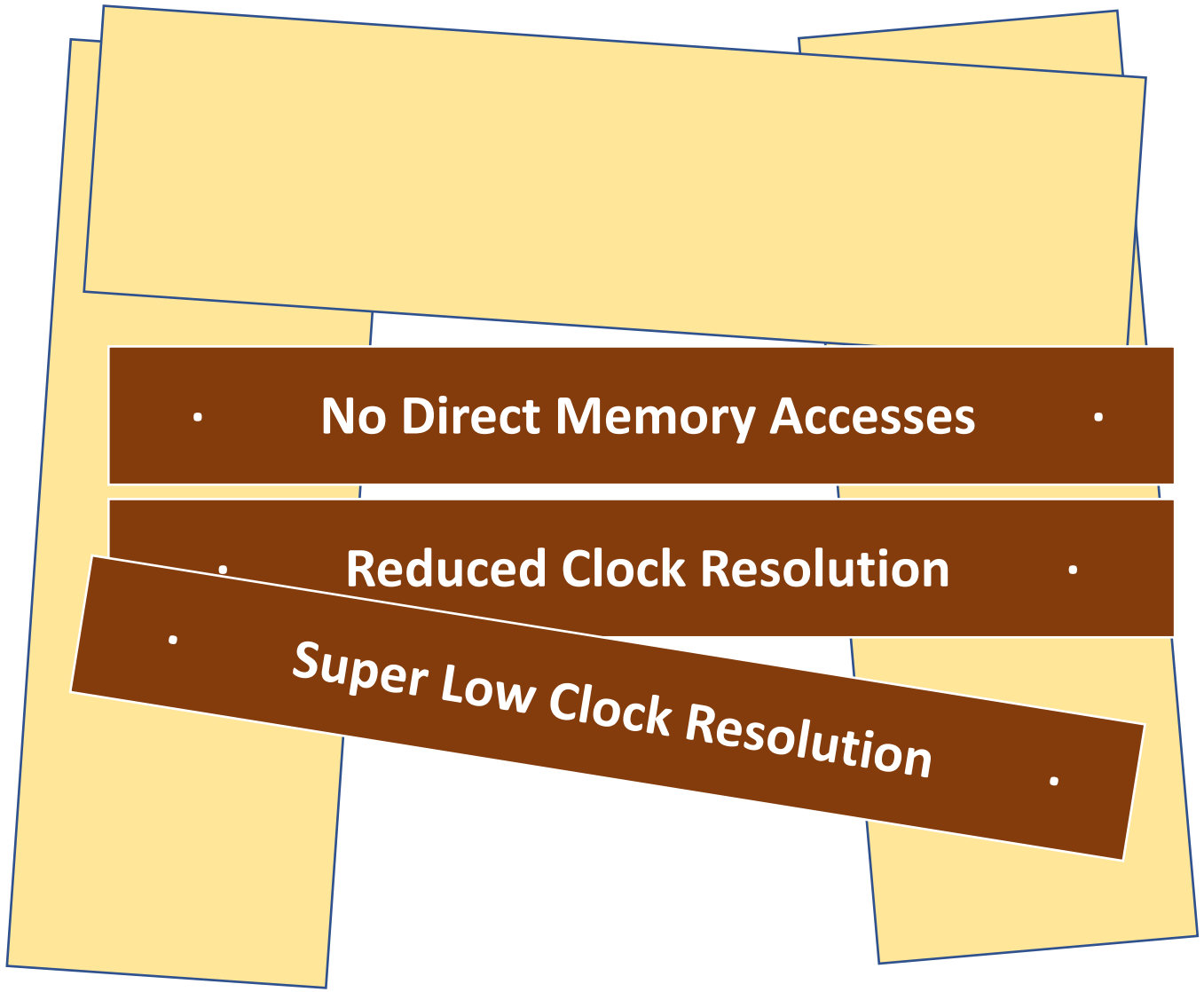



No Direct Memory Accesses
Reduced Clock Resolution

Attack 1: Cache Occupancy [S+19]

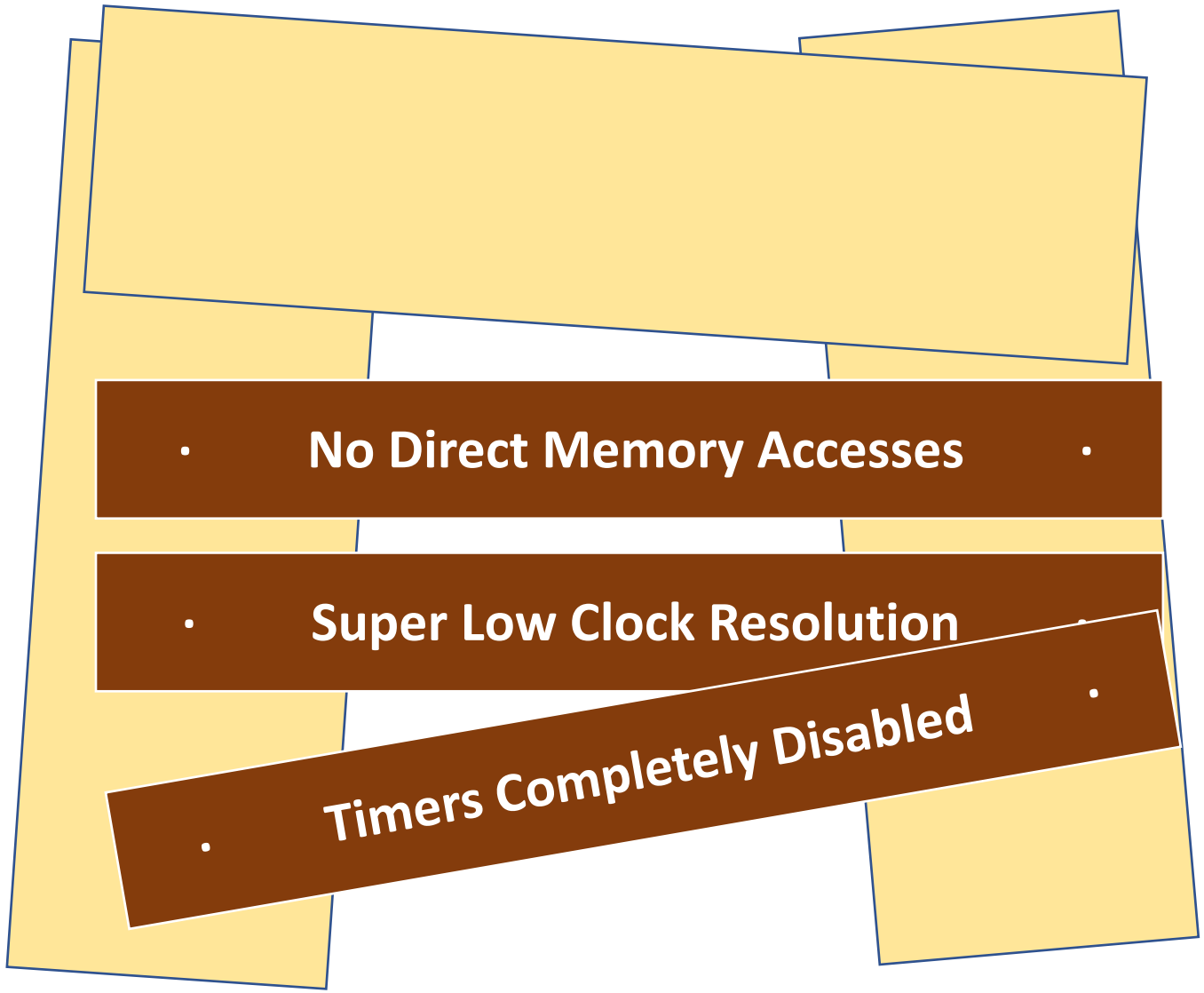


- Required timer resolution reduced to milliseconds
- Cache structure does not need to be reverse engineered

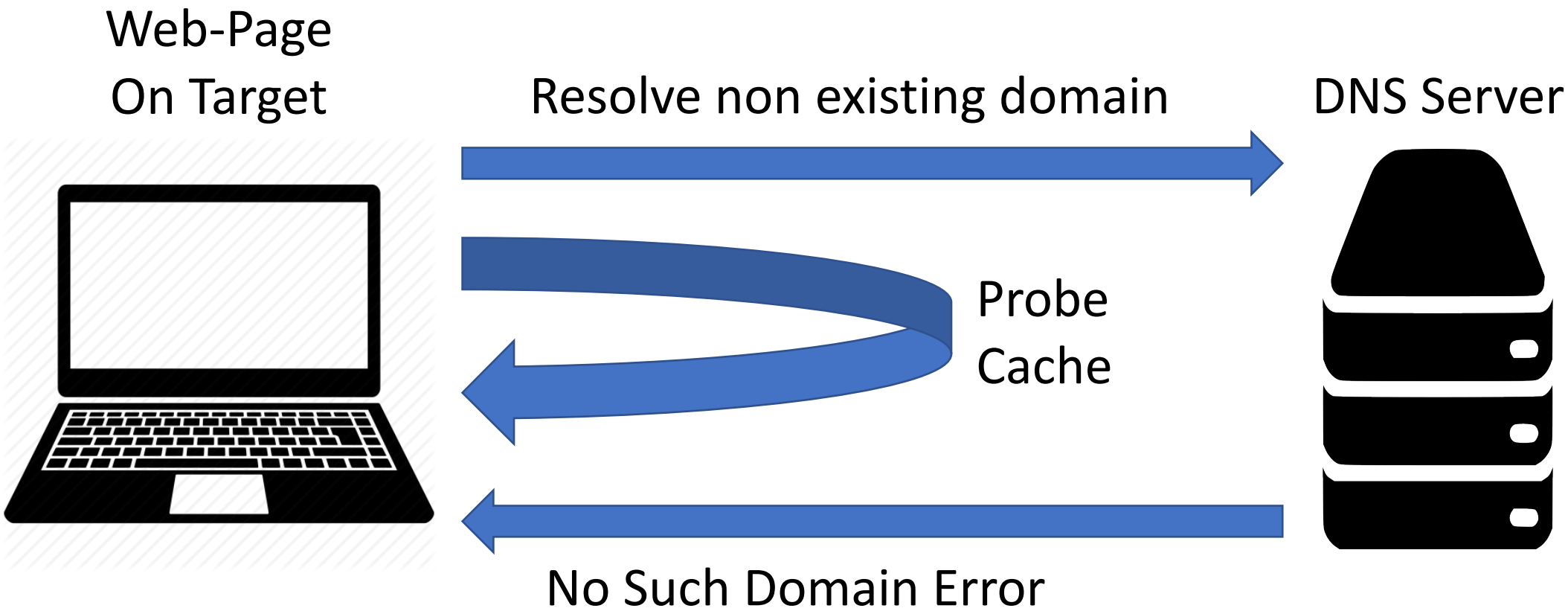

No Direct Memory Accesses
Reduced Clock Resolution
Super Low Clock Resolution

Attack 2: Sweep Counting [S+19]

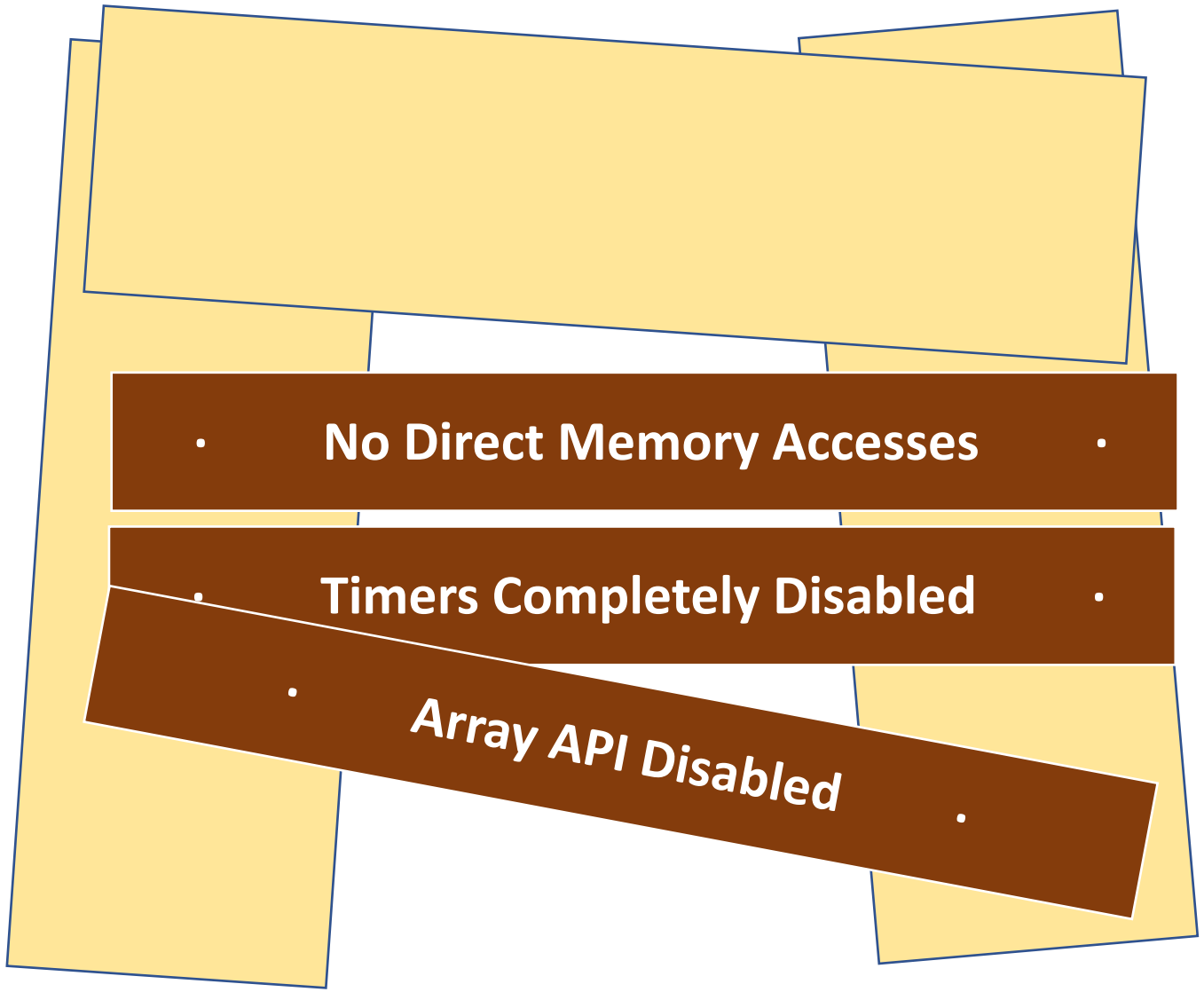
- Count the number of times we can read the buffer in a clock tick
  - Required timer resolution reduced to 10 Hz


No Direct Memory Accesses
Super Low Clock Resolution
Timers Completely Disabled

Attack 3: DNS Racing [New!]

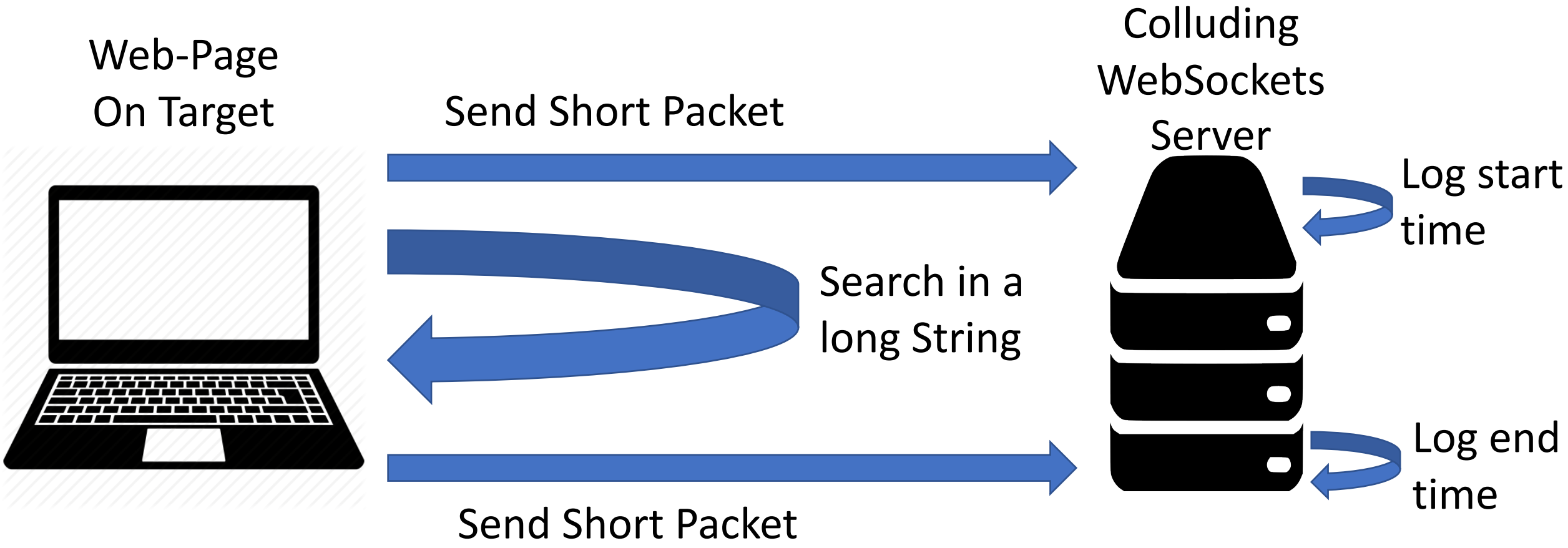


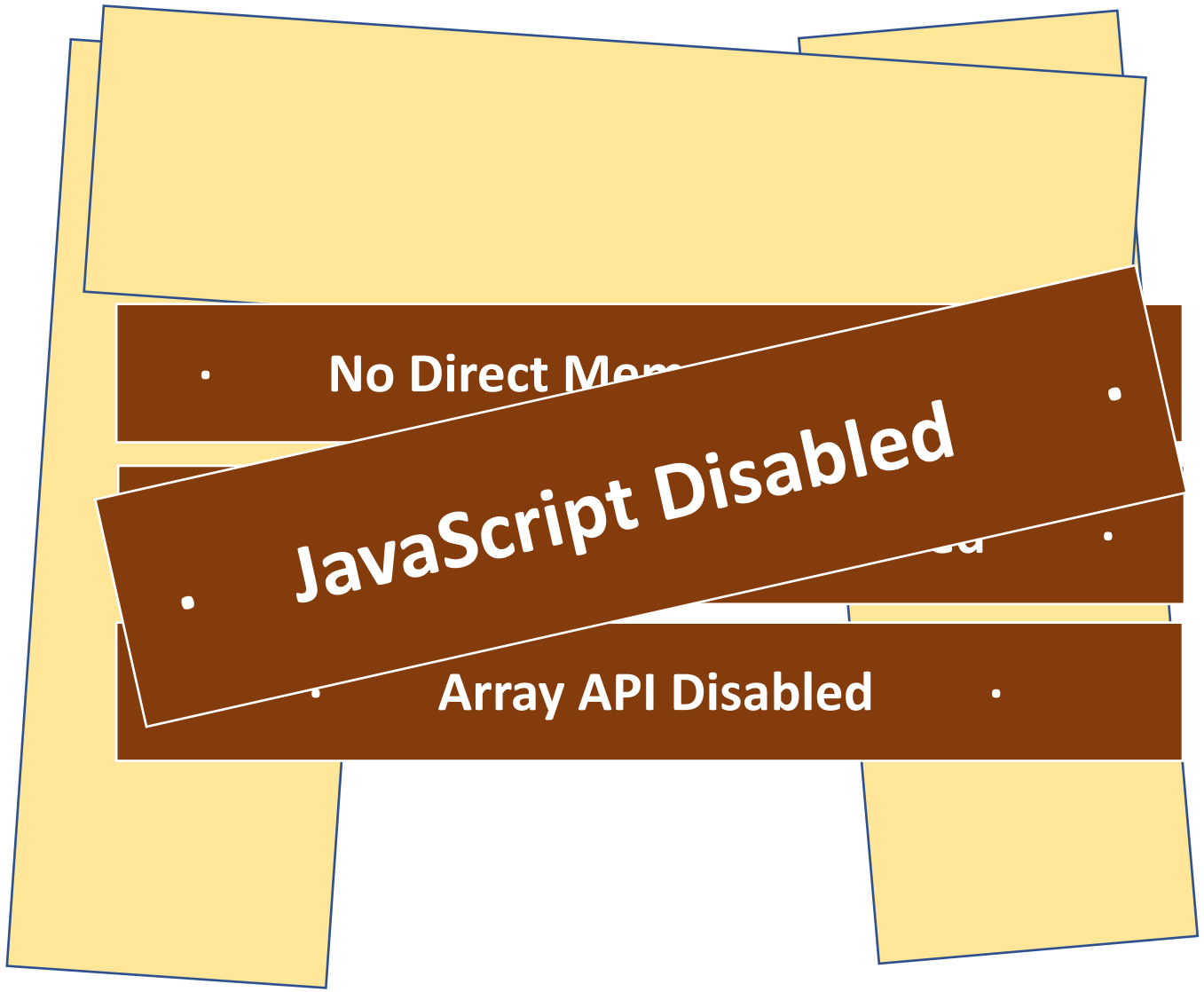
- No timers required!
- Resists jitter well enough to be used between two continents


No Direct Memory Accesses
Timers Completely Disabled
Array API Disabled

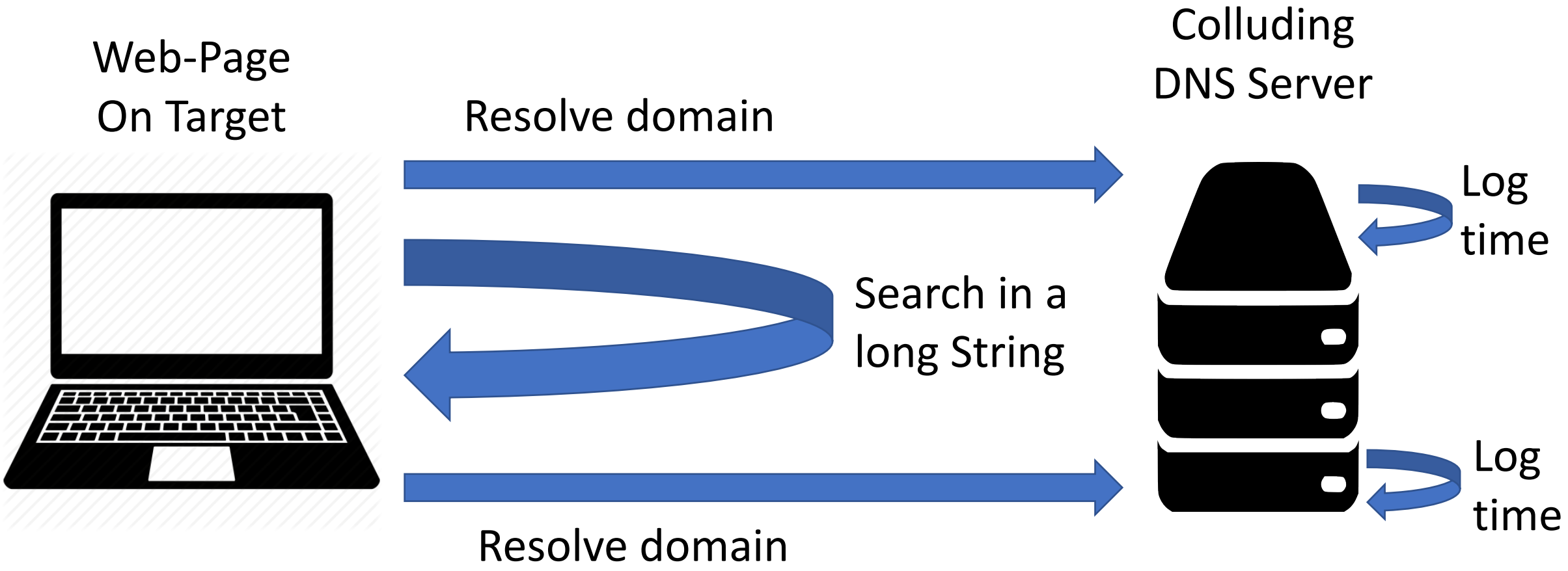
Attack 4: String and Sock [new!]

- Strings are arrays in disguise
- No timers or arrays required!




No Direct Mem
JavaScript Disabled
Array API Disabled

Attack 5: CSS Prime+Probe [New!]



Attack 5: CSS Prime+Probe

```
<div id="pp" class="AAA…AAA">
  <div id="s1">X</div>
  <div id="s2">X</div>
  <div id="s3">X</div>
  .
  .
  .
</div>
```

Search non existing string

==

Probe the LLC

Resolve non existing image

==

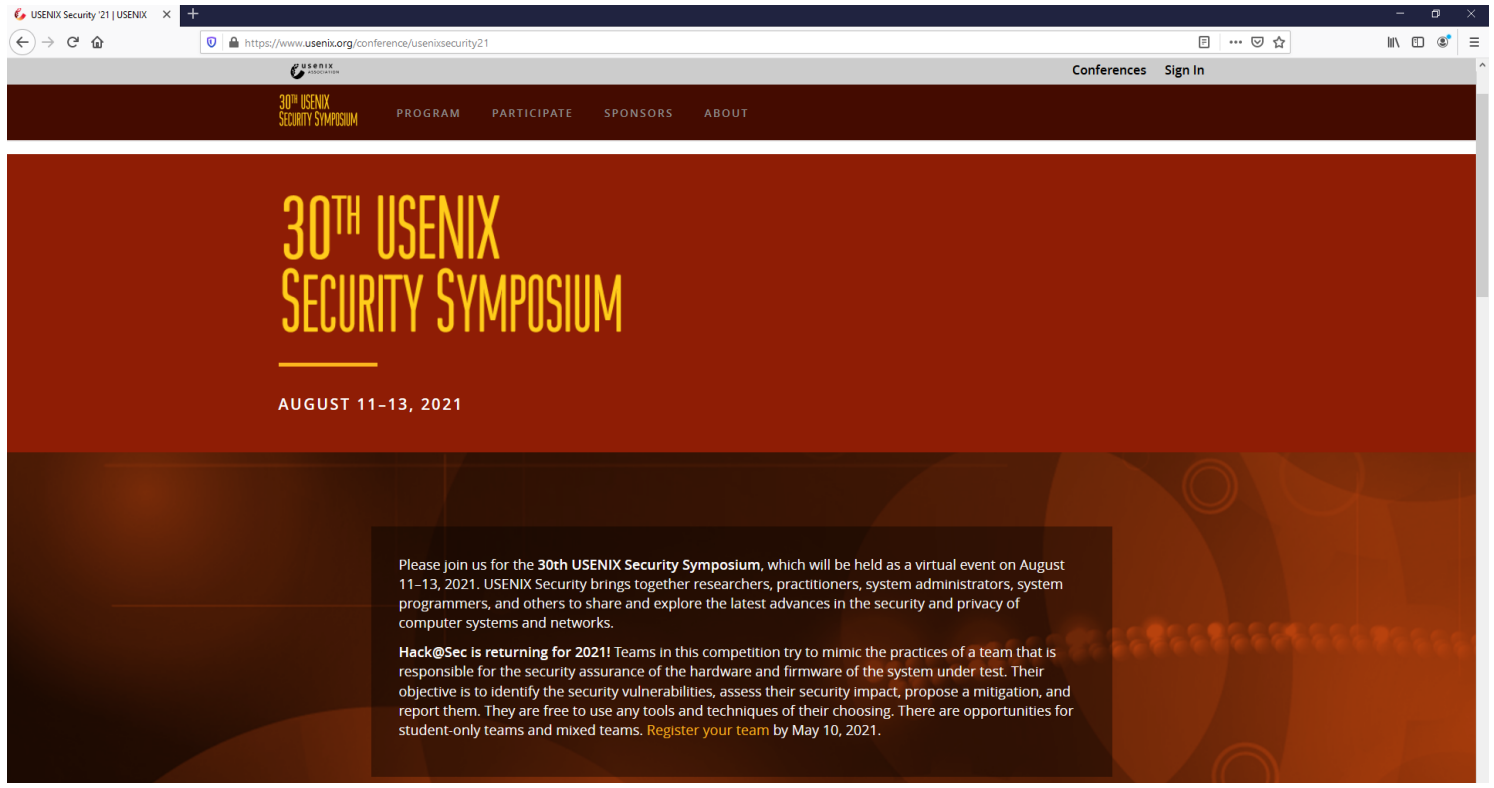
TIMER

```
#pp:not([class*= 'jigbaa']) #s1 {
  background-image: url('https://knbdsd.badserver.com');
}
#pp:not([class*= 'akhevn']) #s2 {
  background-image: url('https://pjemh7.badserver.com');
}
```

Evaluation

- Our method is probably not effective for cryptanalysis
- So, what is it good for?

Website Fingerprinting



Webpage Rendering

https://privateurl.com

Cache Contention Measurement

Time (msec)

Cache Contention

100 Traces

100 URLs

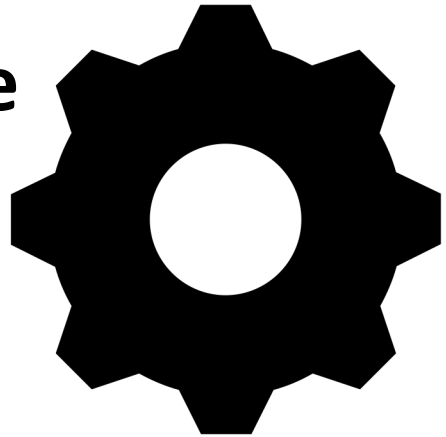
5 Attacks

4 processors

Deep Learning Models

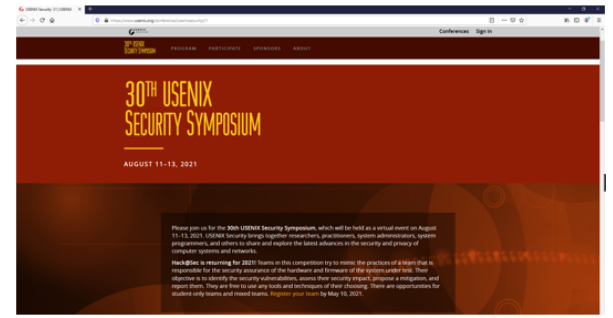
Cache Contention Trace

Input

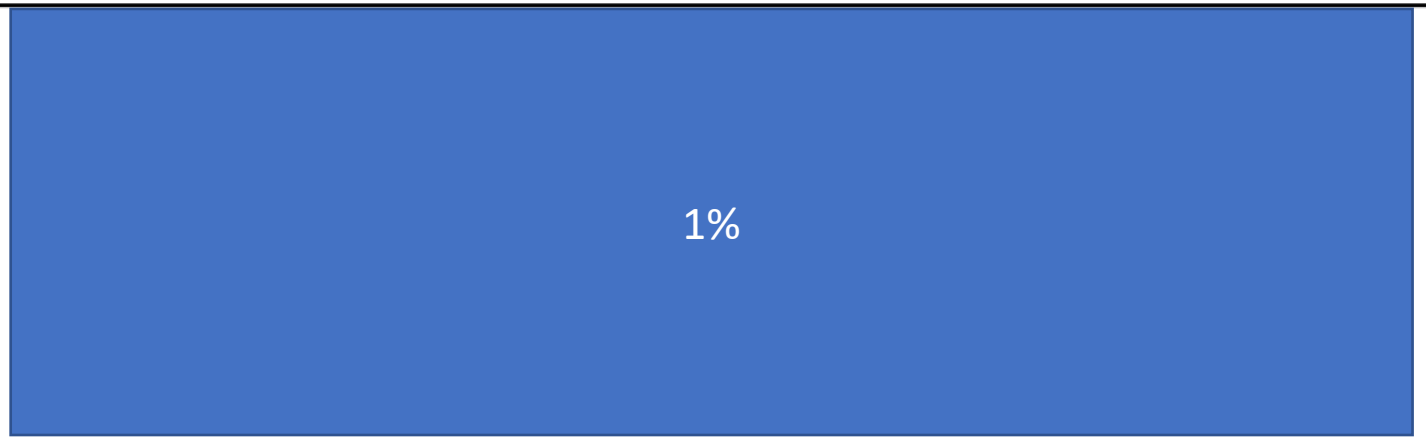


URL

Output



Results

Attack Technique	Intel i5-3470	AMD Ryzen 9 3900X	Apple M1	Samsung Exynos 2100
Cache Occupancy				
Sweep Counting				
DNS Racing				
String and Sock				
CSS Prime+Probe				

Conclusion

- Restricted environments don’t prevent cache contention attacks.
- Lower attack requirements make it architectural agnostic.
- Protection against µ-architectural leaks should be applied at the source, not at the receiver

https://orenlab.sise.bgu.ac.il/p/PP0