CS 576 – Systems Security
Data Execution Prevention

Georgios (George) Portokalidis

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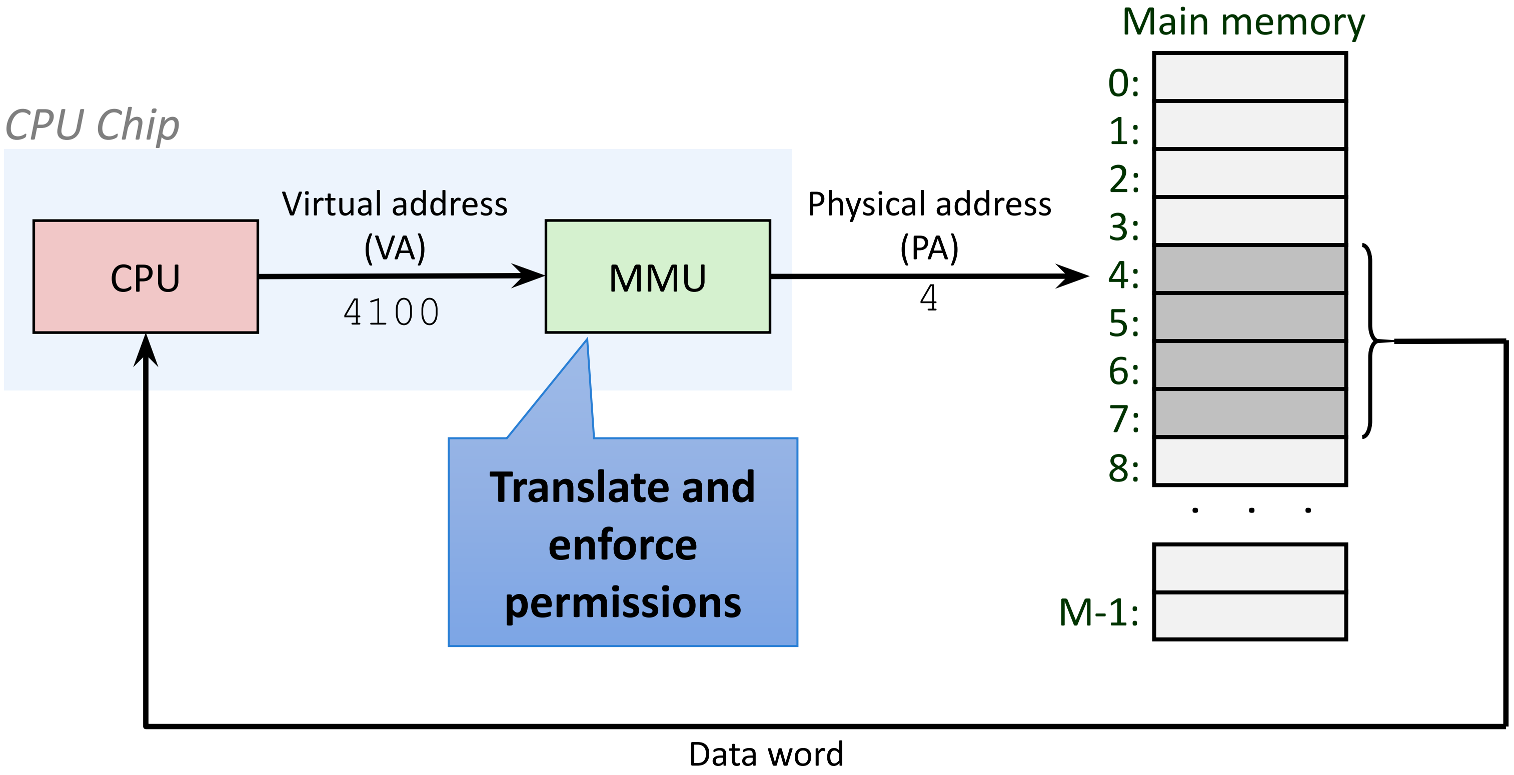
The Memory Management Unit (MMU) - Paging

- Used in all modern servers, laptops, and smart phones
- One of the great ideas in computer science



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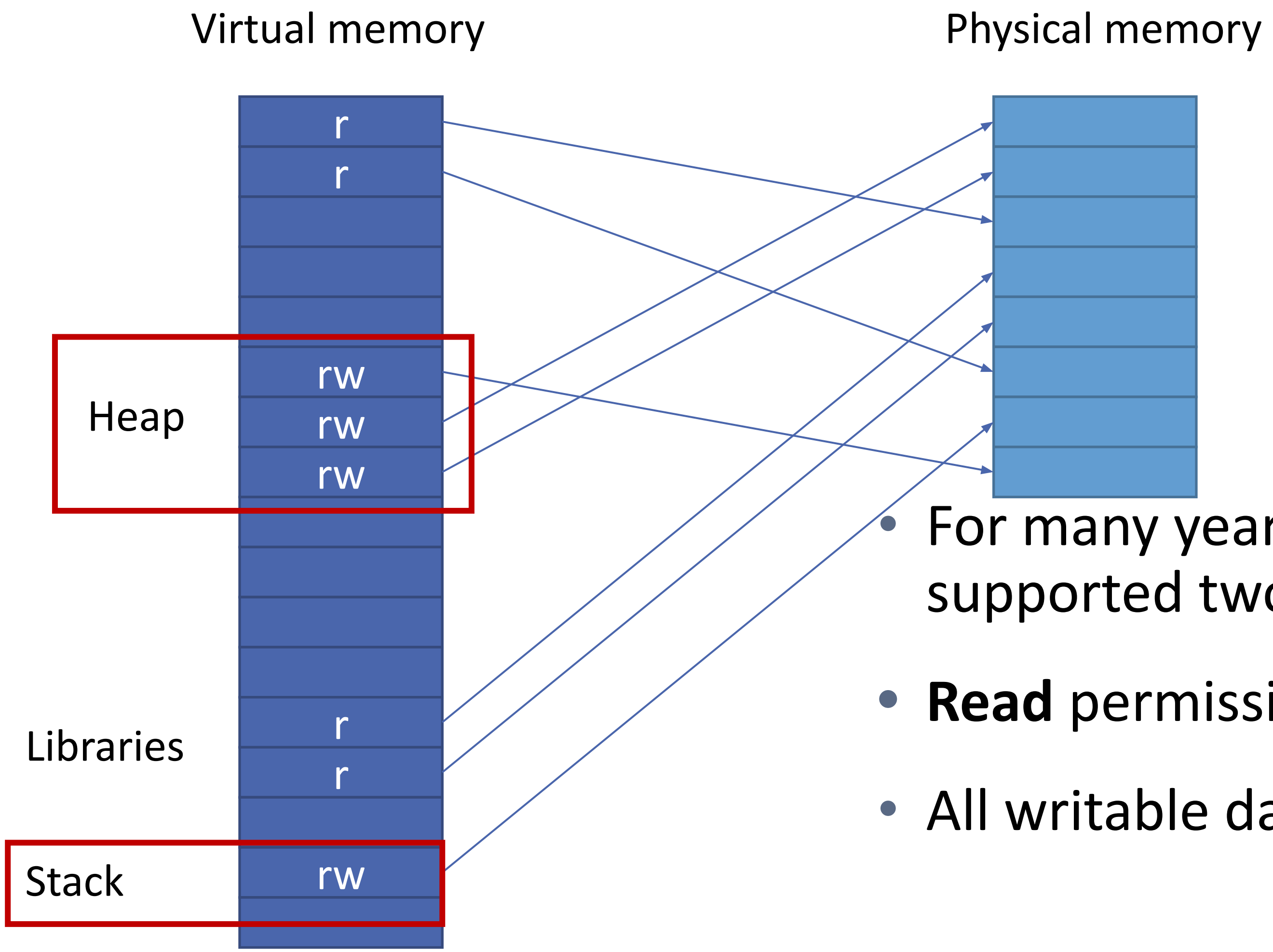

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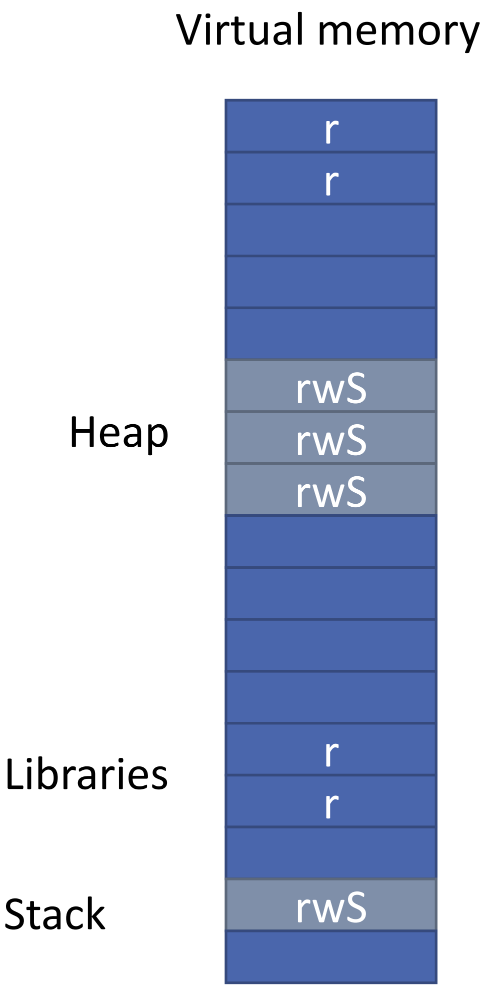

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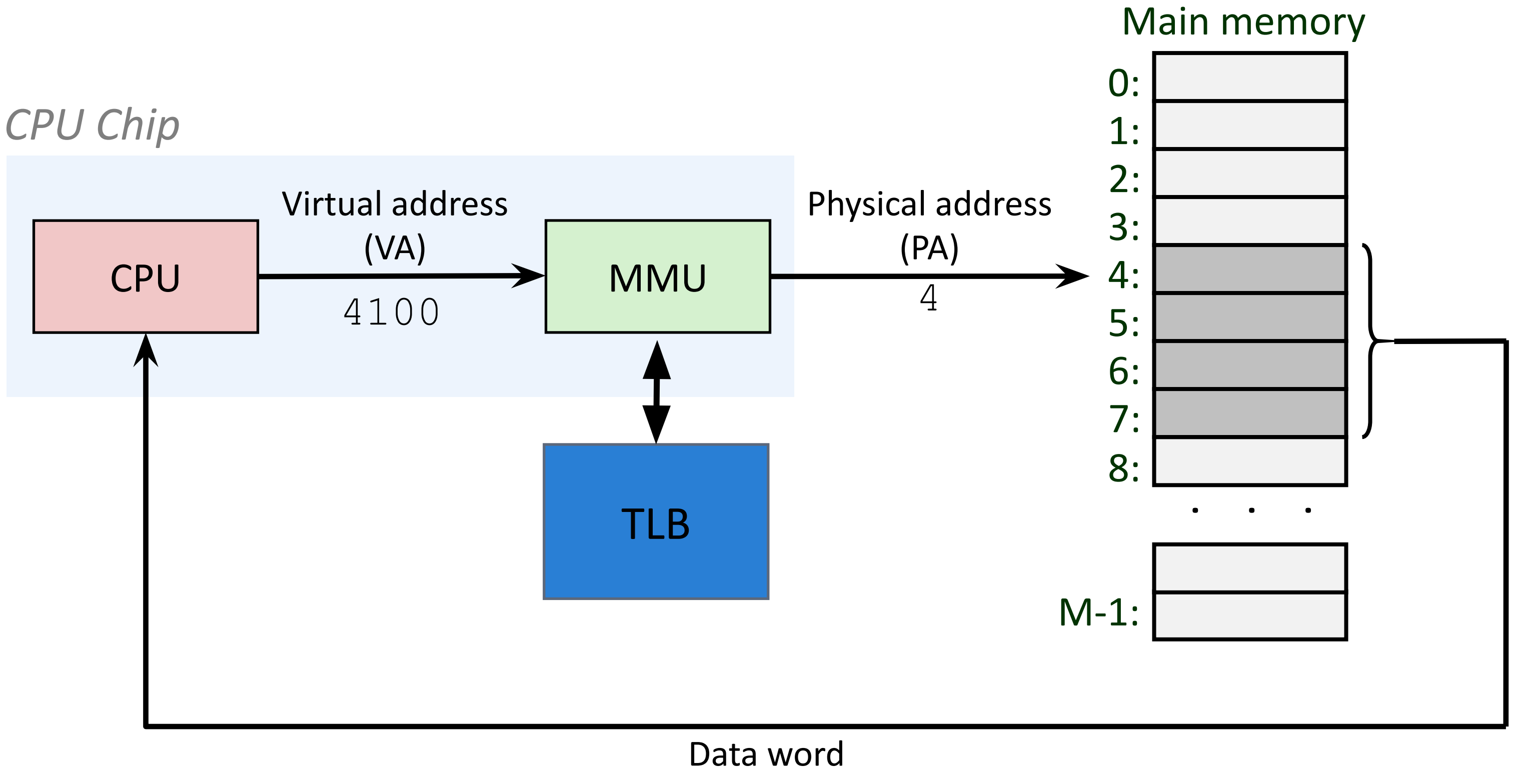
- A cache for storing the translations for the most frequently accessed pages



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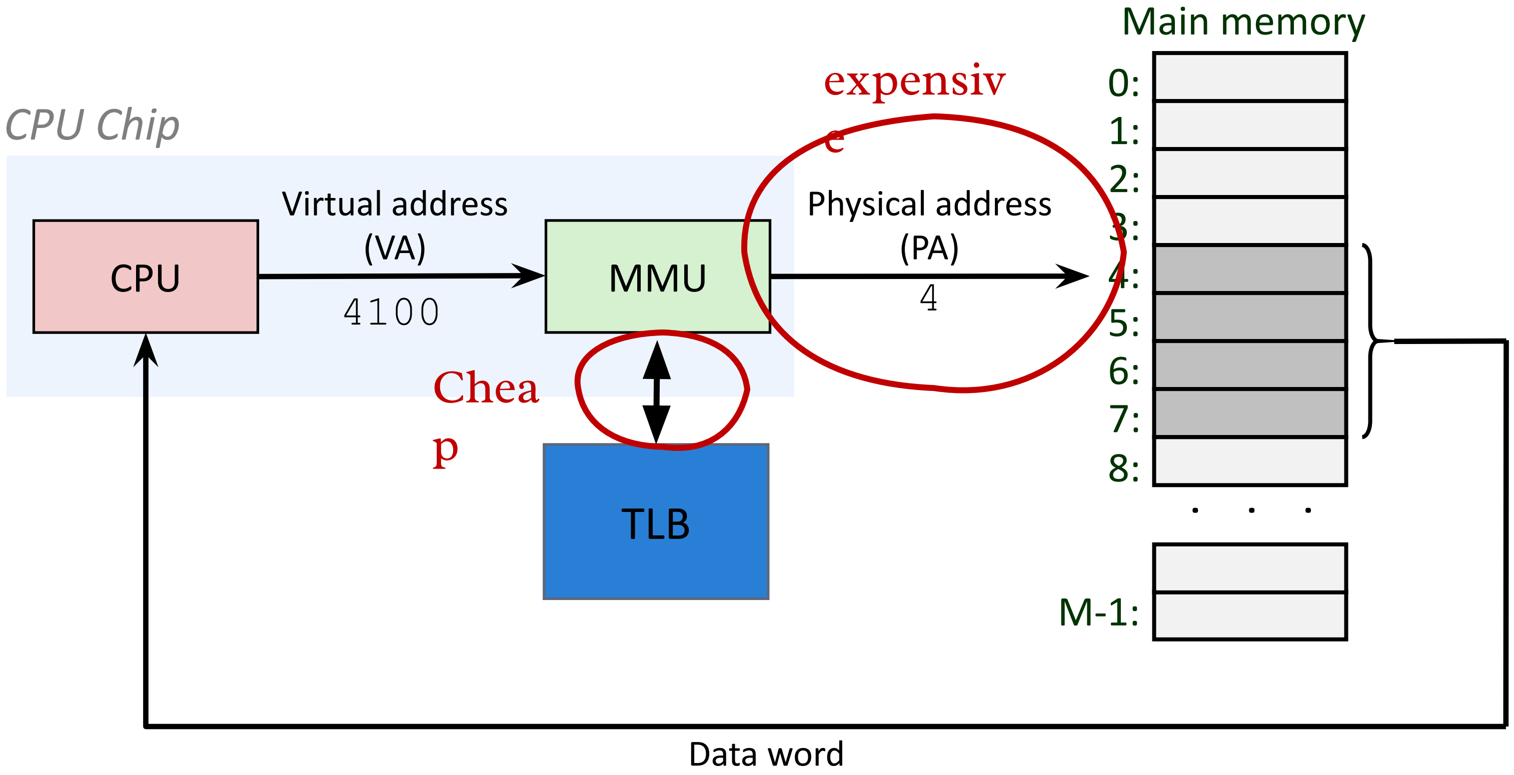

Split TLBs

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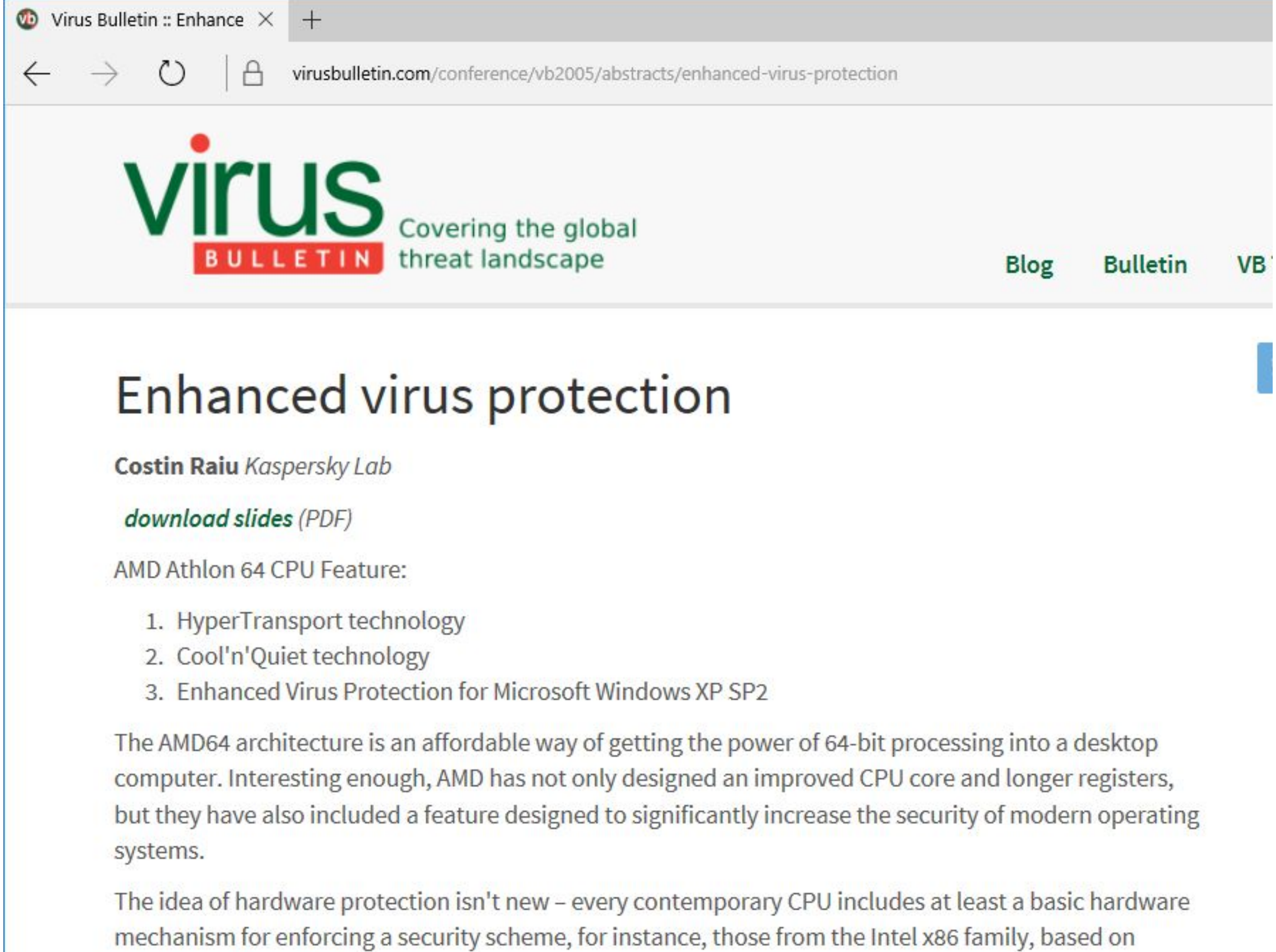
- **Marketed as antivirus technology**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Costin Raiu *Kaspersky Lab*

download slides *(PDF)*

AMD Athlon 64 CPU Feature:

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Adoption

- A non-executable stack was not immediately adopted
- The OS occasionally needed to place code in the stack
    - For example, trampoline code for handling UNIX signals
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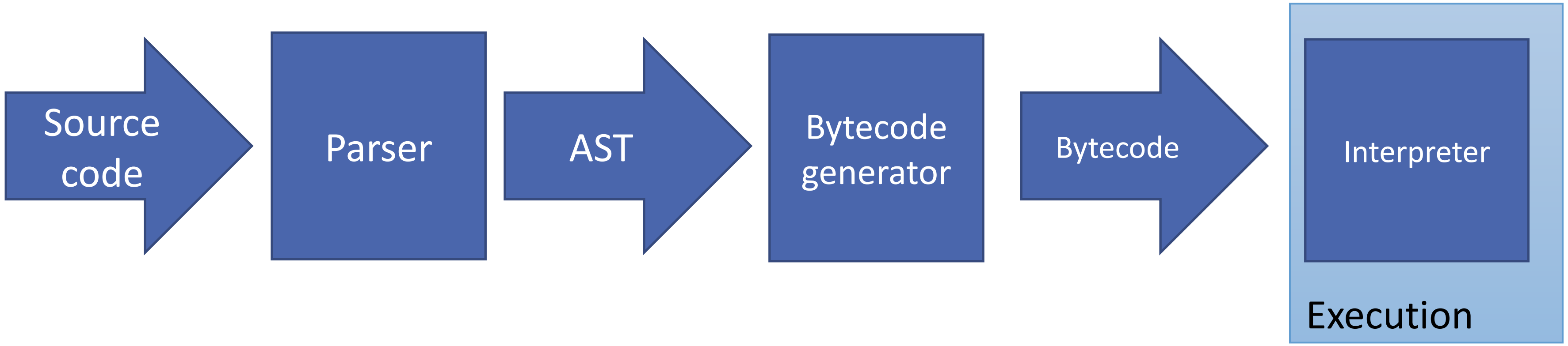
Unless You Are a Browser…

- Very popular software
  - Probably installed on every client device

- Large and complex software

- Execute JavaScript

How Does JavaScript Run



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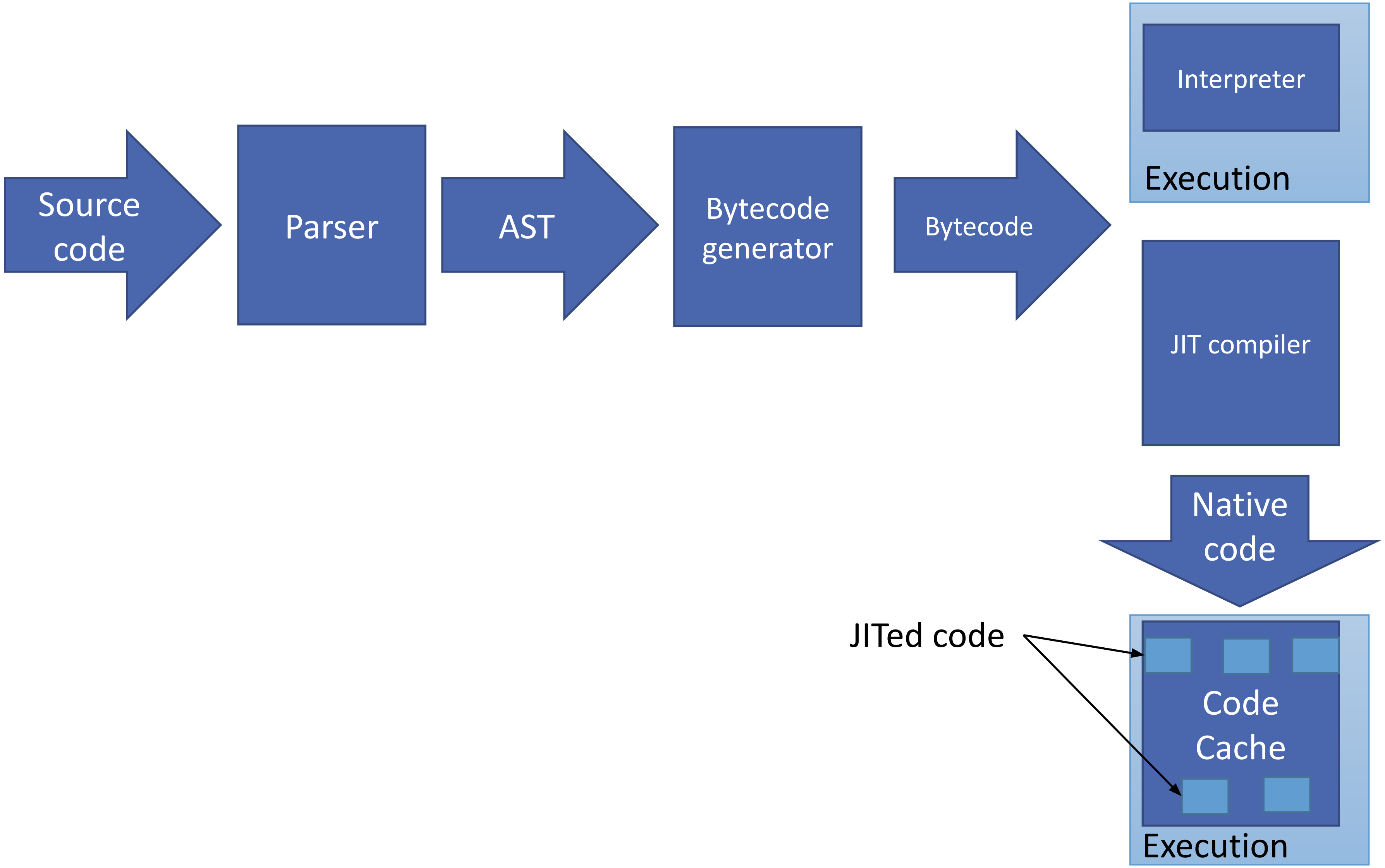

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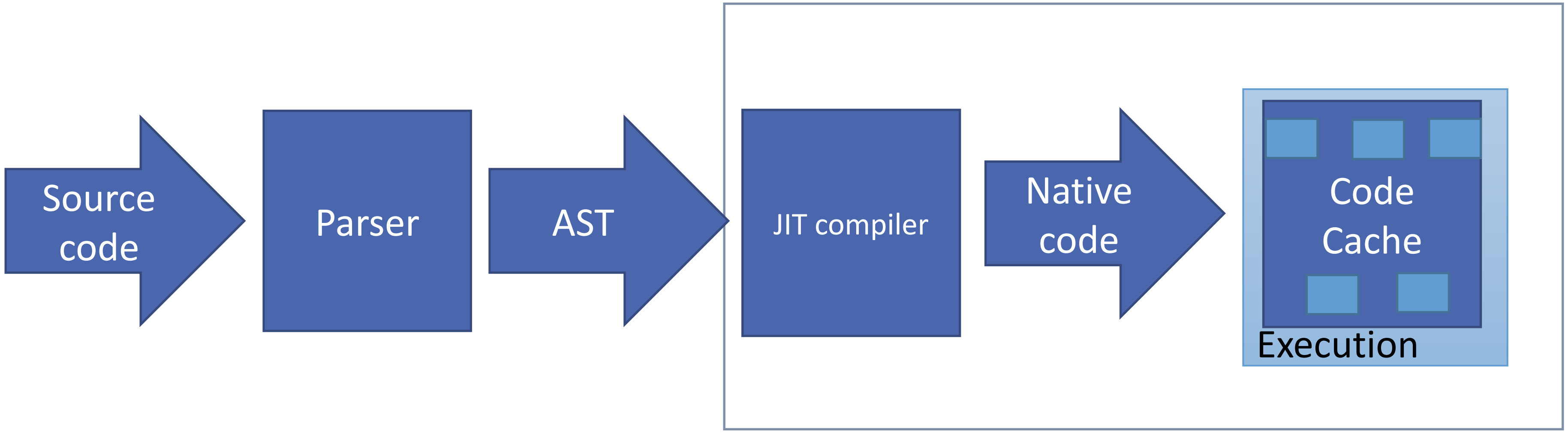

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- Bytecode generation skipped
- Directly emit native code
- Overall JavaScript execution improved by 150%

Code Cache

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    - Code is continuously generated
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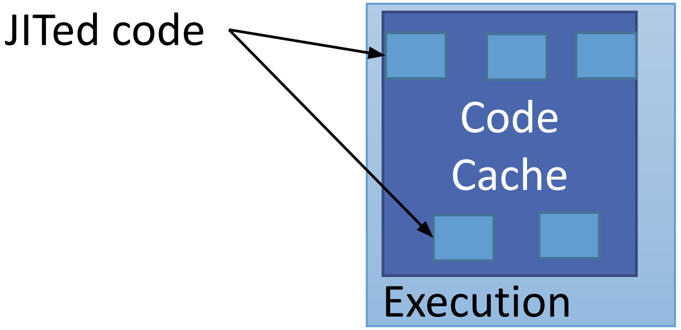

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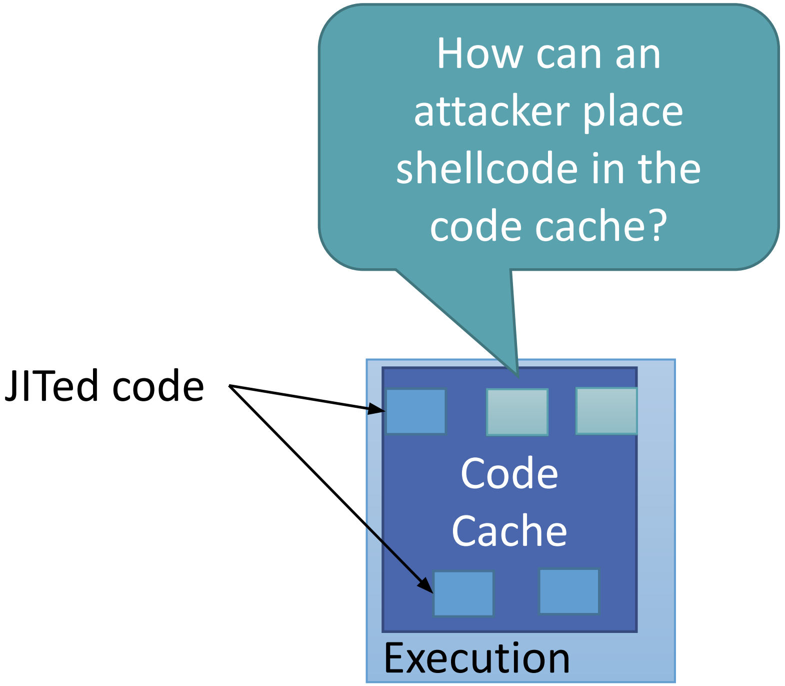

From JS to Code Cache

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Code-Injection Attacks Against Browsers

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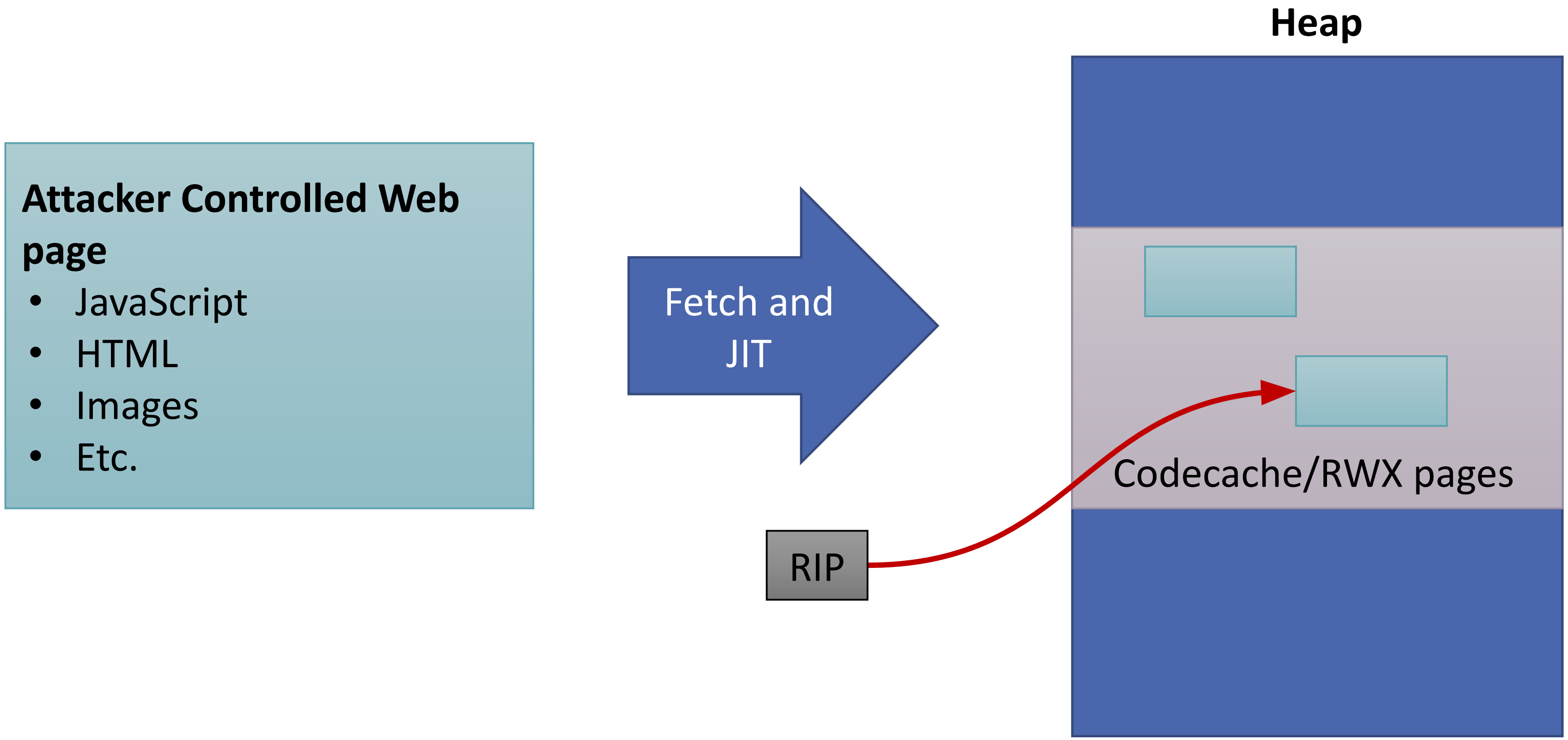

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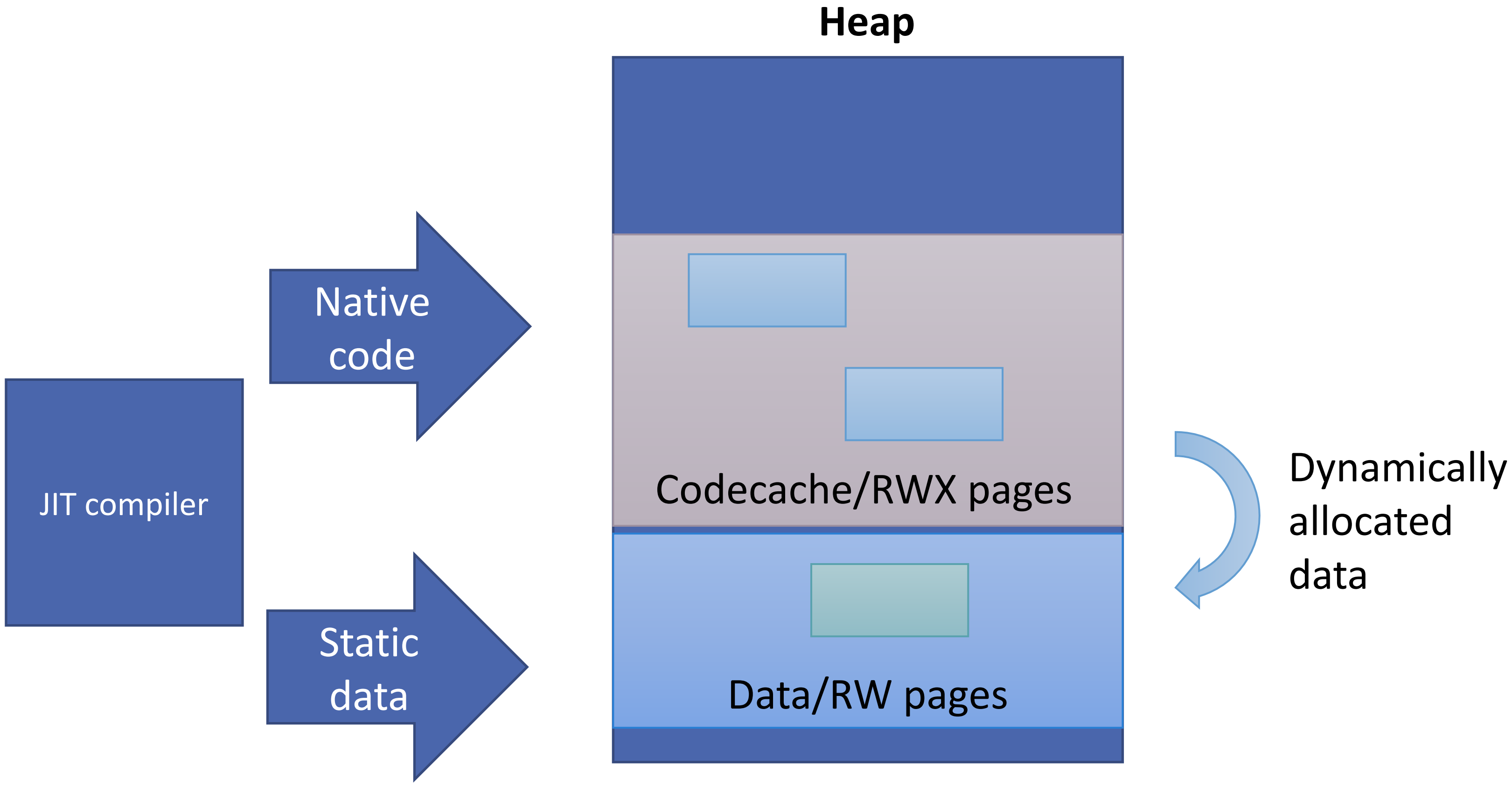

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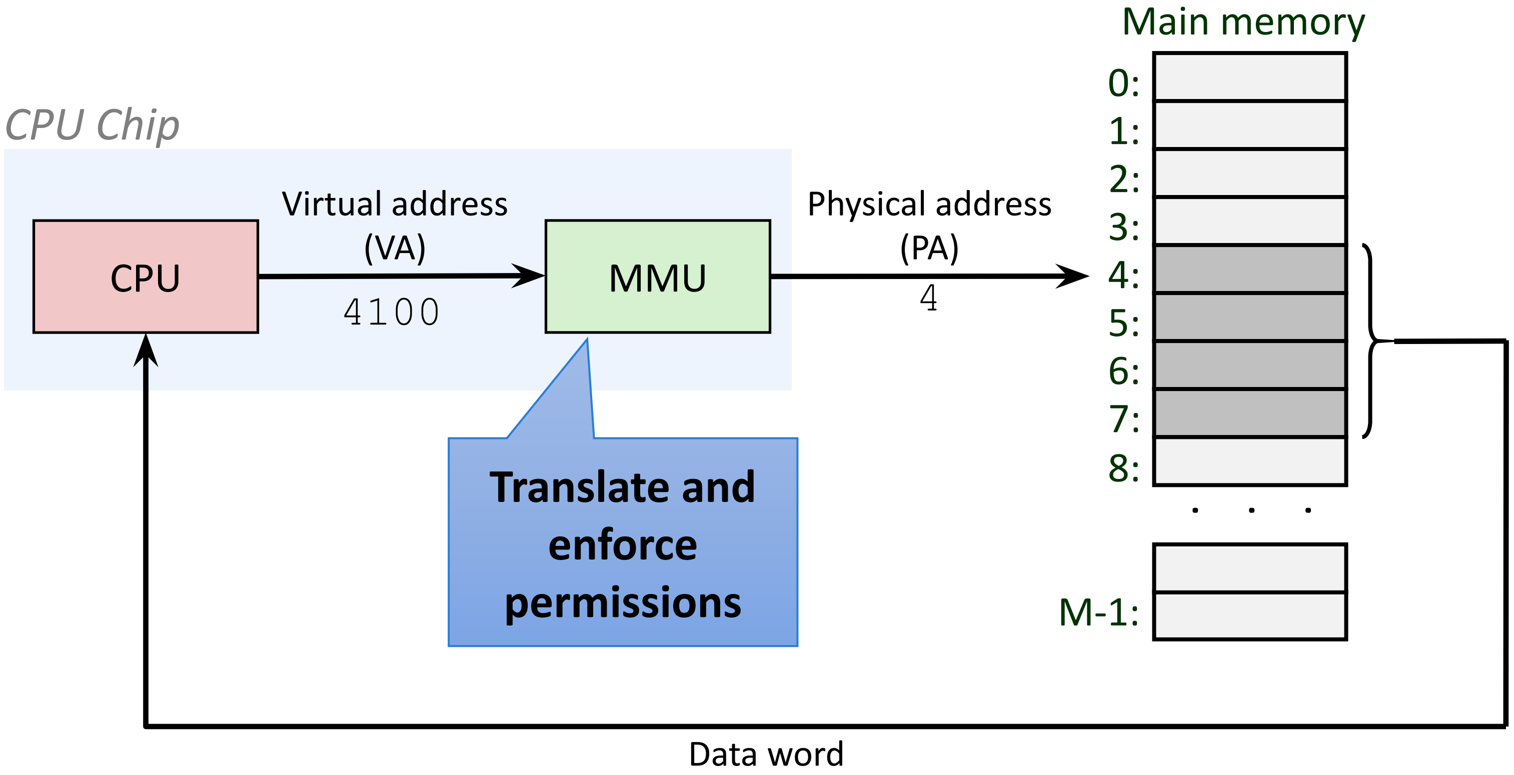

Translate and enforce permissions

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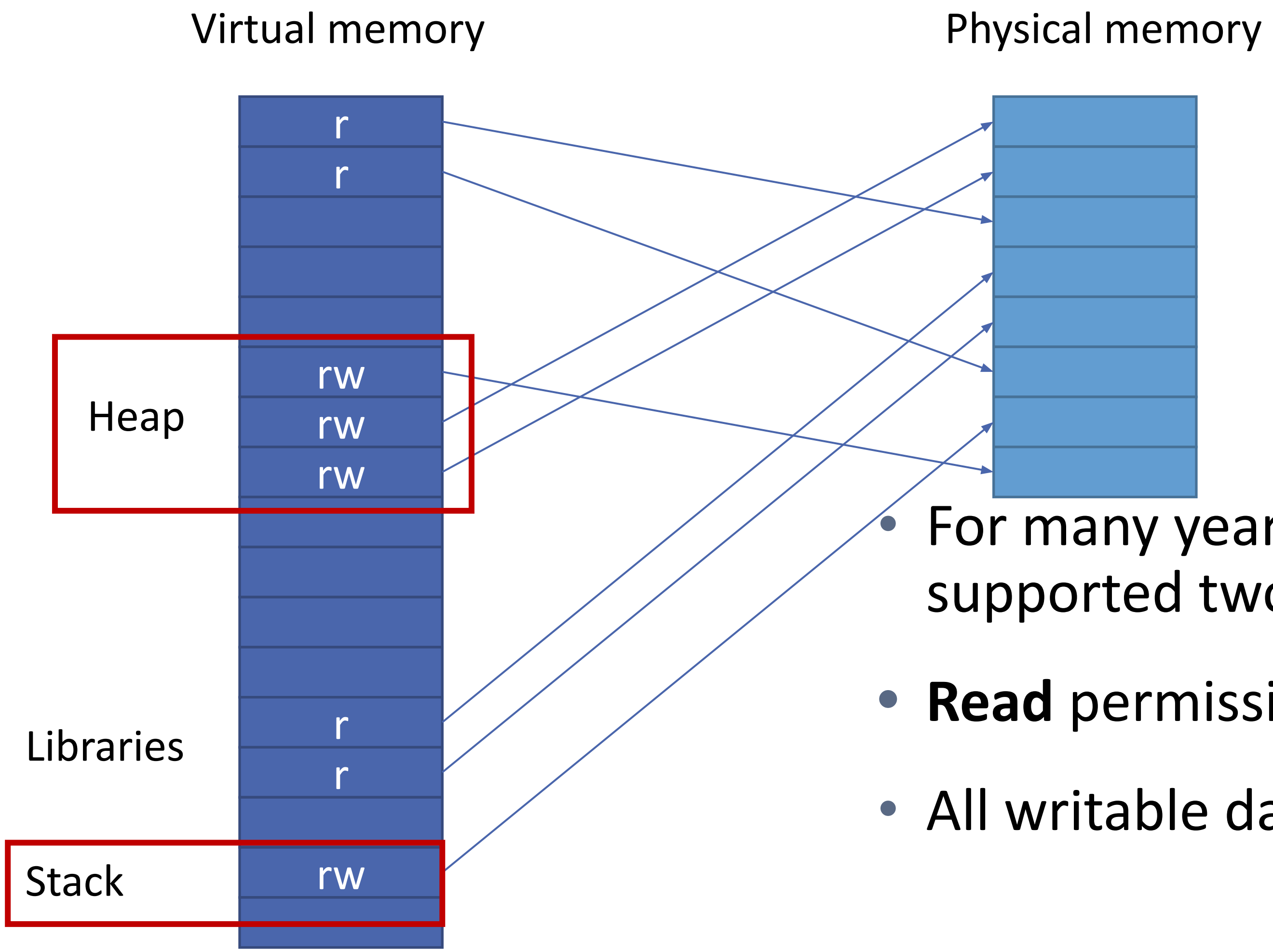

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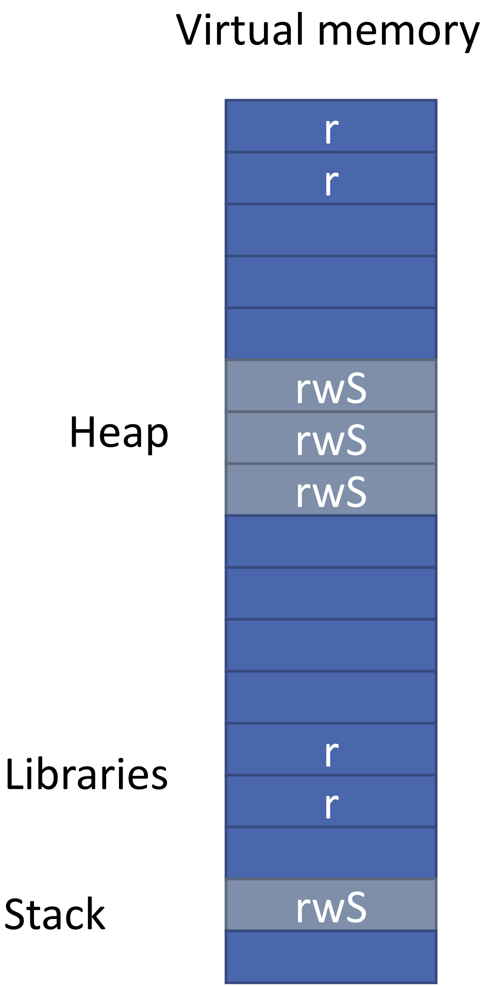

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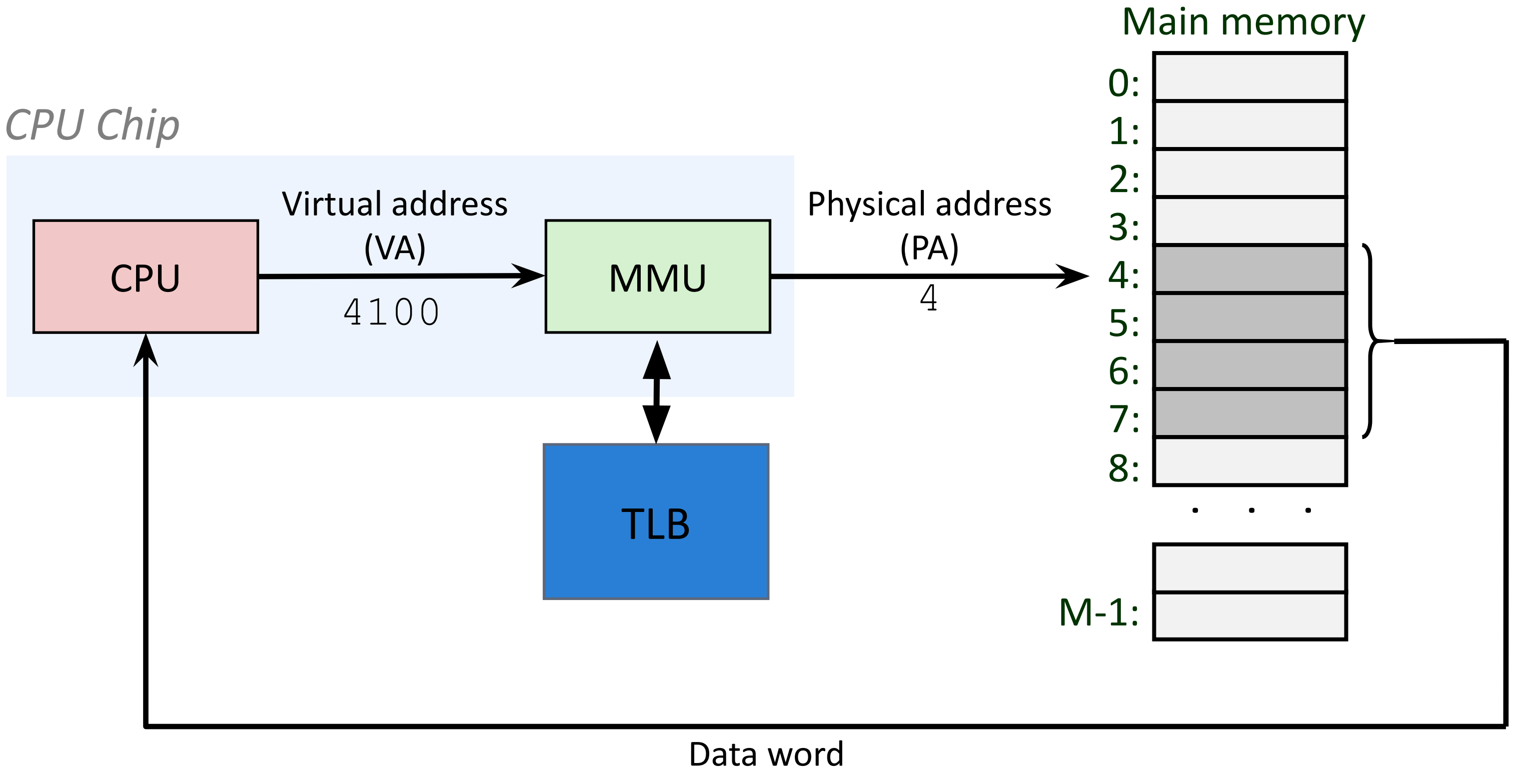

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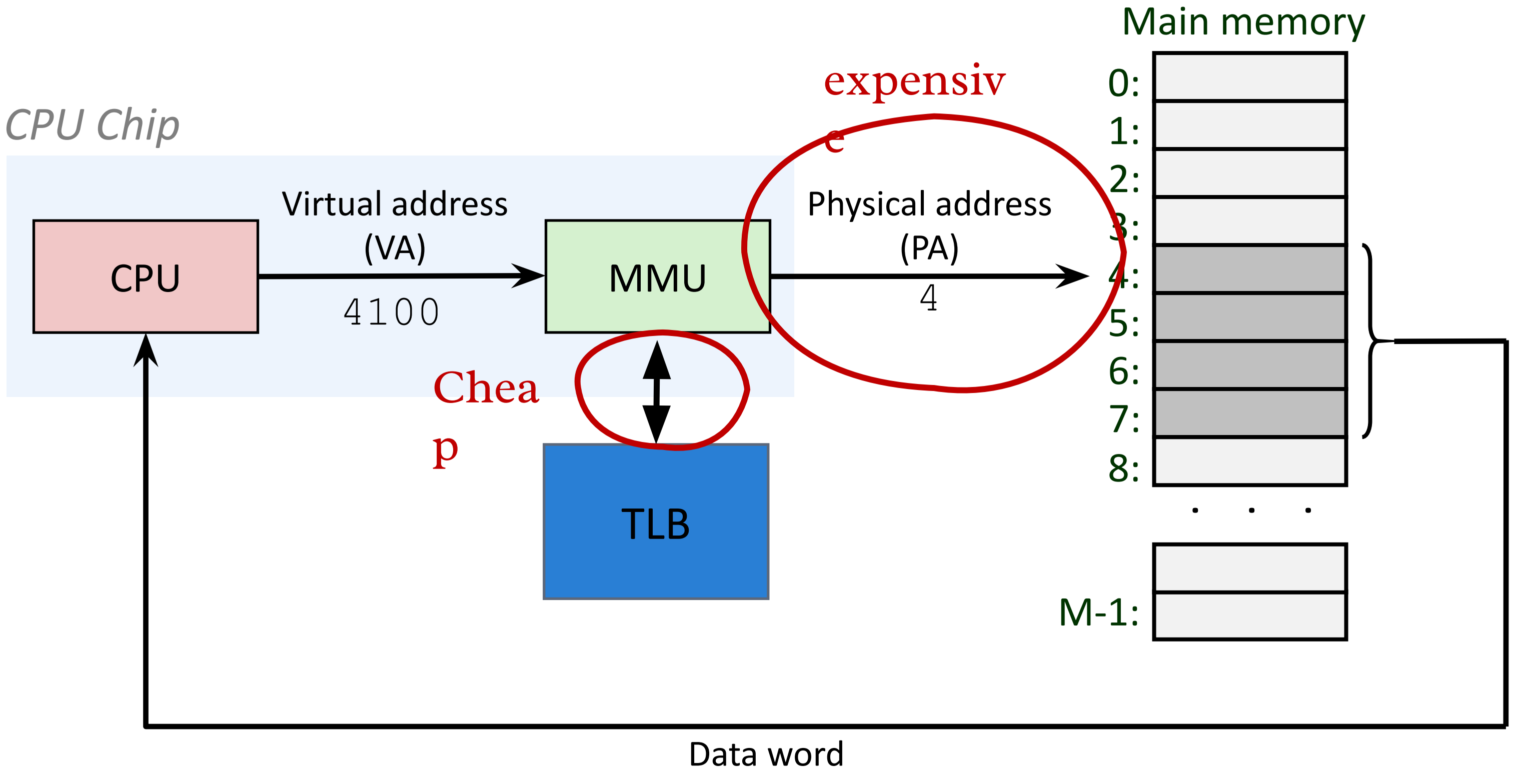

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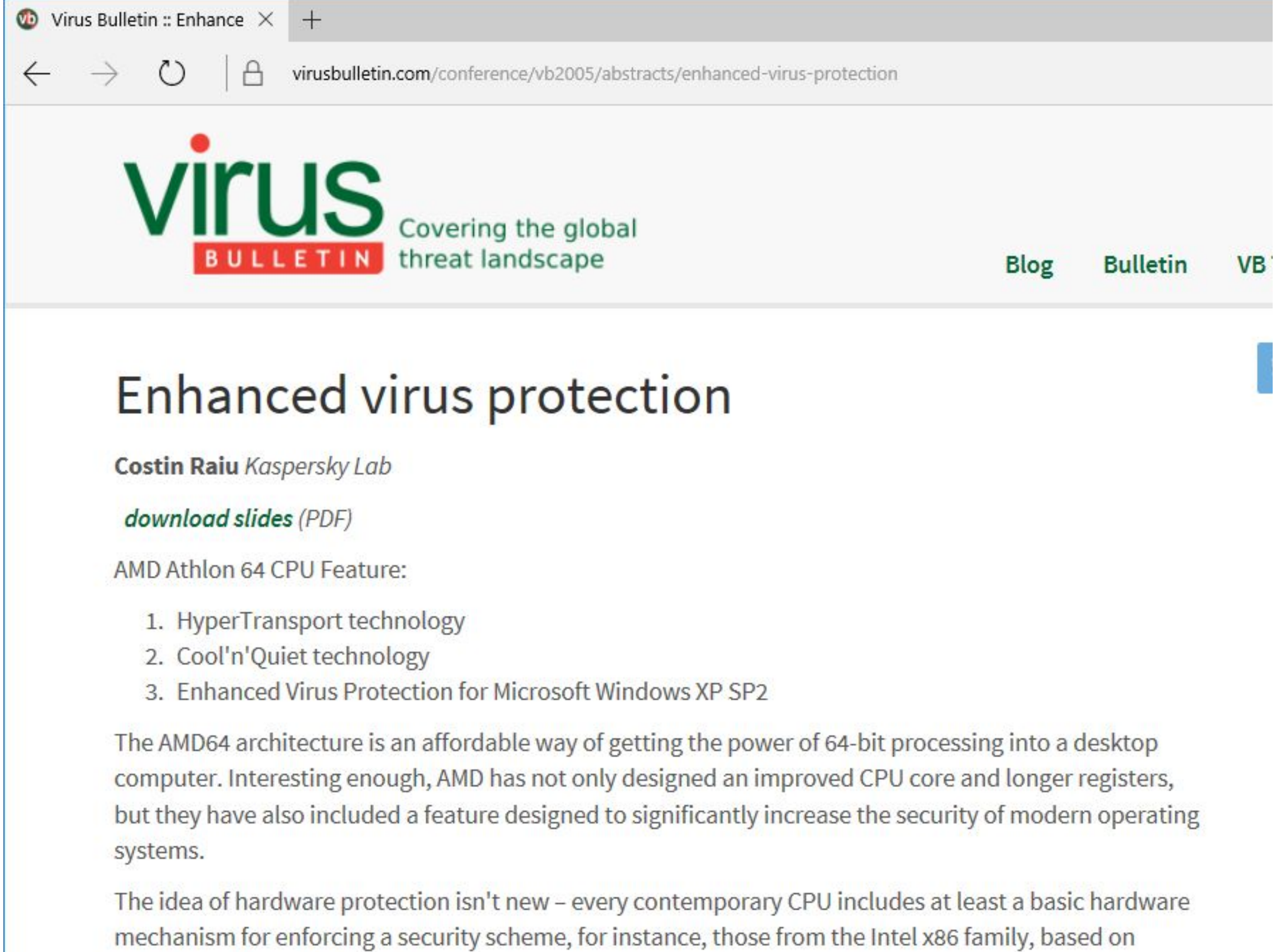
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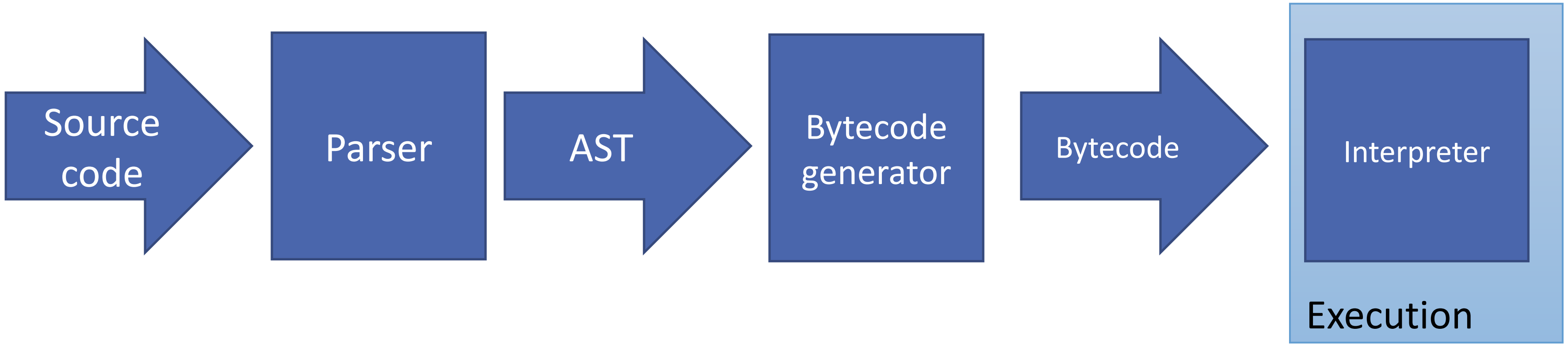

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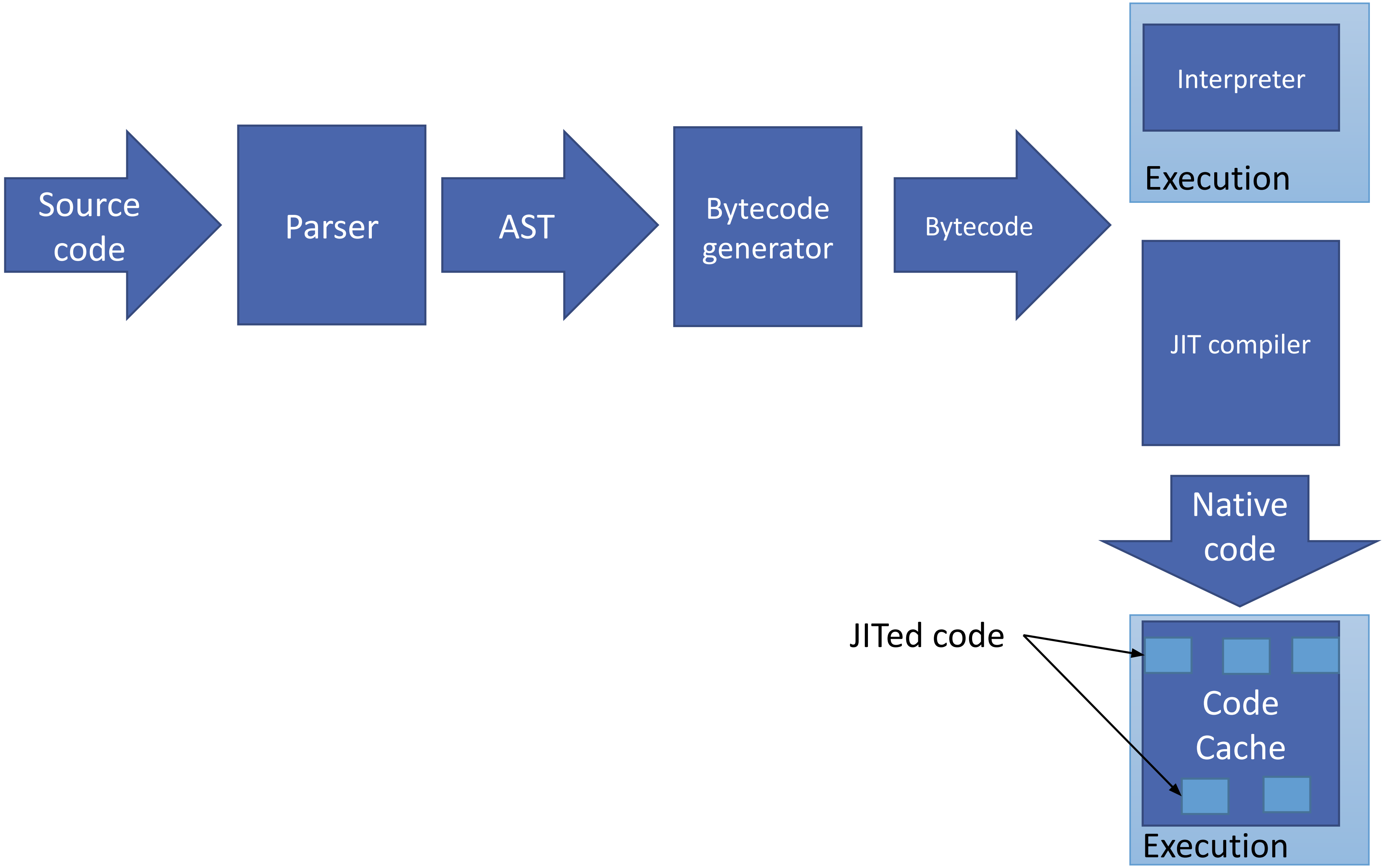

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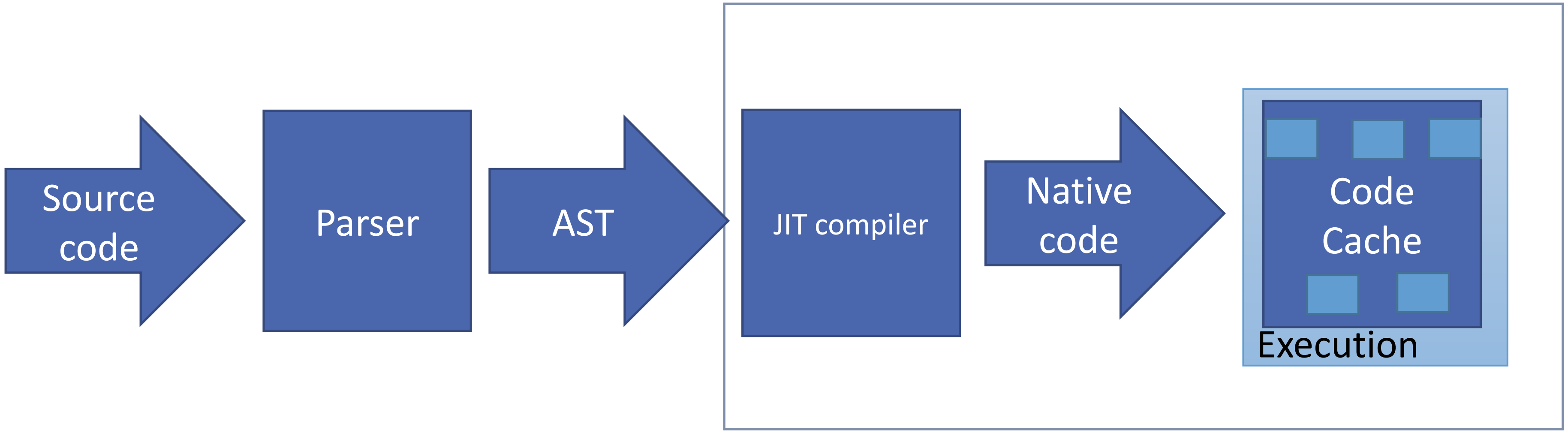

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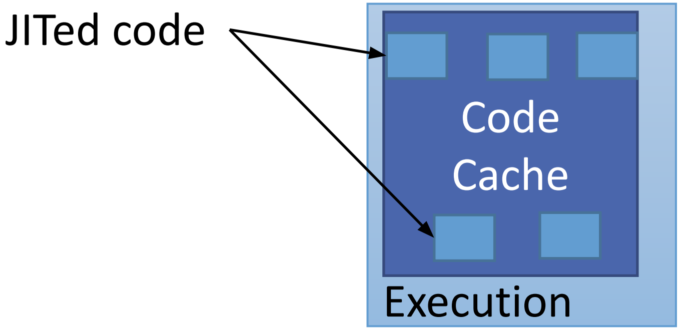

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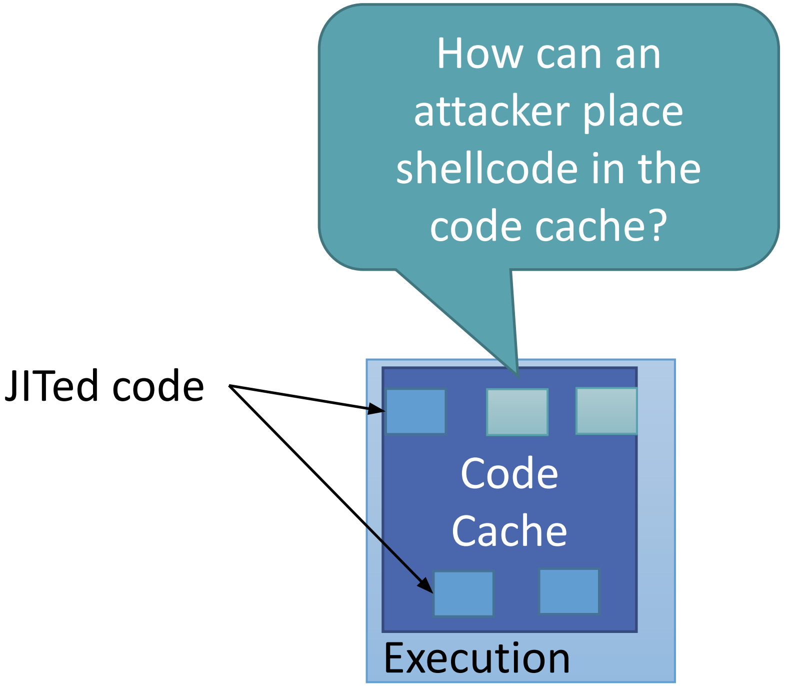

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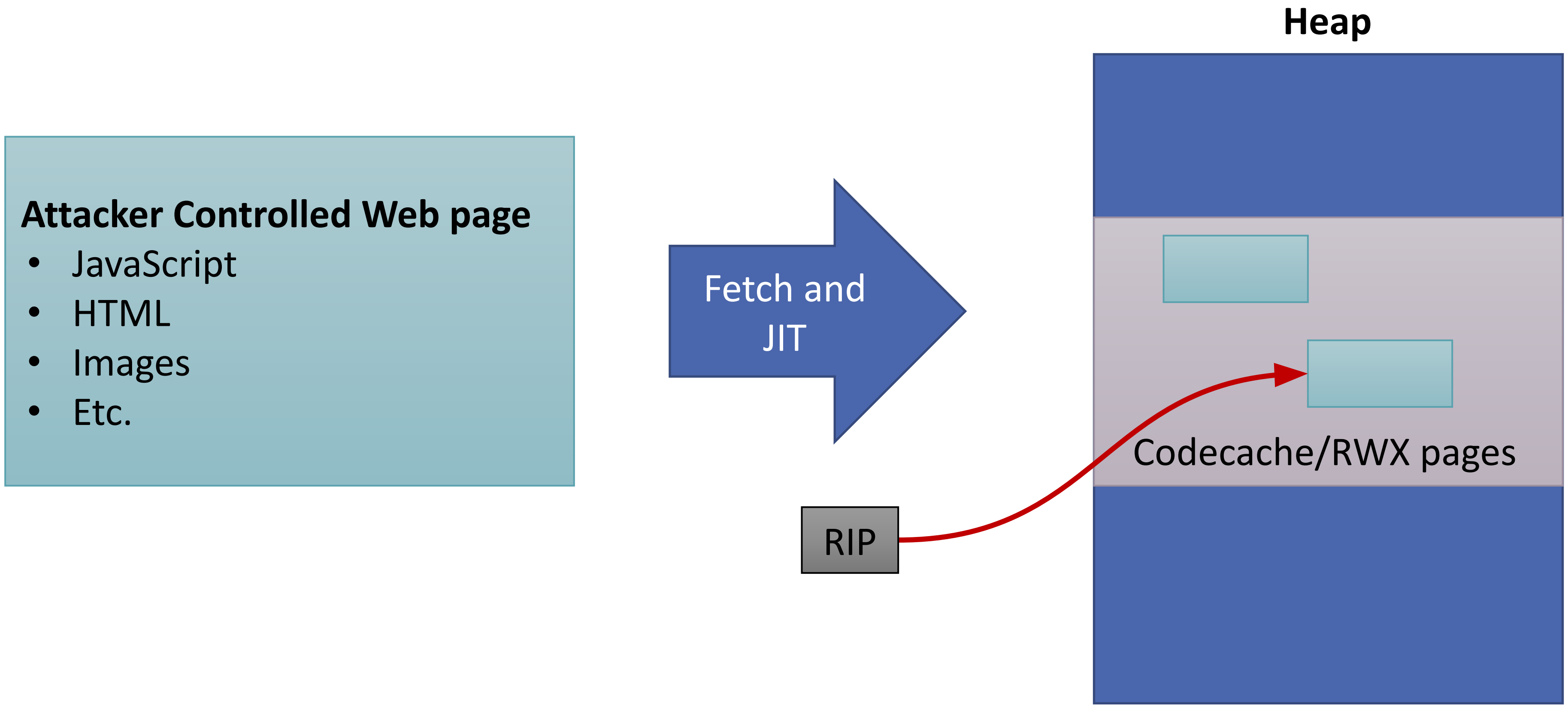

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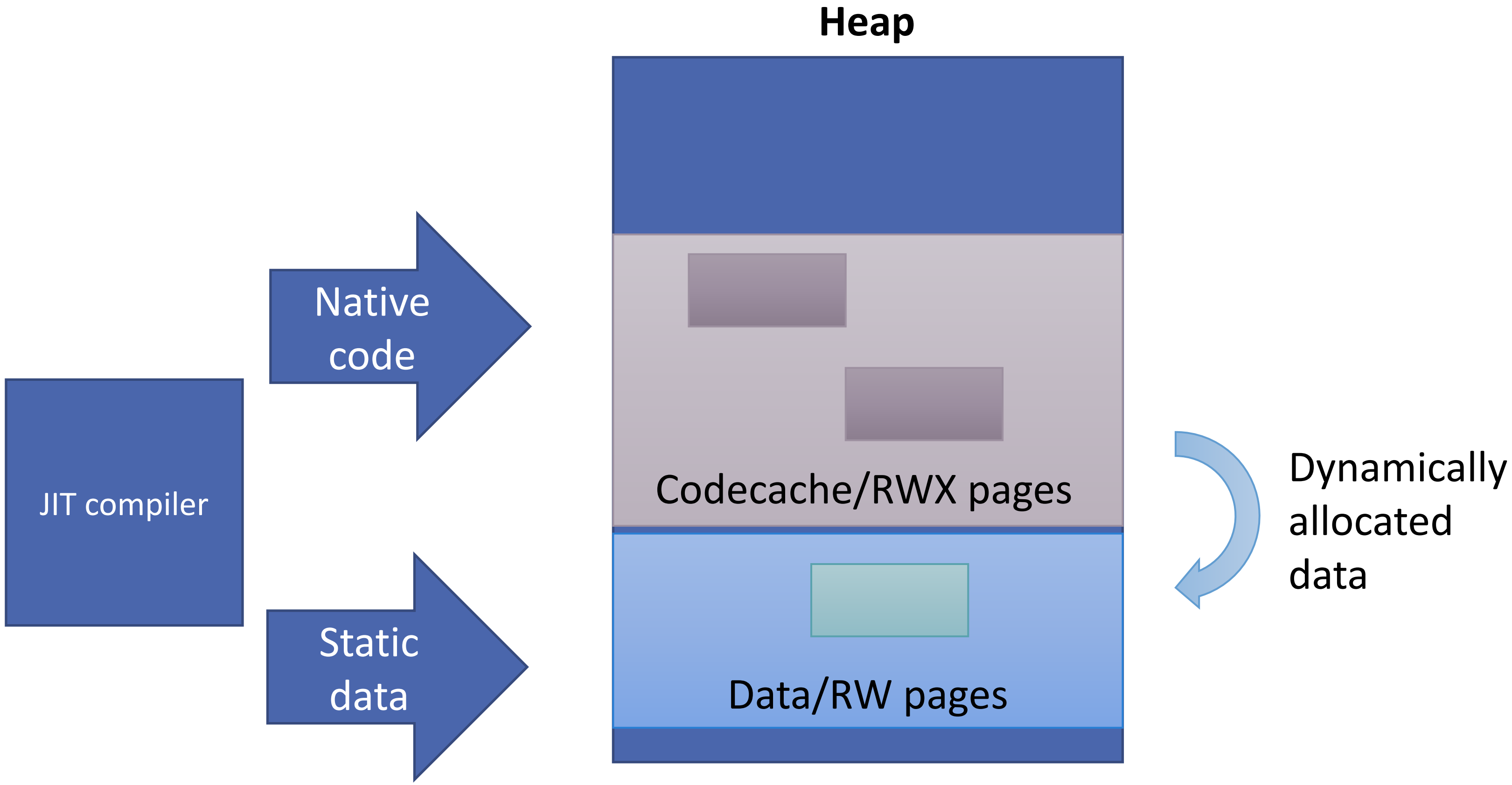
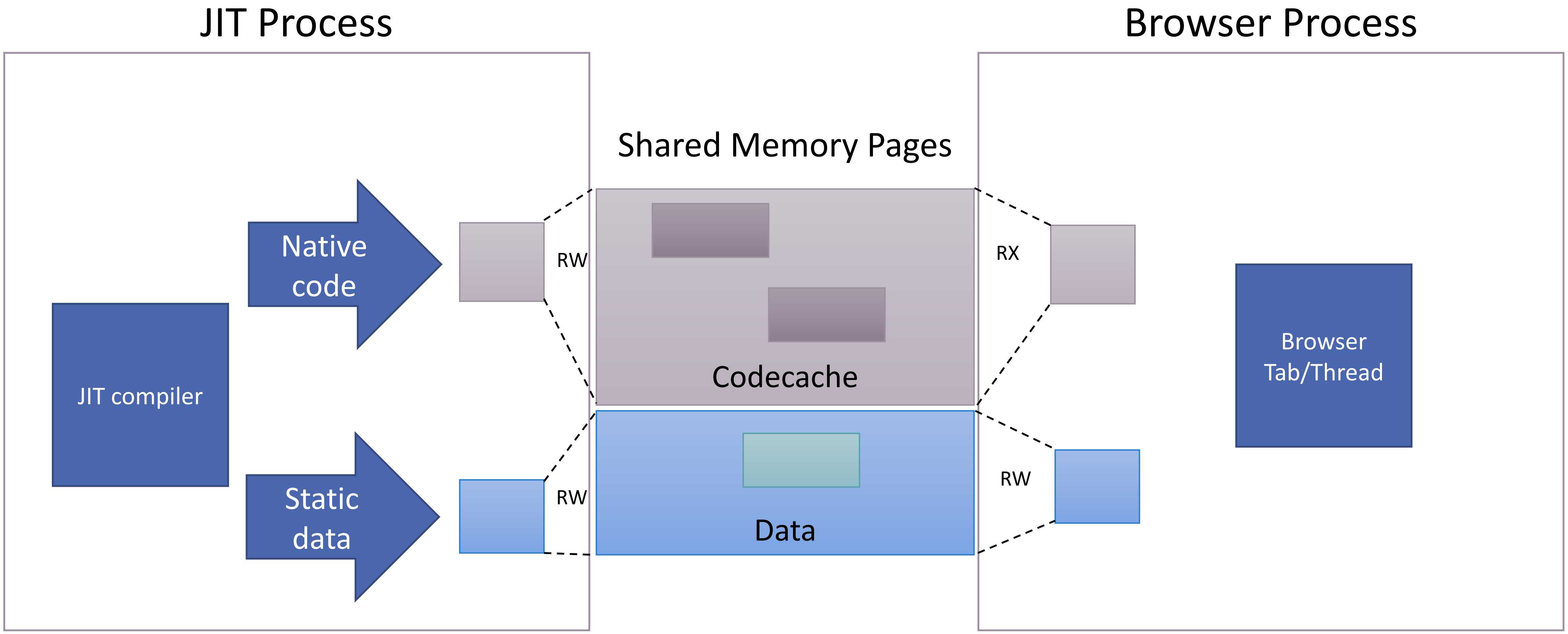


W^X Semantics in Browser Processes



Additional Reading

- The Devil is in the Constants: Bypassing Defenses in Browser JIT Engines
  - https://www.portokalidis.net/files/devilinconstants_ndss15.pdf
- libmpk: Software Abstraction for Intel Memory Protection Keys (Intel MPK)
  - https://www.usenix.org/system/files/atc19-park-soyeon.pdf