Port Contention Goes Portable: Port Contention Side-Channels in Web Browsers

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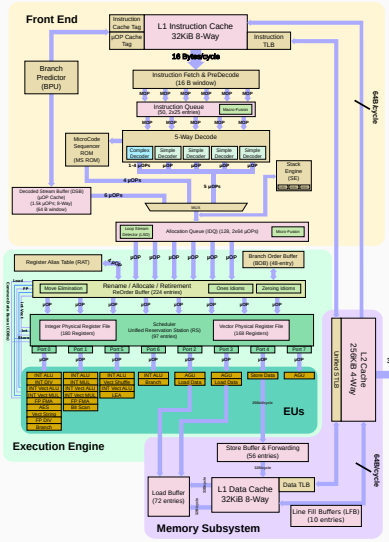
Background: Microarchitectural attacks

Exploit subtle timing differences caused by the microarchitecture.

Cache attacks are the most famous, but most microarchitectural optimizations are targeted.



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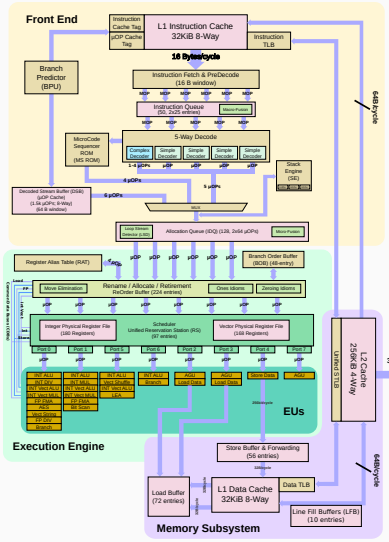
Here: CPU Ports



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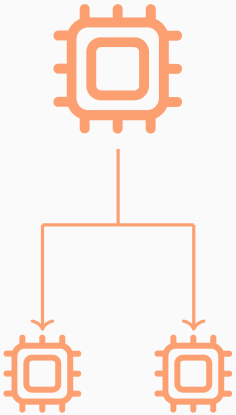

Simultaneous computation technology of Intel.

- Physical cores are shared in several (often 2) logical cores
- Abstraction at the OS level

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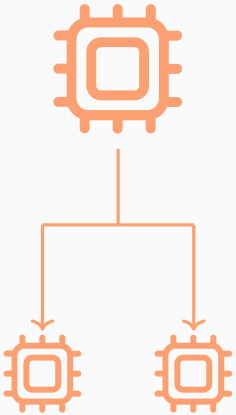
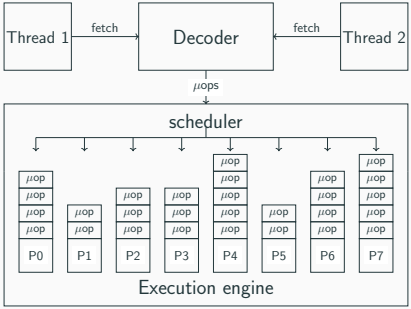


Simultaneous computation technology of Intel.

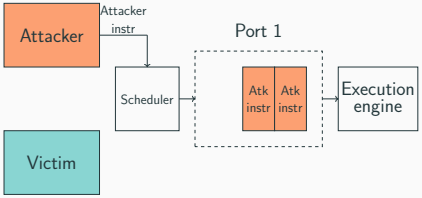
- Physical cores are shared in several (often 2) logical cores
- Abstraction at the OS level
- **Hardware resources are shared between logical cores**

Background: Execution pipeline

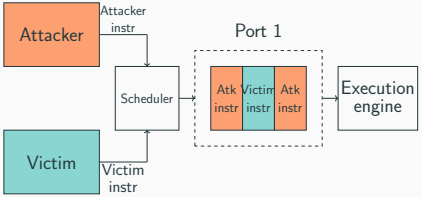
- Instructions are decomposed in micro-operations (μops) to optimize Out-of-Order computation
- The decomposition of instructions into μops is deterministic
- μops are dispatched to specialized execution units through **CPU ports**



Background: Port contention[1]



No Contention All the attacker instructions are executed in a row, **fast execution time**



Contention Attacker instructions are delayed, **slow execution time**

[1] Aldaya et al. , Port Contention for Fun and Profit, S&P, 2019

Port contention prerequisites

- Attacker code must run on the victim's hardware
- Attacker and victim must be on the **same physical core**
- Attacker must have access to high-resolution timers

Background: JavaScript and WebAssembly

- Runs code on the **client's hardware**.
- JIT compilation.
- Sandboxed

- Runs code on the **client's hardware**
- Compiled from another language
- Sandboxed
- Smaller, more atomic instructions

Threat model

Client side languages run on the client's hardware.

We can run port contention attacks on the victim's hardware

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Malicious website or advertisement

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Solution: Exploit JavaScript multithreading and work with the scheduler

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Build auxiliary timers with a resolution of several nanoseconds[2].

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Build auxiliary timers with a resolution of several nanoseconds[2].

For most experiments in this paper, we use a timer based on `SharedArrayBuffer`.

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PC-Detector

We don't know the port usage of WebAssembly instructions.

So we built **PC-Detector**

Test the contention of 244 WebAssembly instructions with our knowledge of native port usage.

PC-Detector - Description

PC-Detector is also composed of a native *spammer* and a web *tester*.

For each WebAssembly instruction, we run the following experiments:

Control : The web script runs alone in the browser

Contention on Port x : The web script runs while the native component repeatedly calls an instruction creating contention on Port x

We test all instructions with ports 0,1,(2,3),5 and 6.

PC-Detector - Results

We tested over 200 different instructions.

- 80 instructions creating contention
- 4 ports: 0, 1, 5 and 6
- Best instruction is `i64.rem_u`

Side-Channel Artificial Example - Description

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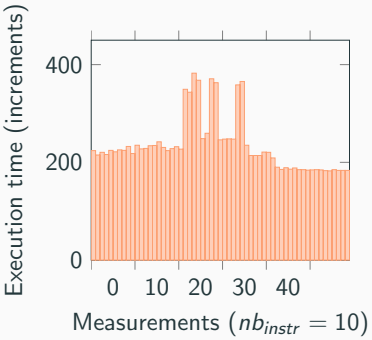

Figure 1: Secret key: 1101001.

- Able to detect 1024 native instructions in a single trace

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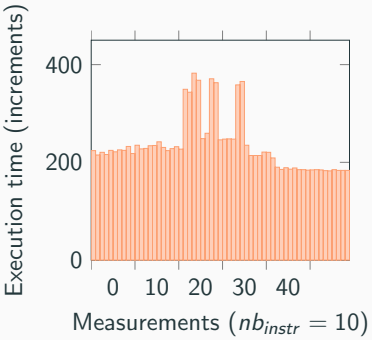

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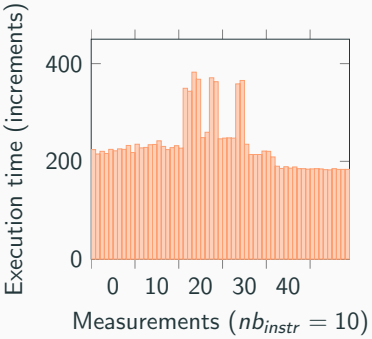


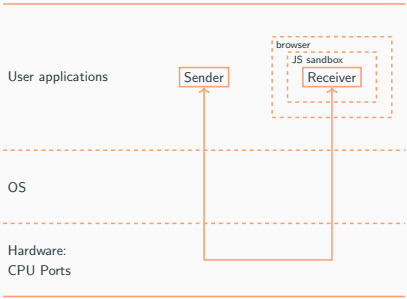
Figure 1: Secret key: 1101001.

- Able to detect 1024 native instructions in a single trace
- Spatial resolution similar to web-based cache attacks (Prime+Probe)
- Timers are the main bottleneck

Covert Channel

Composed of two components:

- **Native:** C/x86 sender
- **Web:** JavaScript/WebAssembly receiver



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- 200 bit/s
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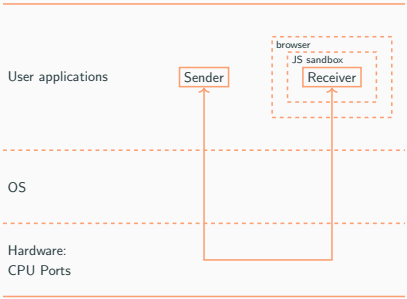

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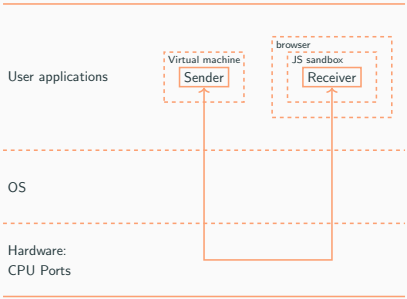

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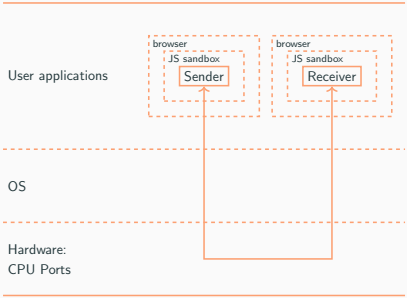
- Cross Browser



Countermeasures

Hardware: Disable SMT, dynamic SMT

OS: Port-independent code, port-aware scheduler

Browser: Removing high-resolution timers, process isolation.

Conclusion

- First implementation of port contention in the browser
- Fastest covert channel existing in the browser
- High spatial resolution
- Breaks the isolation of browser: cross-origin communication is possible, even through virtualized environments

Questions?

Contact me here: thomas.rokicki@irisa.fr

Feel free to read the paper for more technical details!

Find the code here: https://github.com/MIAOUS-group/web-port-contention