Scalable Cloud Security via Asynchronous Virtual Machine Introspection

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Introduction

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- Existing techniques for prevention are slow to detect attacks.
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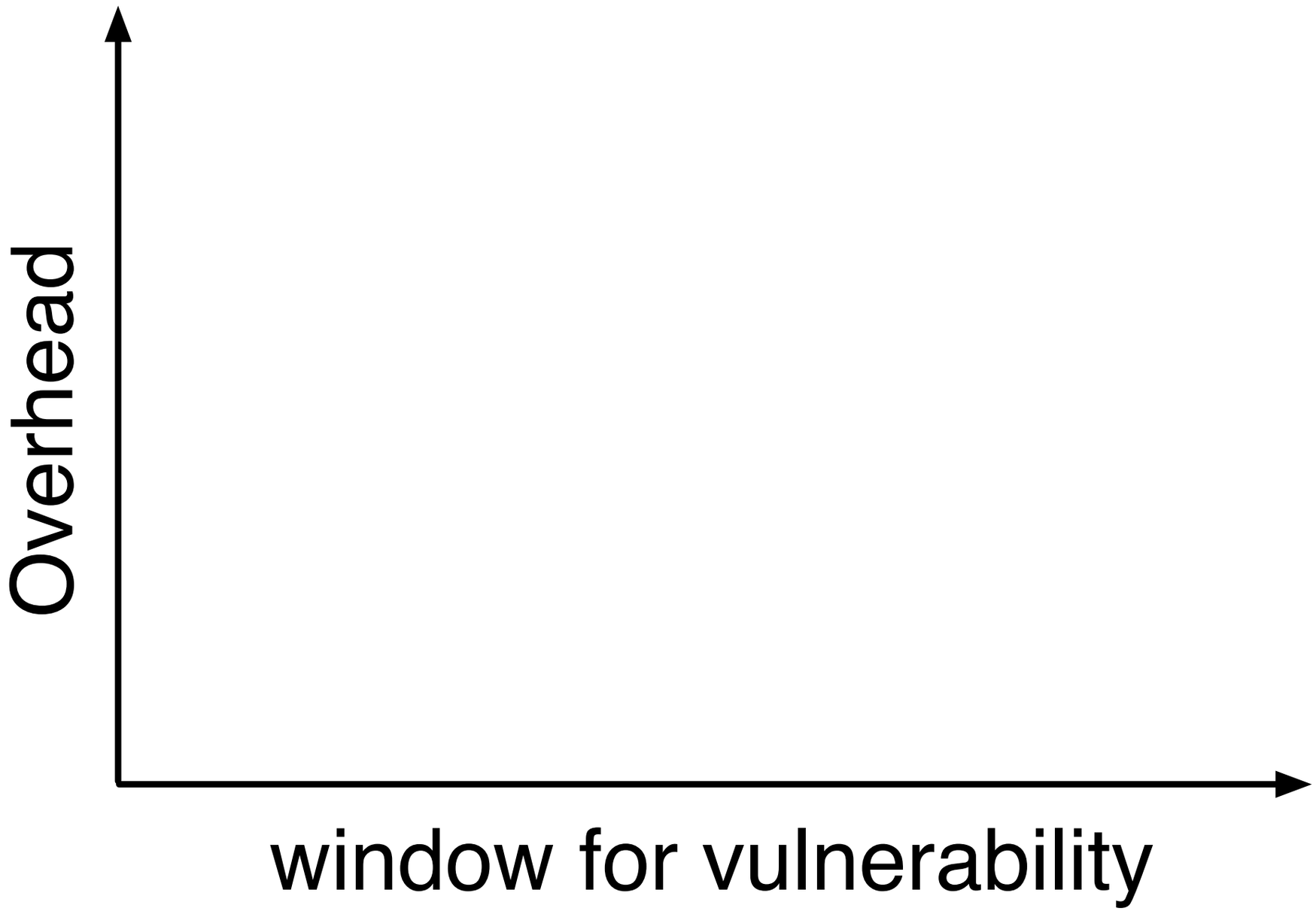
How can the cloud detect attacks inside a VM?
How to provide strong security guarantees at low cost?

ScaaS

- **Scanning as a Service** framework for security in cloud data centers.
    - Scans for a wide range of attacks within both application and the operating system.
- Uses an **asynchronous checkpointing** mechanism to replicate a VM's memory onto a Scanner host for analysis.
- Uses **VM introspection** techniques to study the memory of the virtual machine.

Where do we stand?



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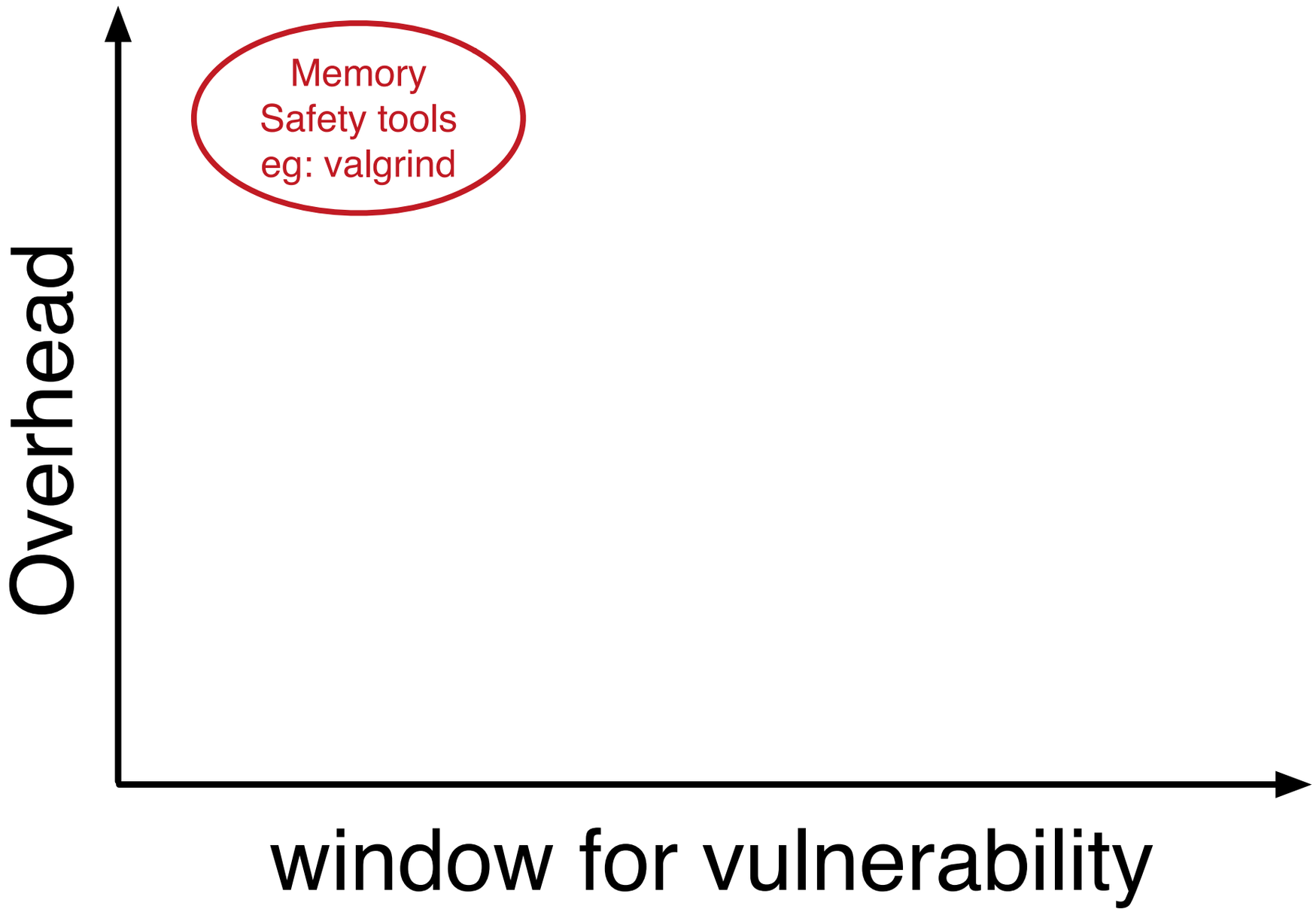

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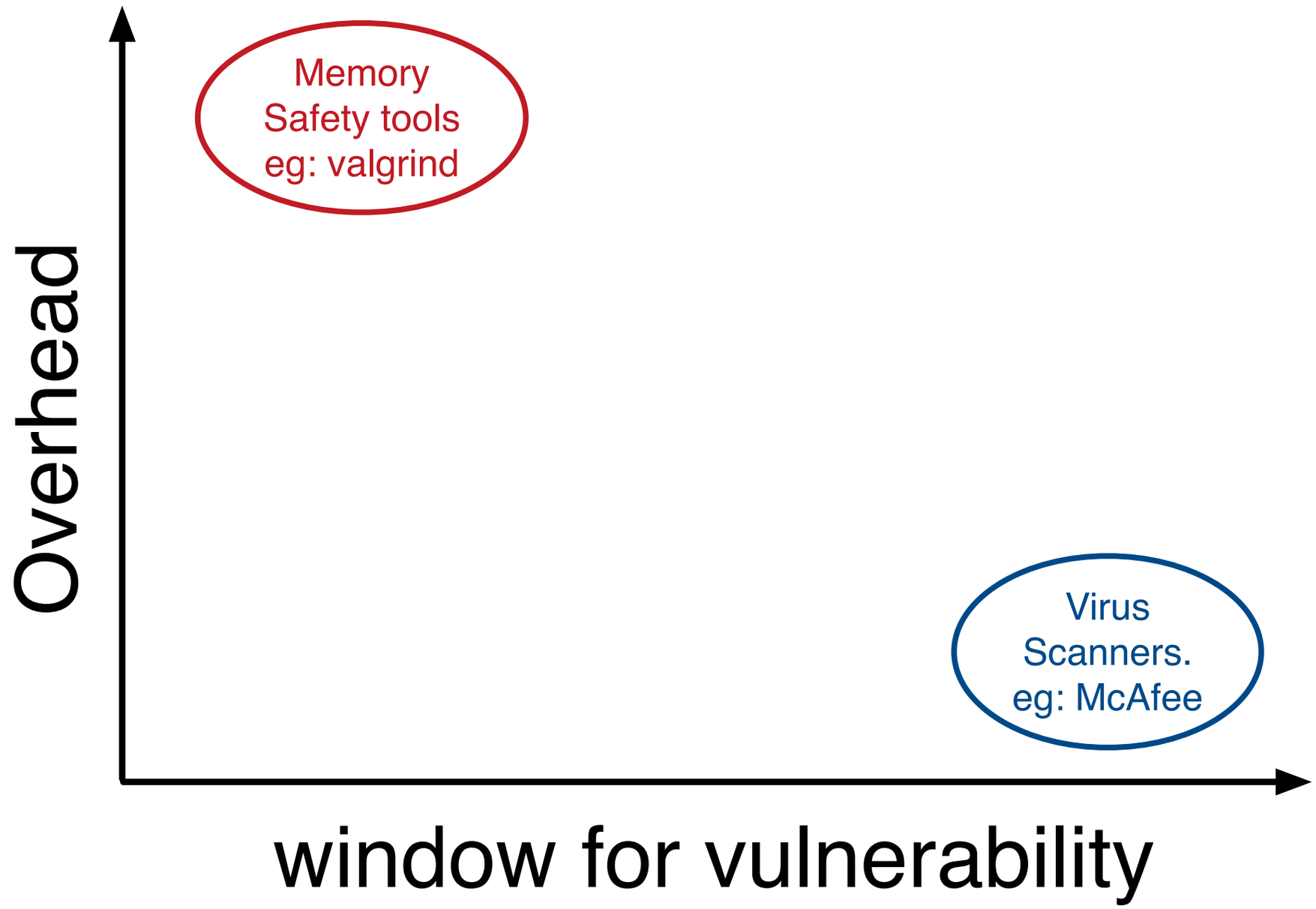

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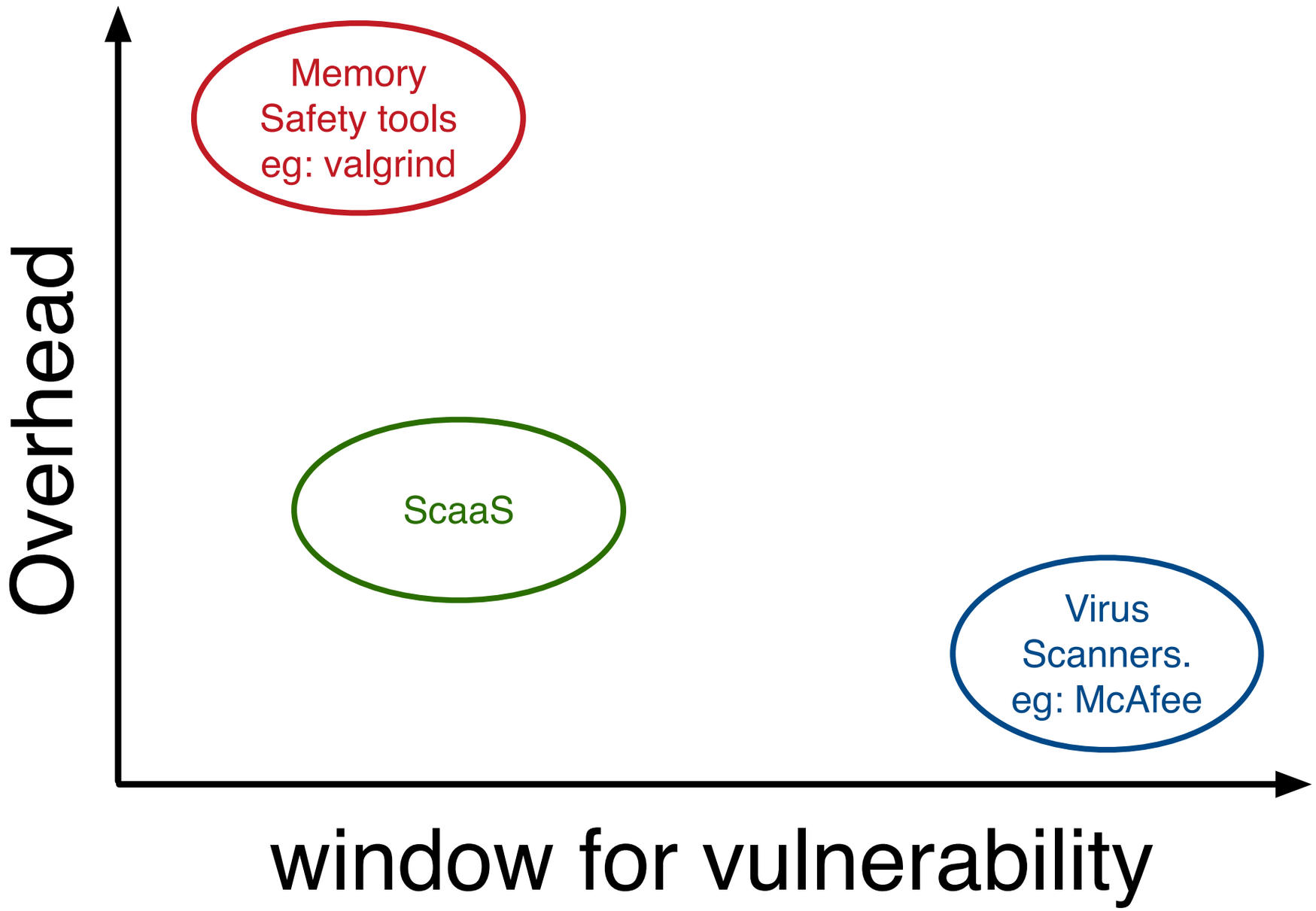
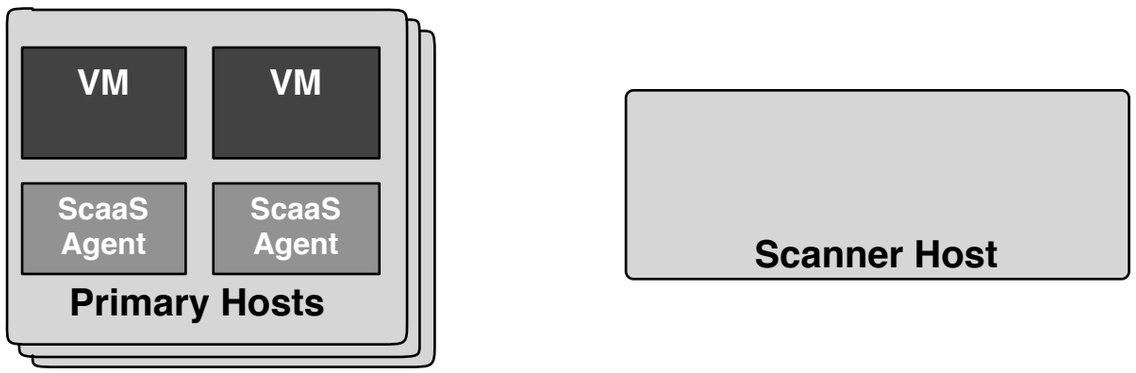


ScaaS Architecture



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- A Scanner host uses VM introspection techniques to search for evidence of vulnerabilities.
    - Ensures integrity of Key Kernel data structures.

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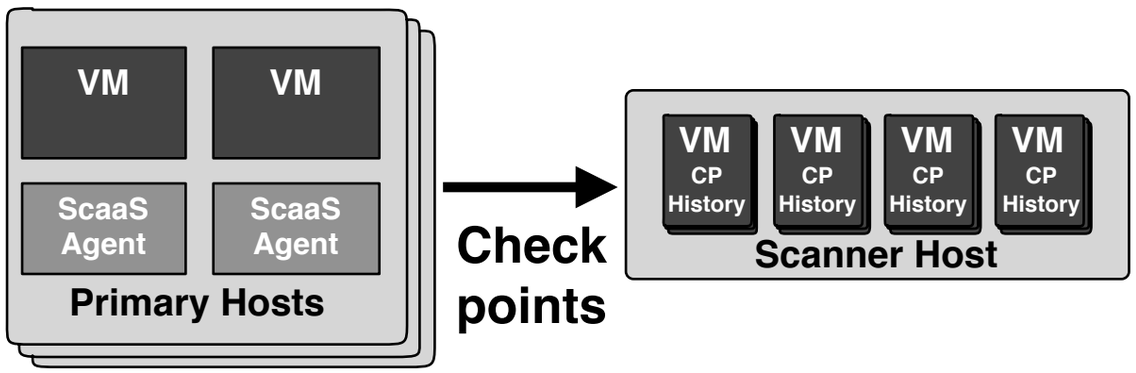

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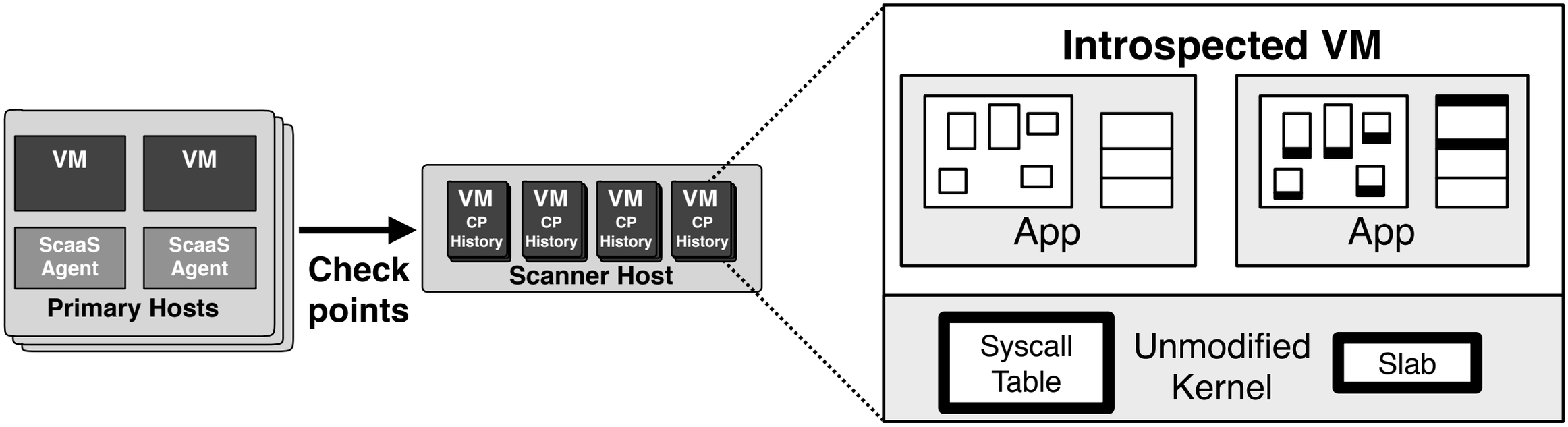

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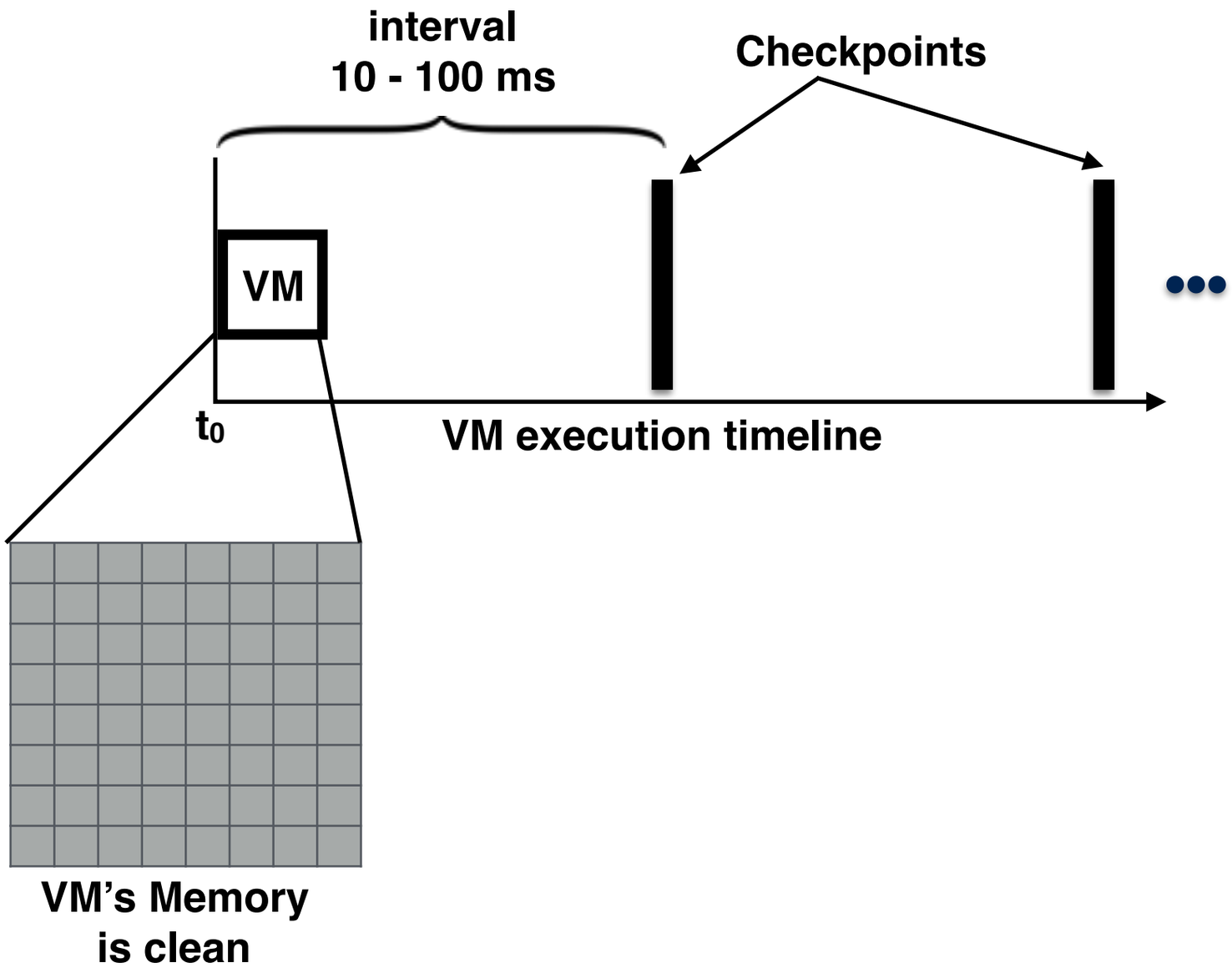

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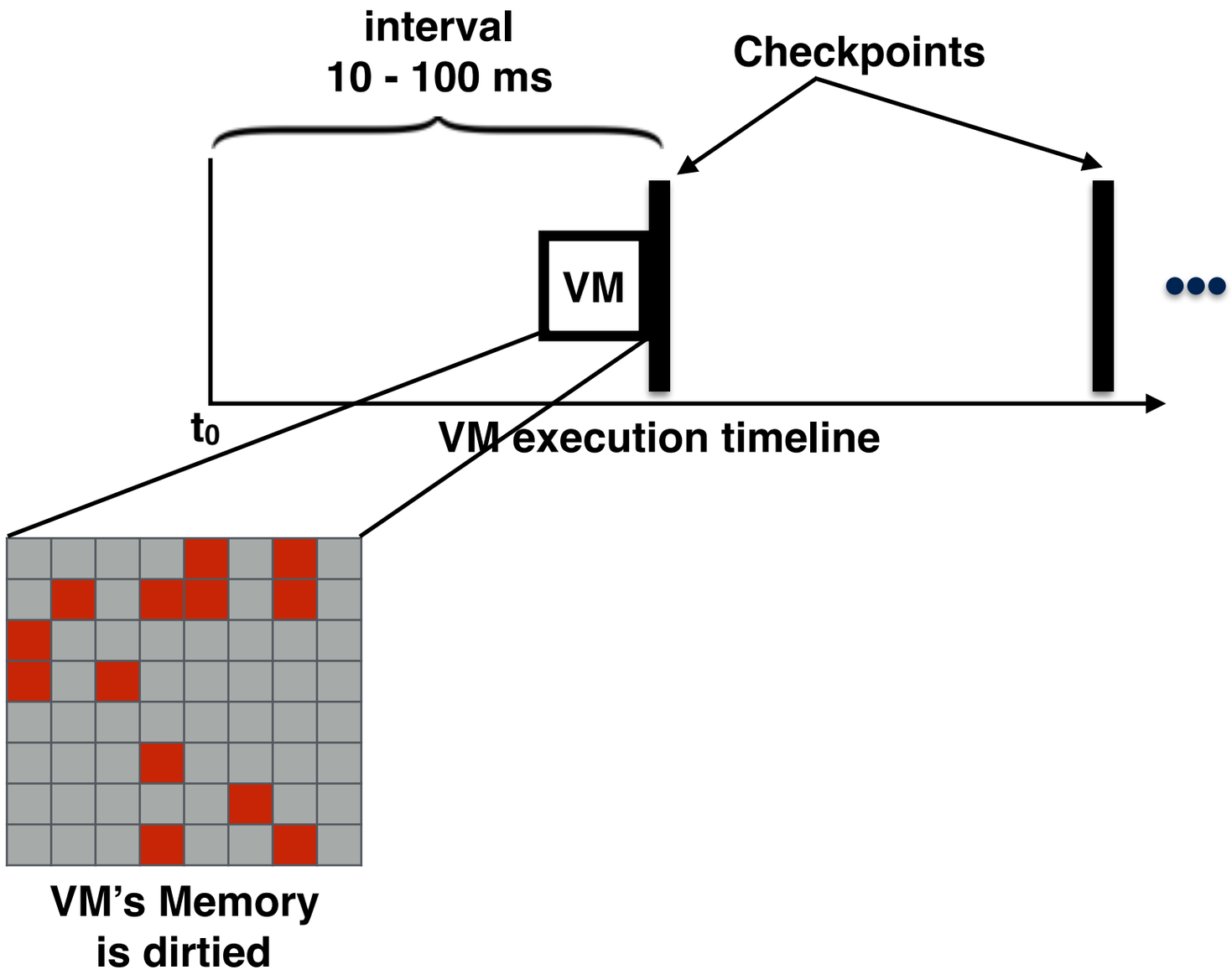

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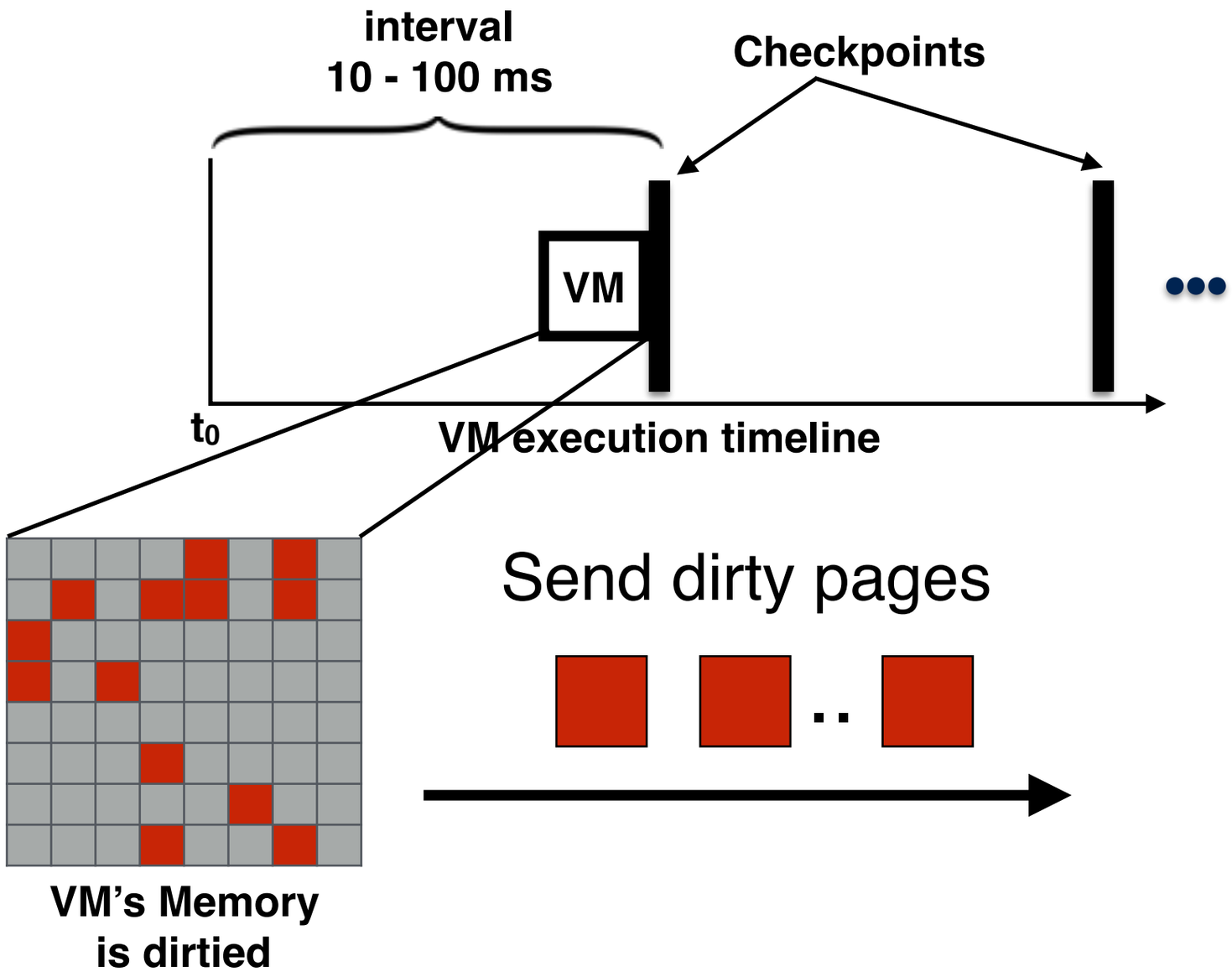

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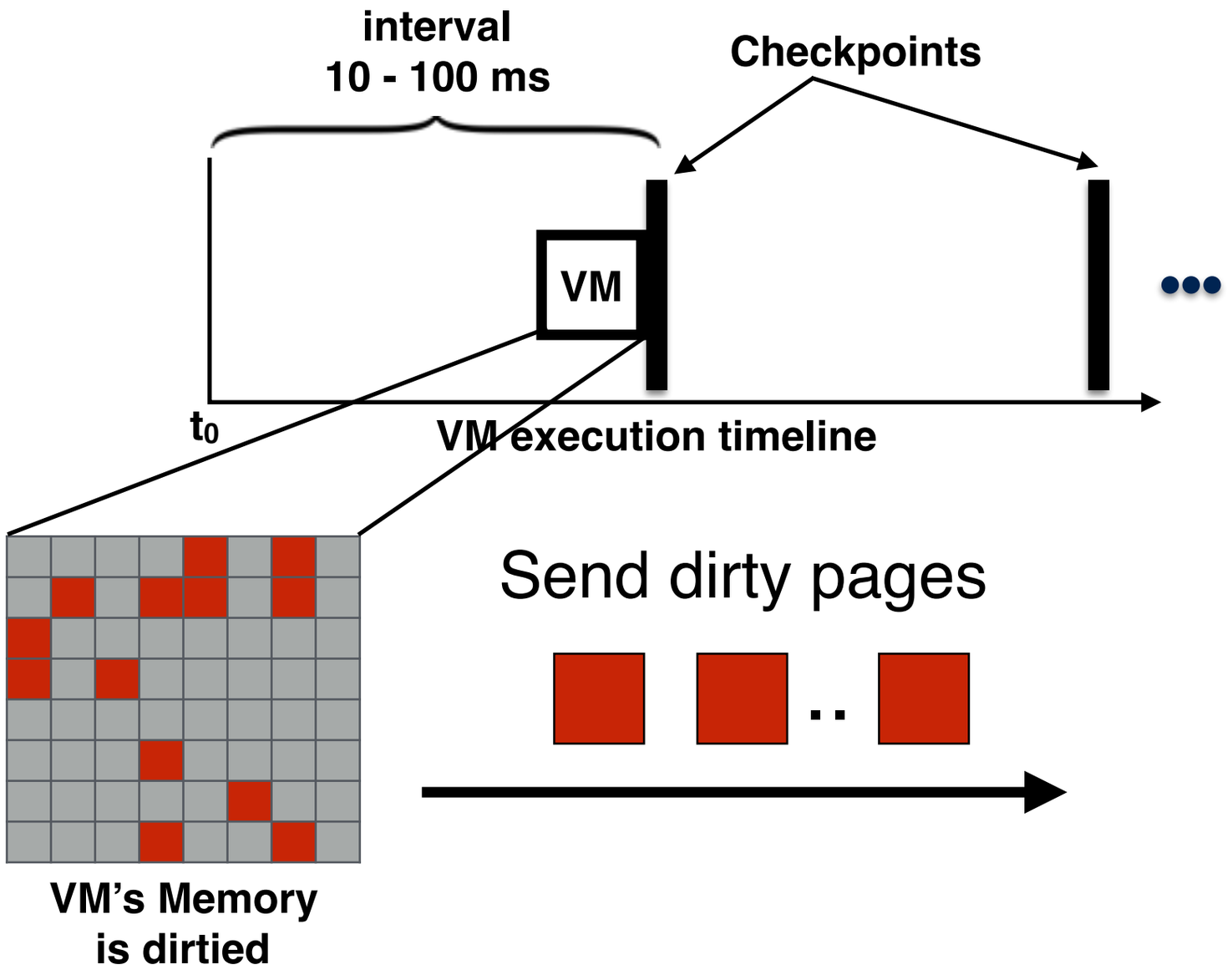

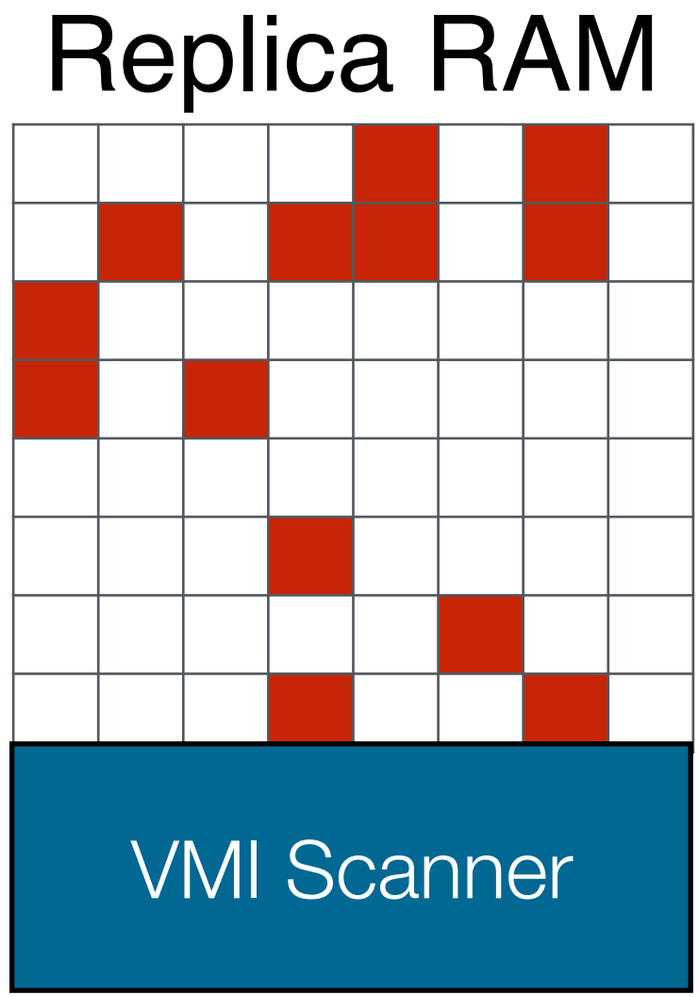

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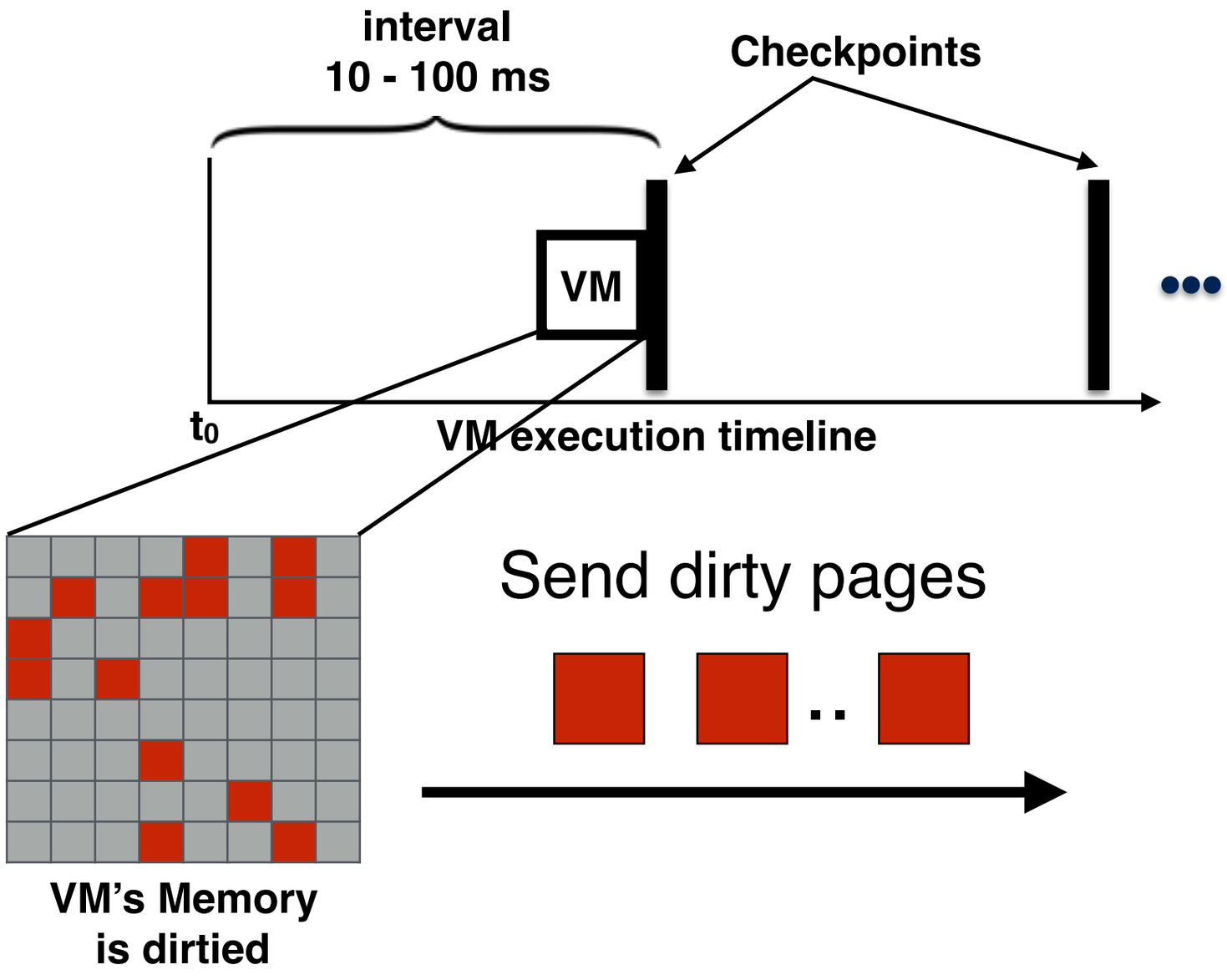

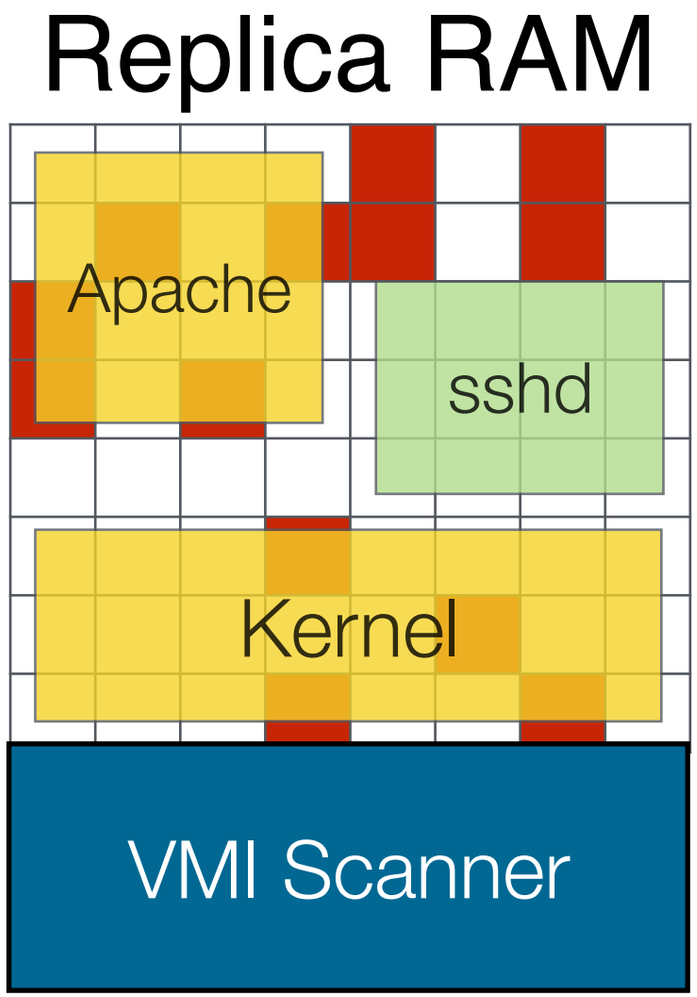

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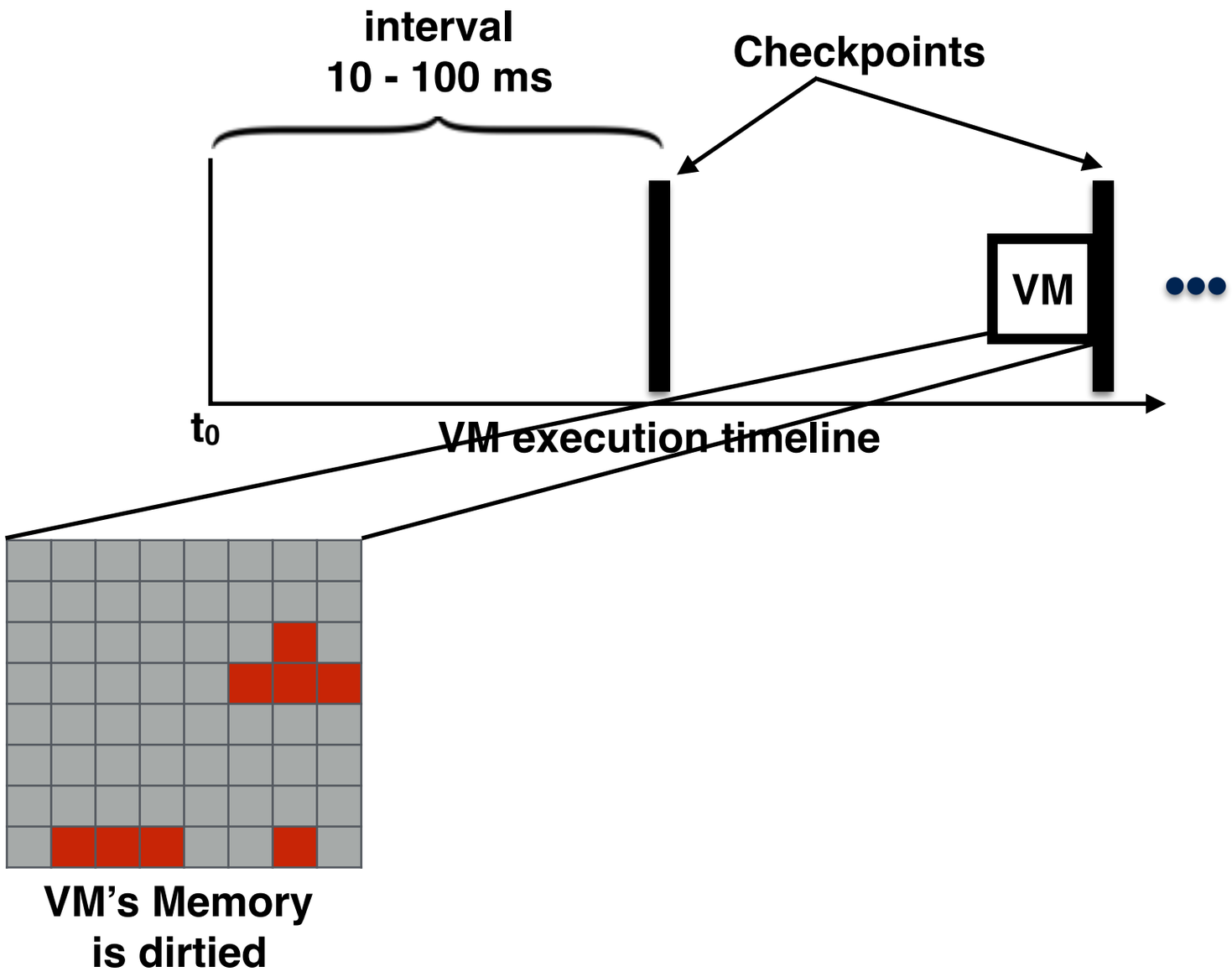

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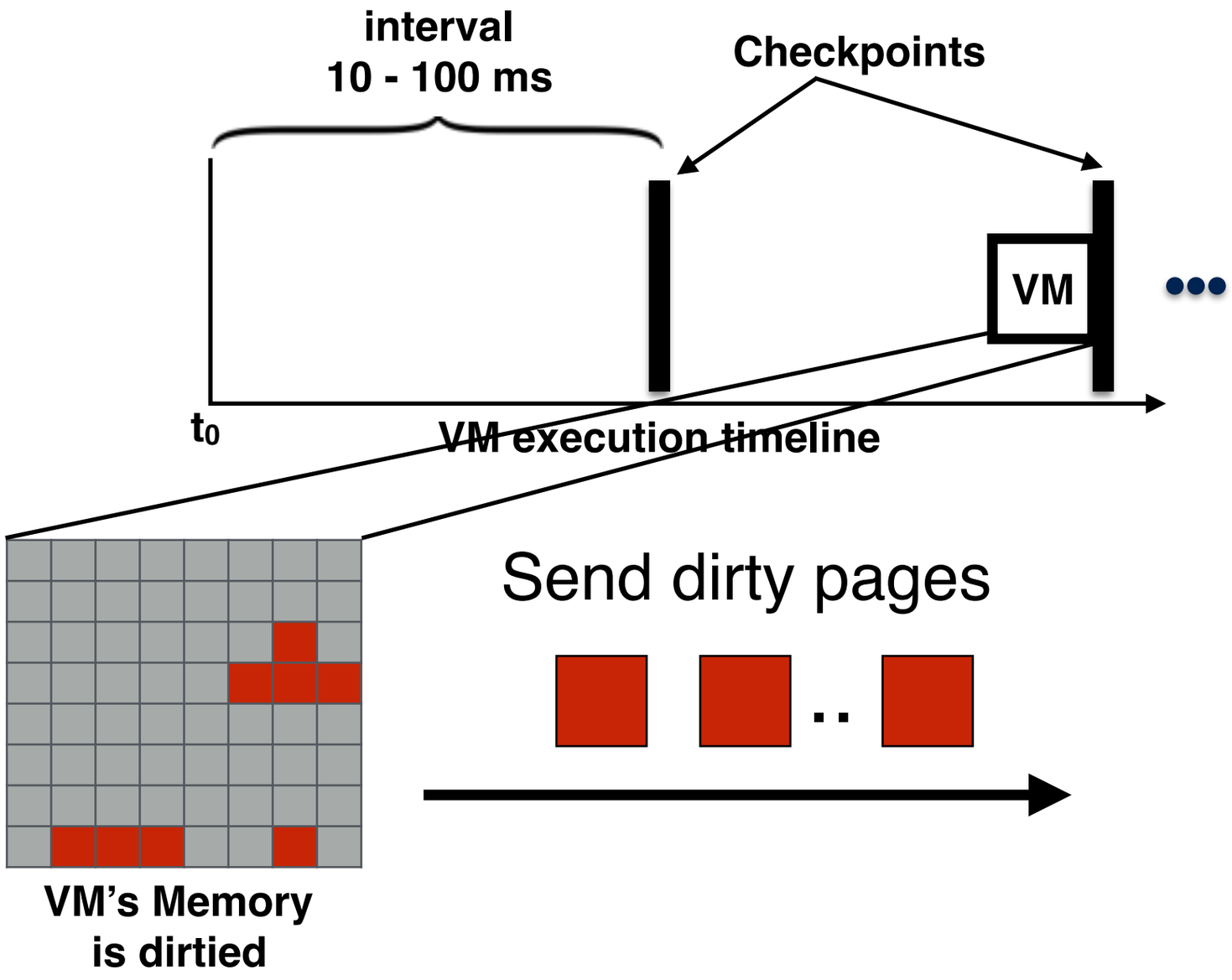

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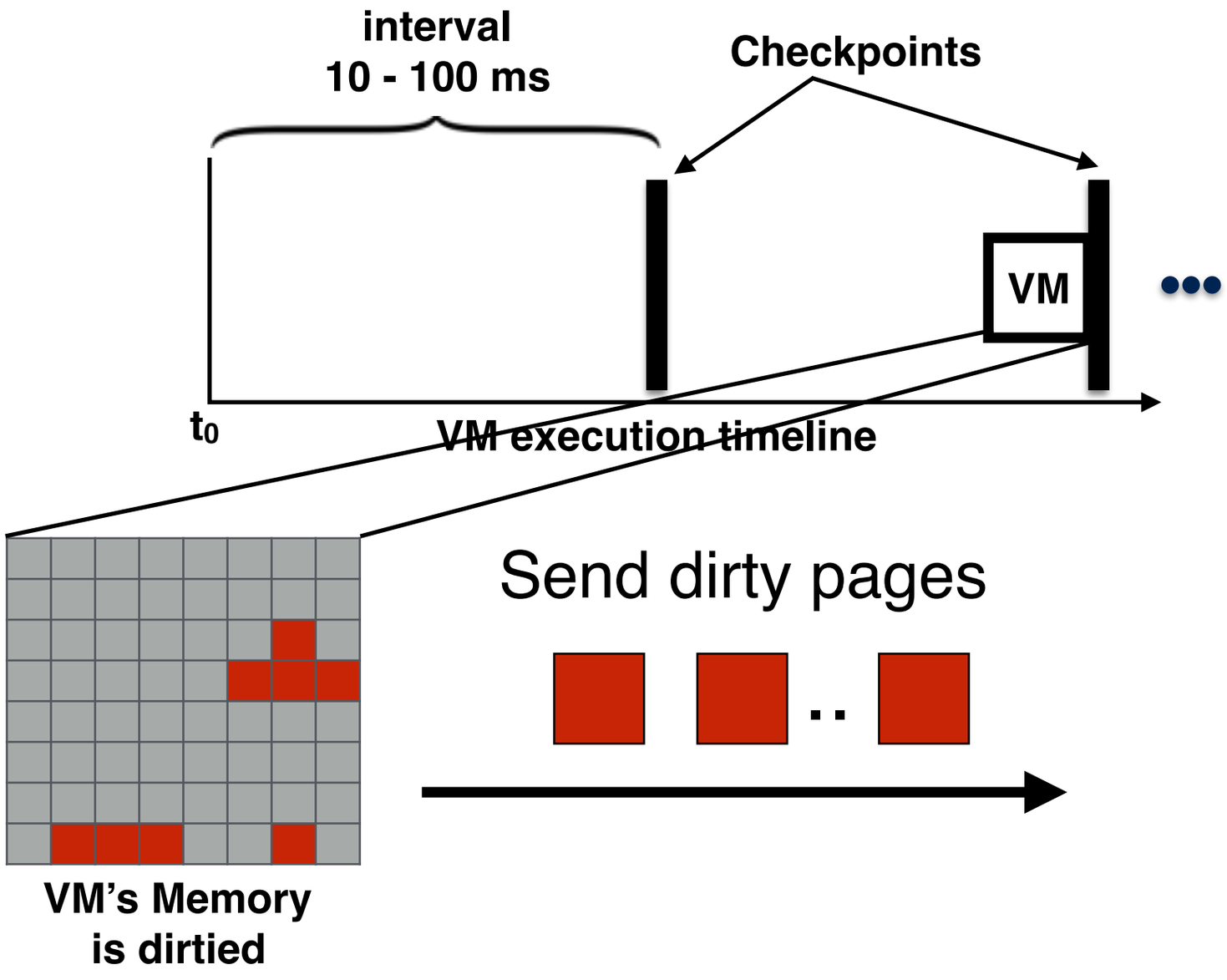

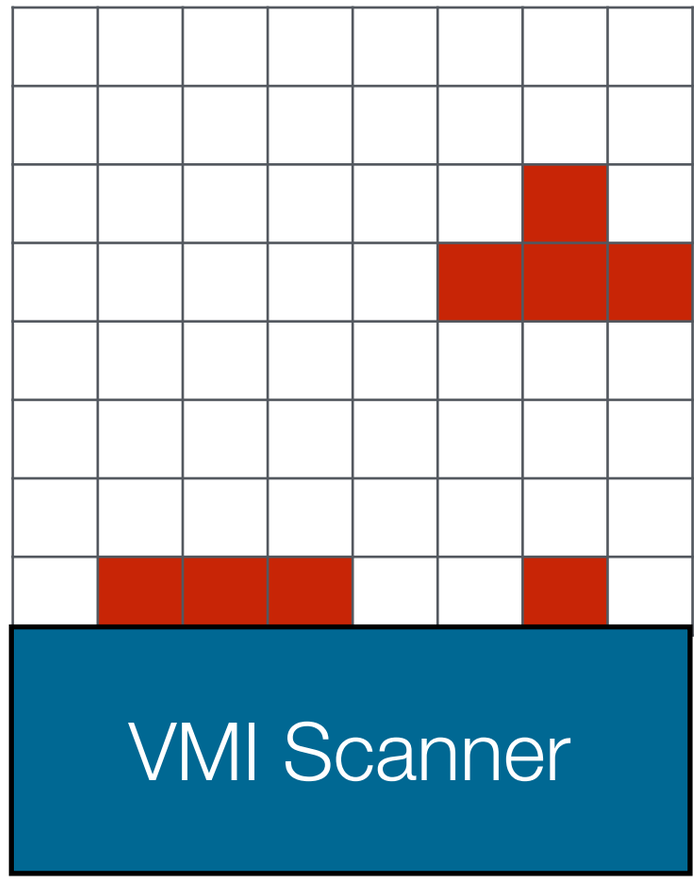

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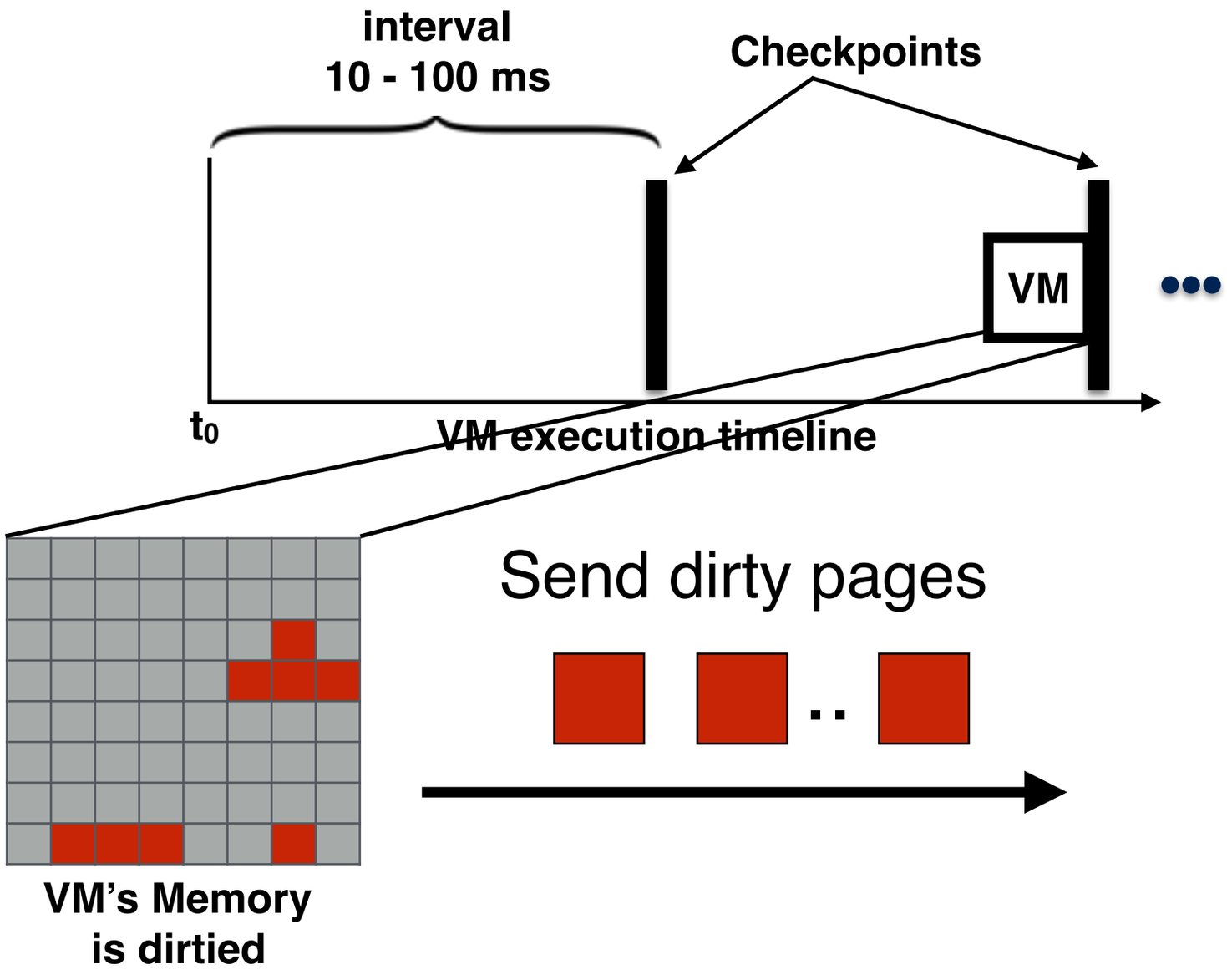
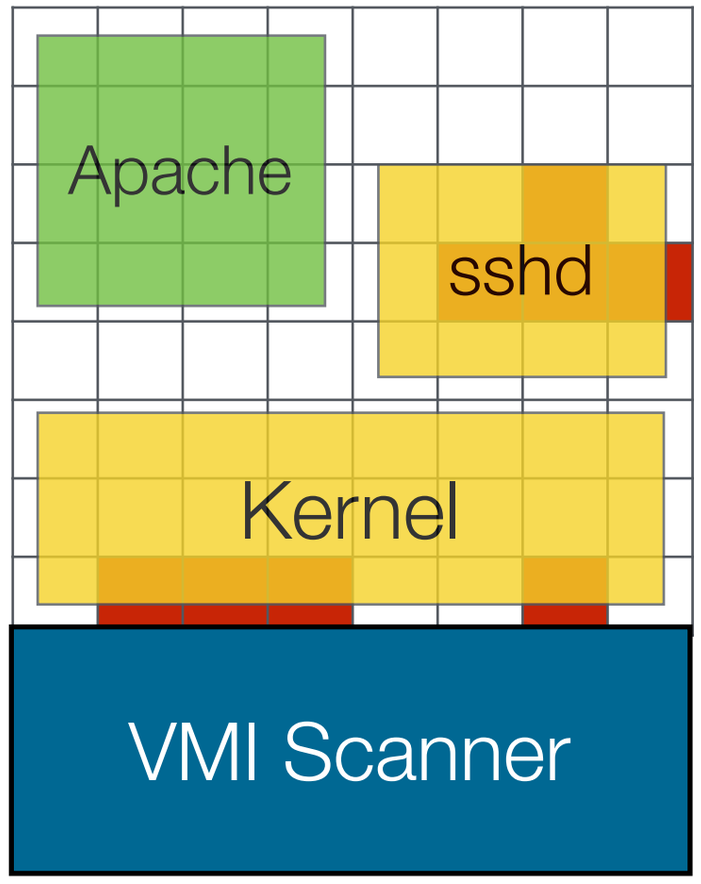
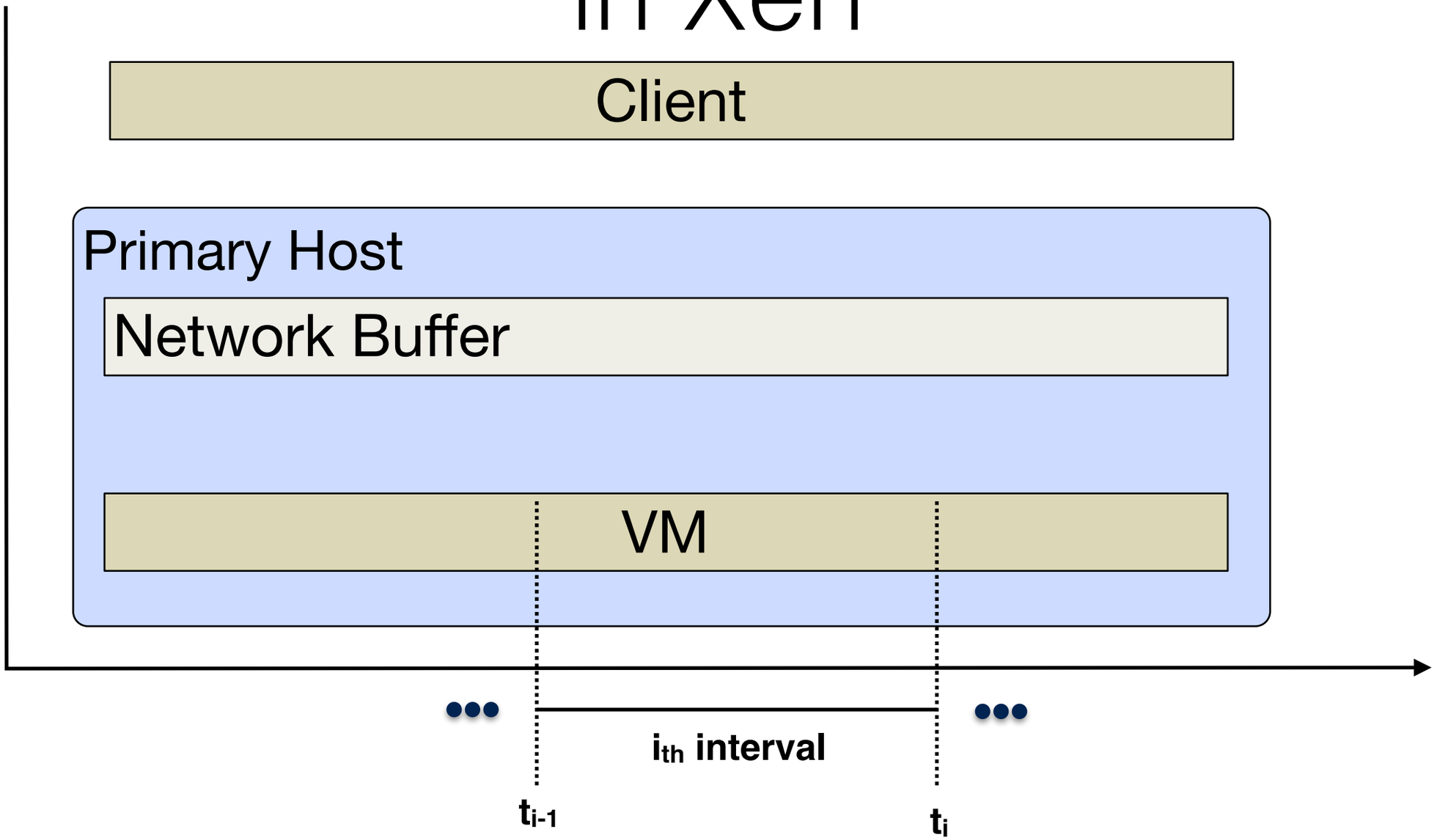




Network buffering using Remus in Xen



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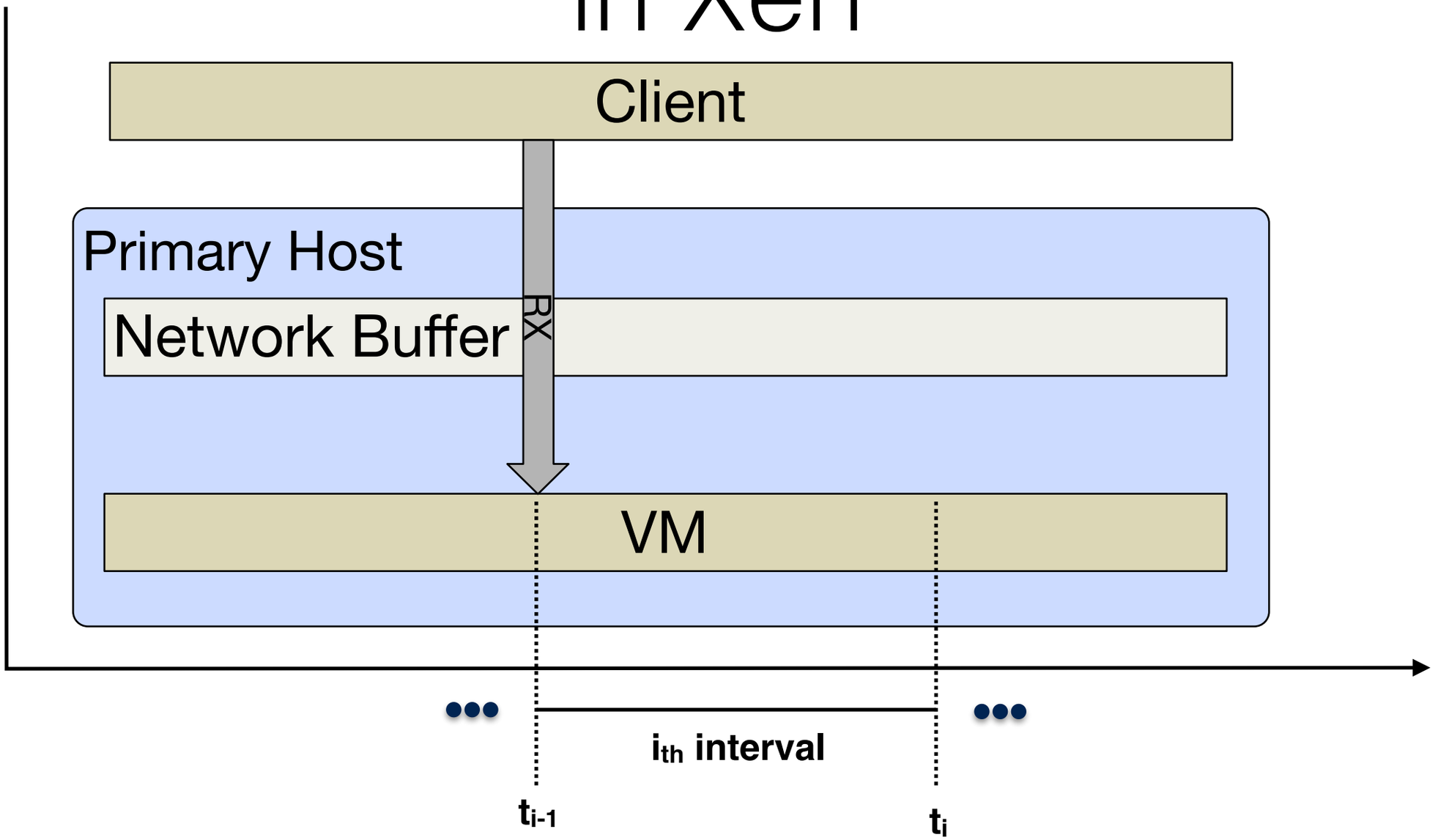

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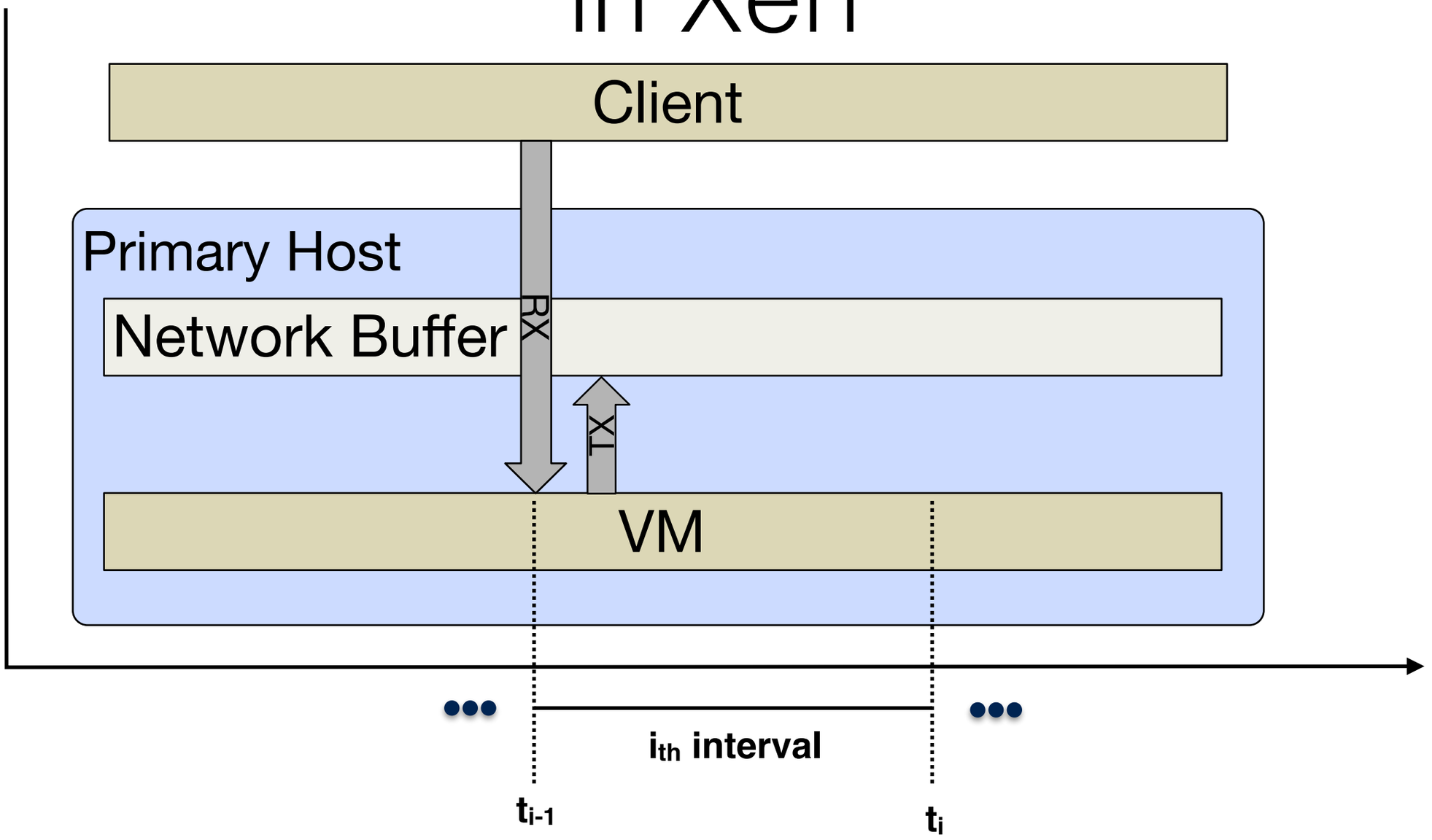

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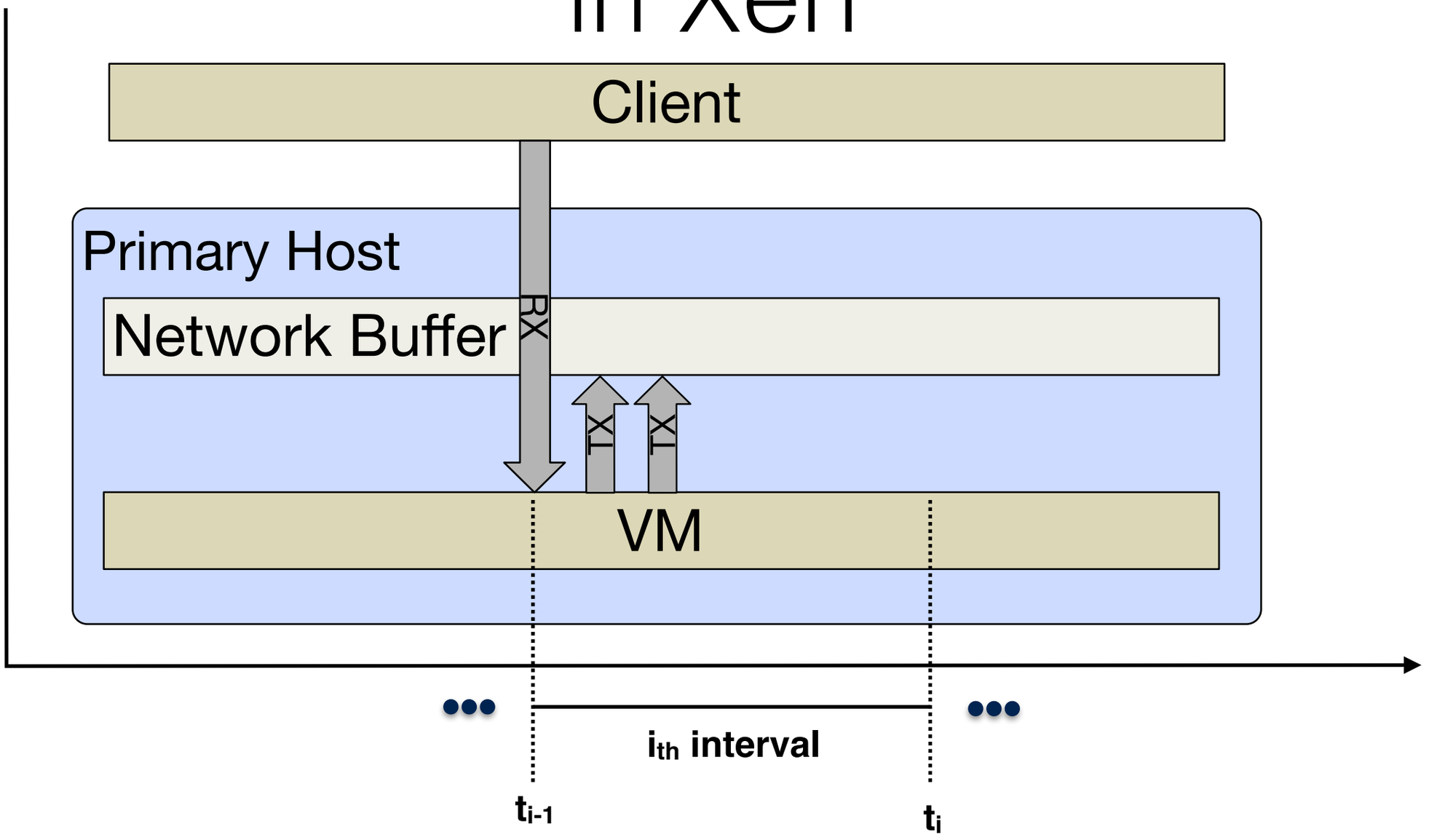

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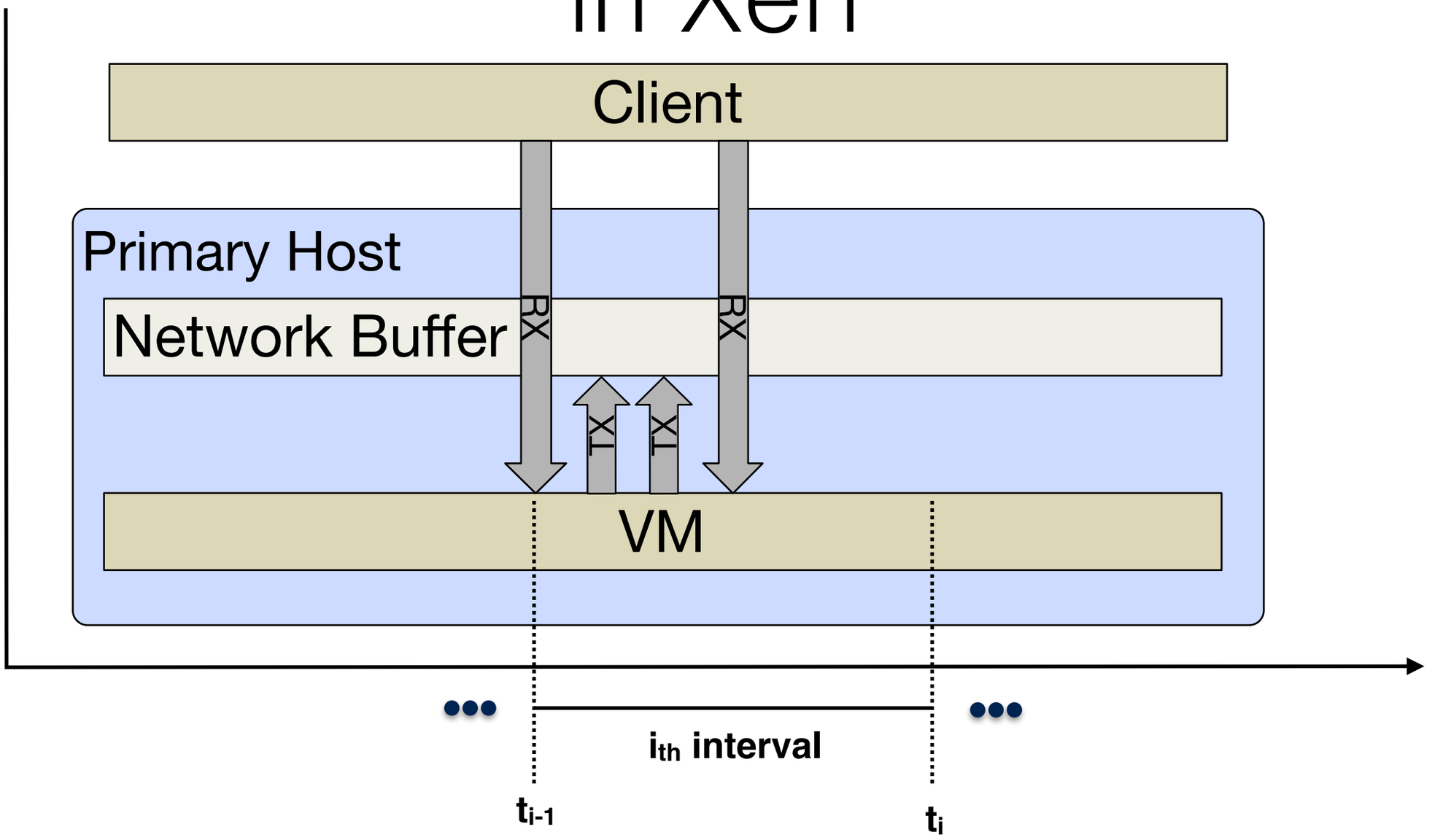

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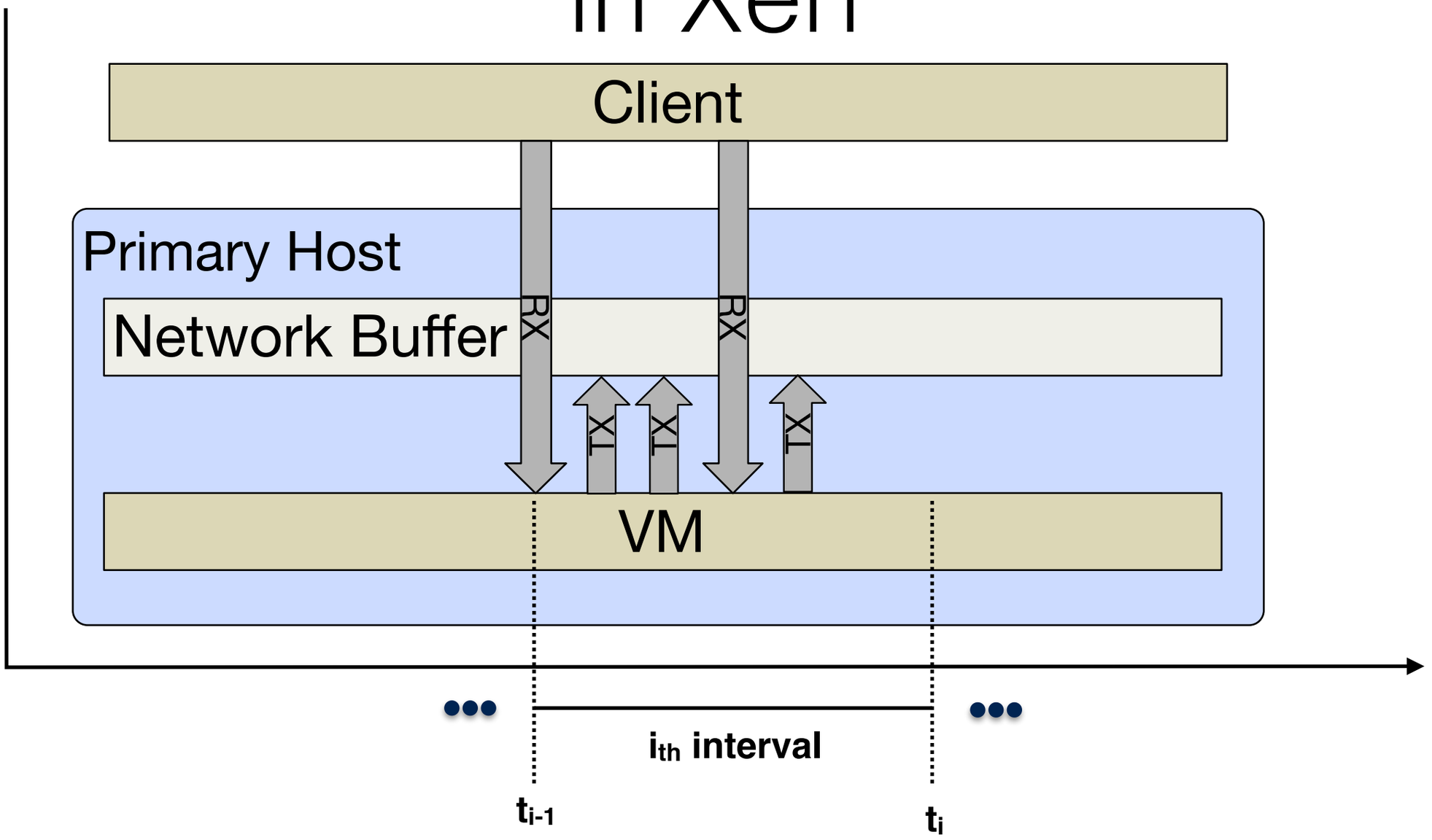

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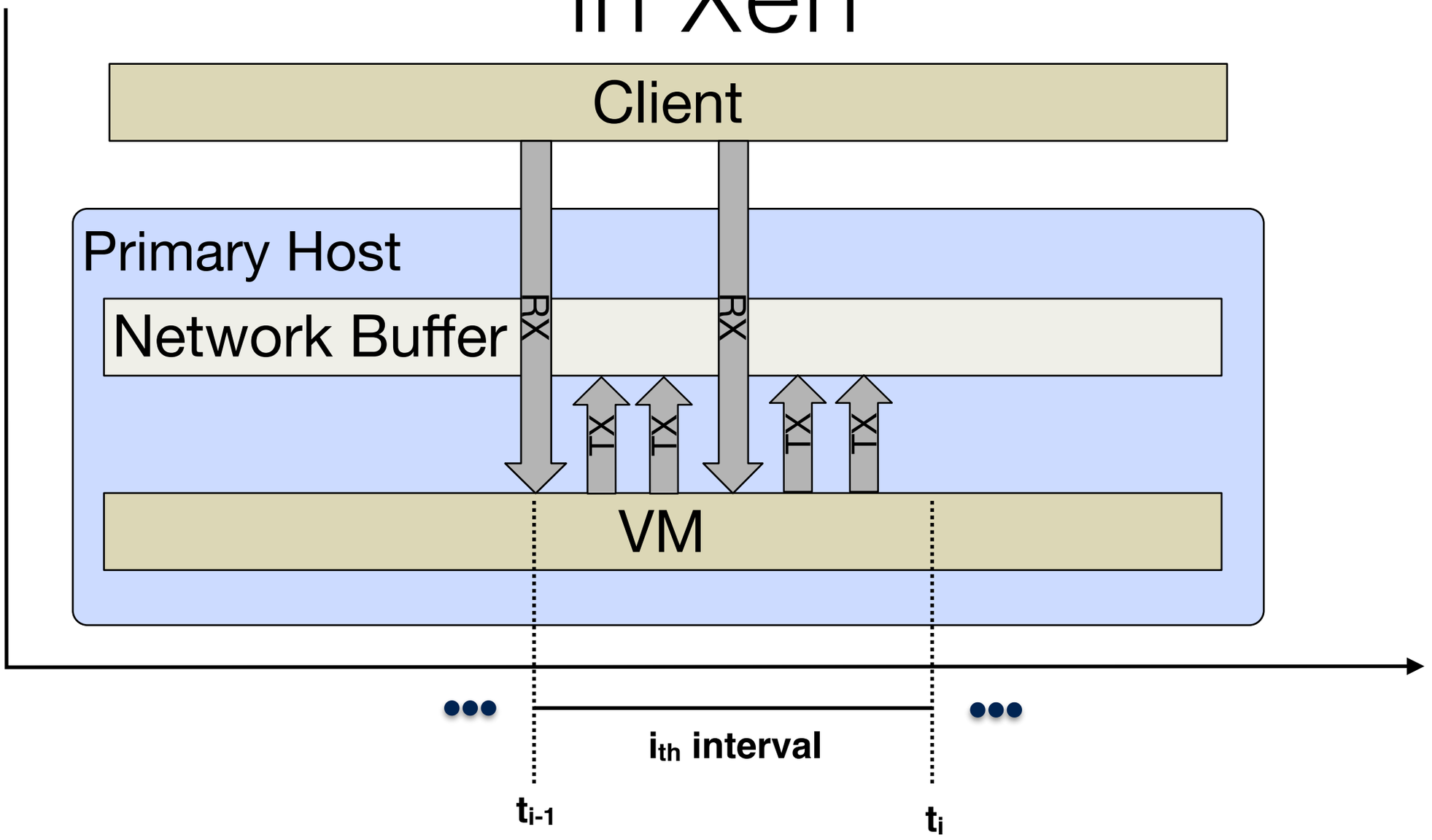

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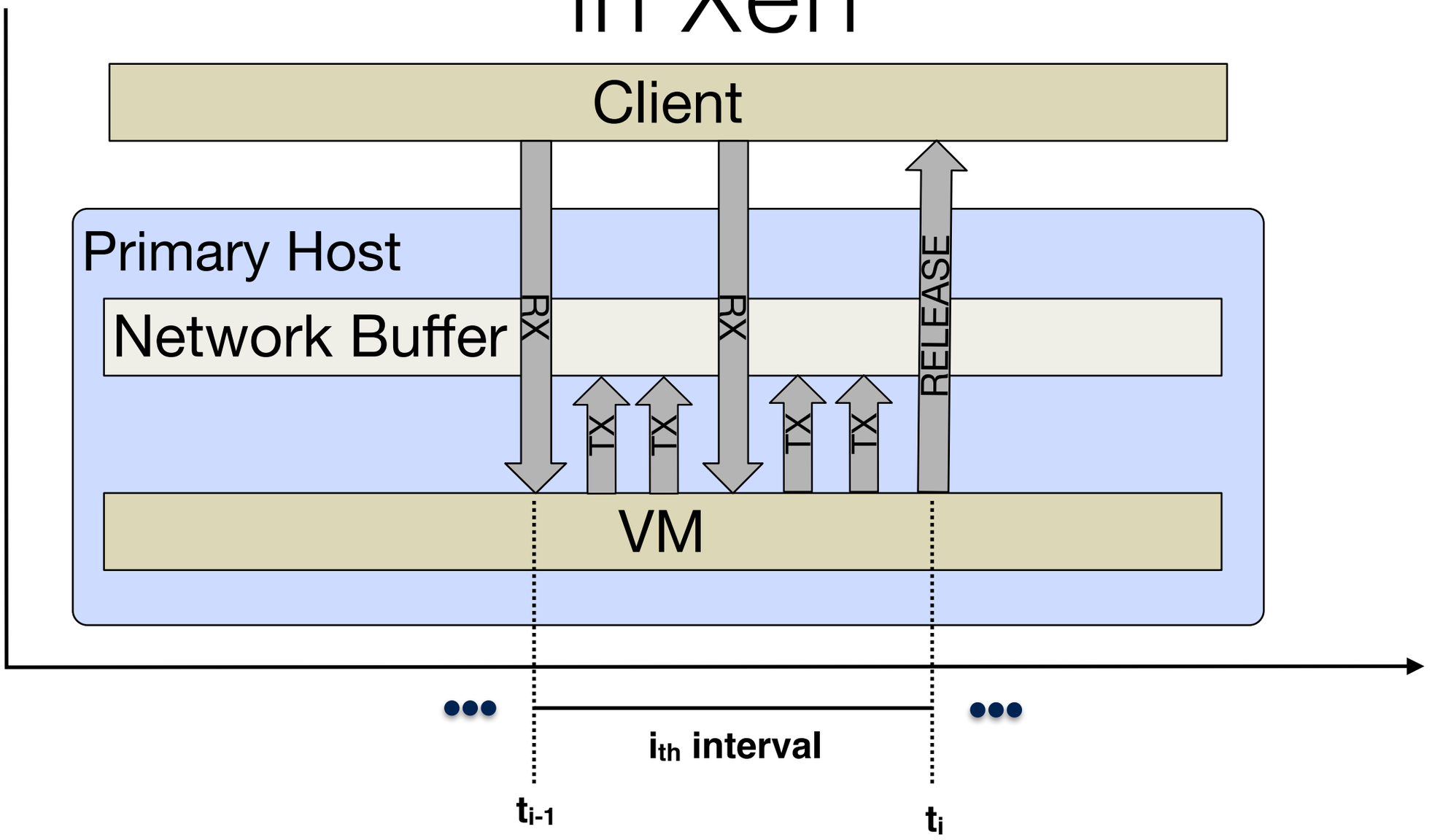

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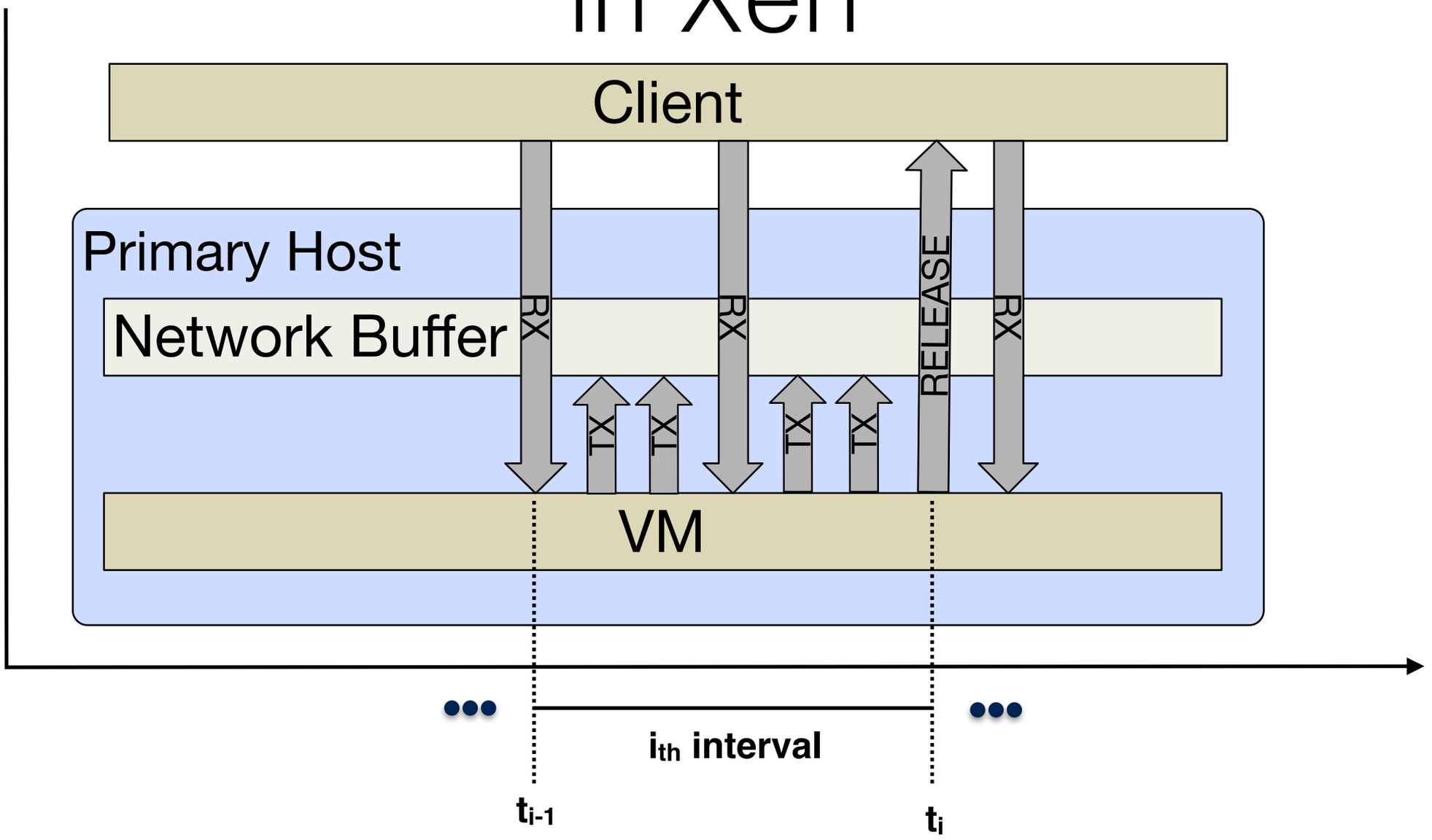

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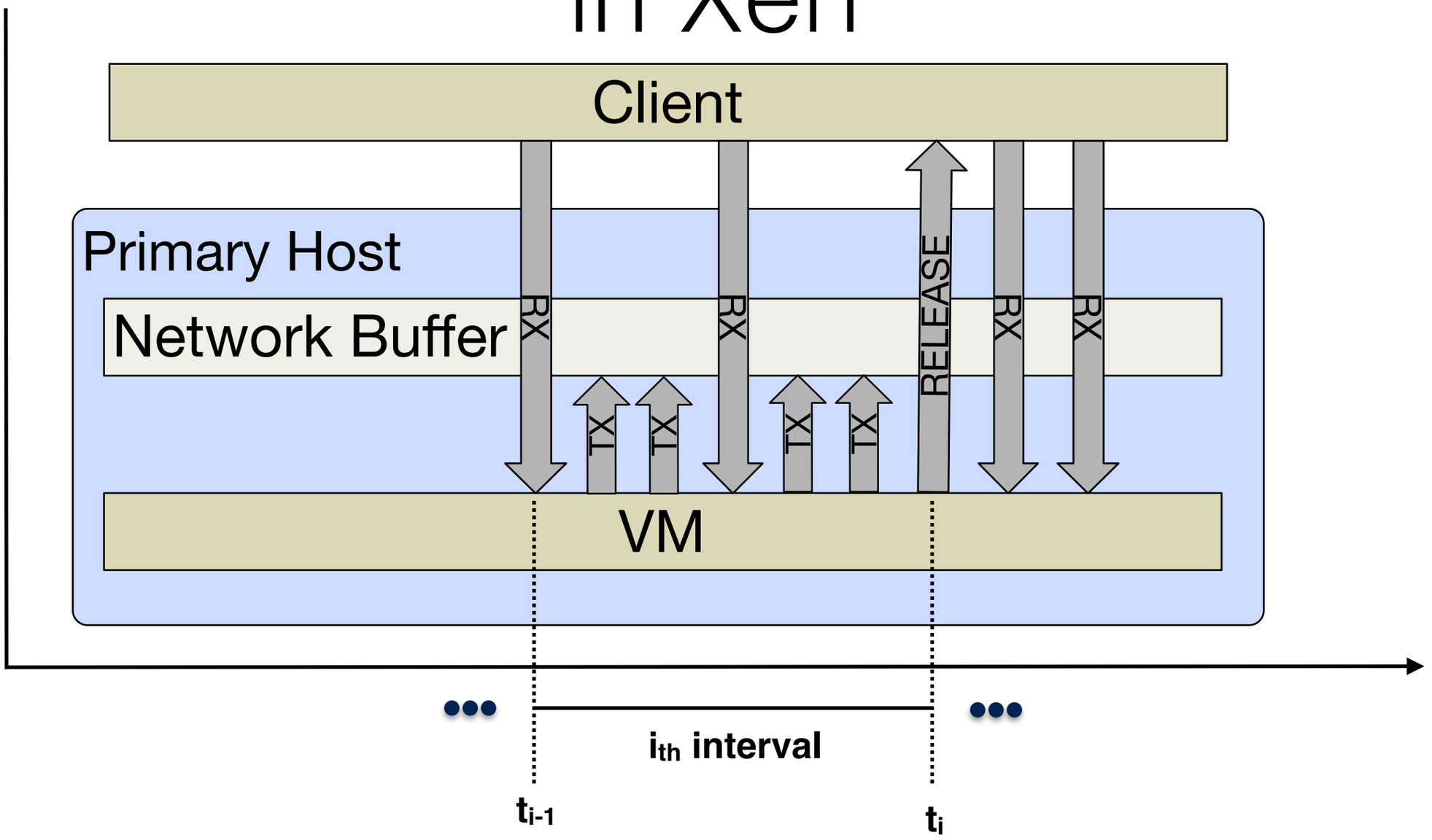

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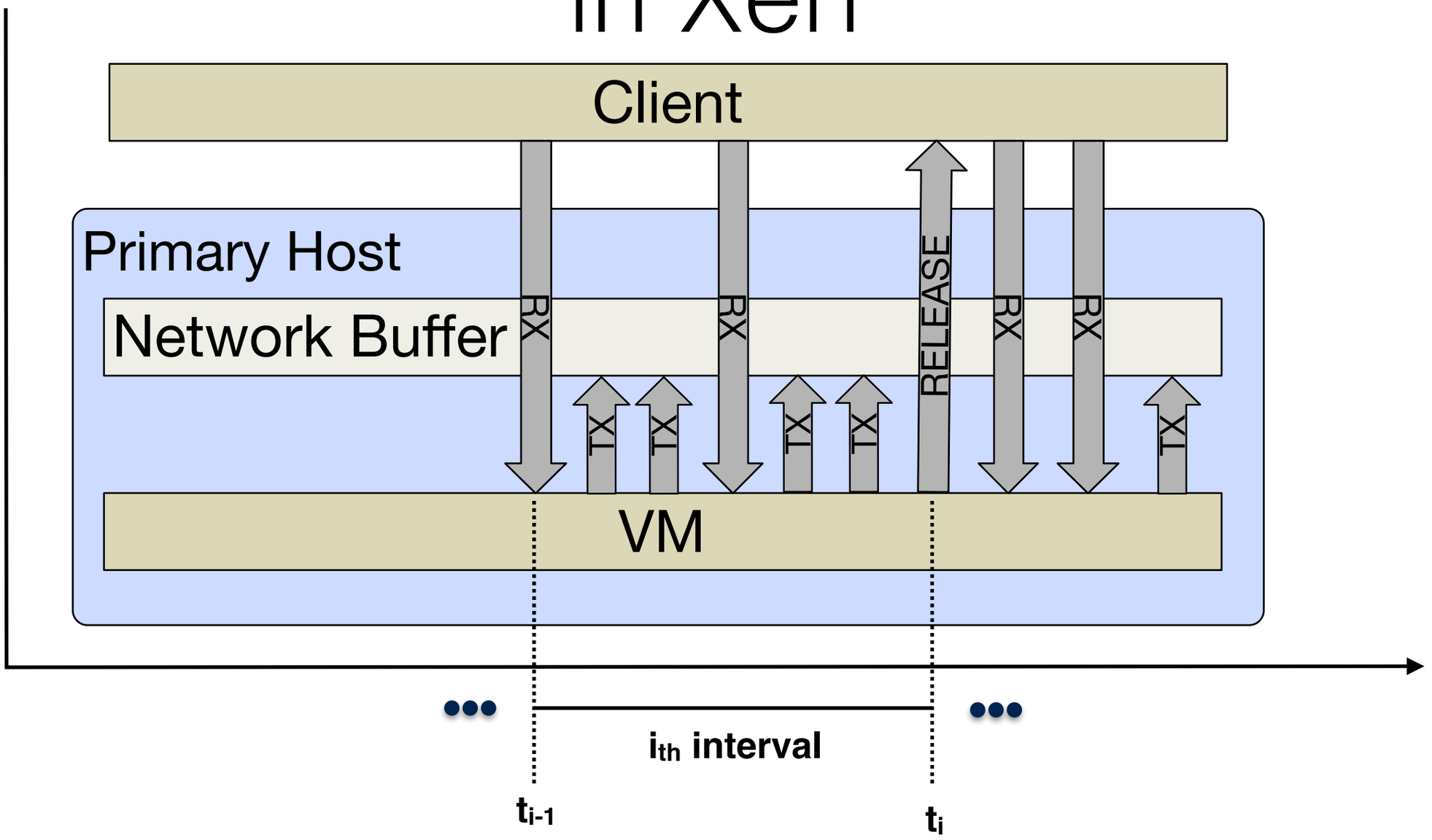

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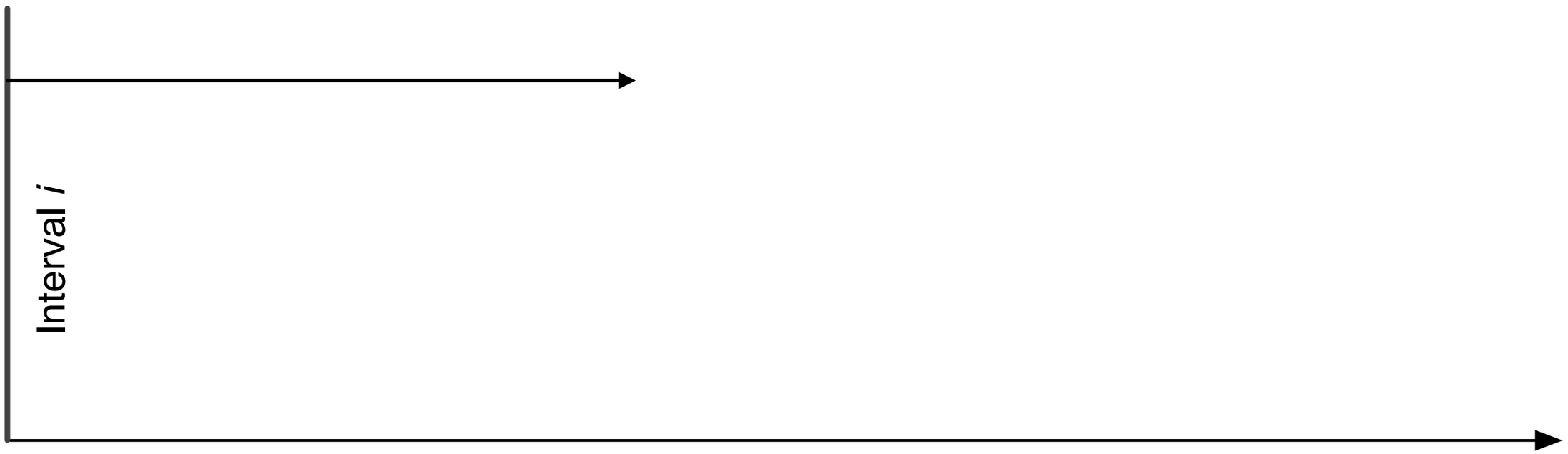

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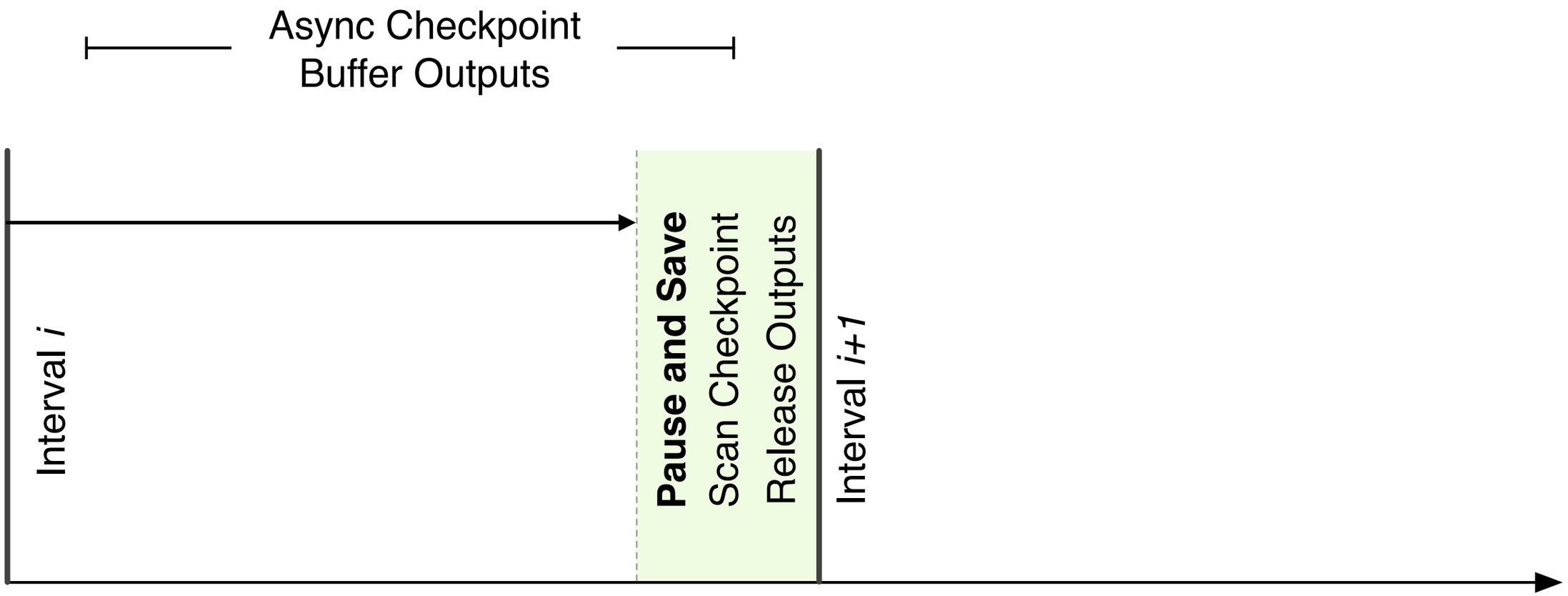

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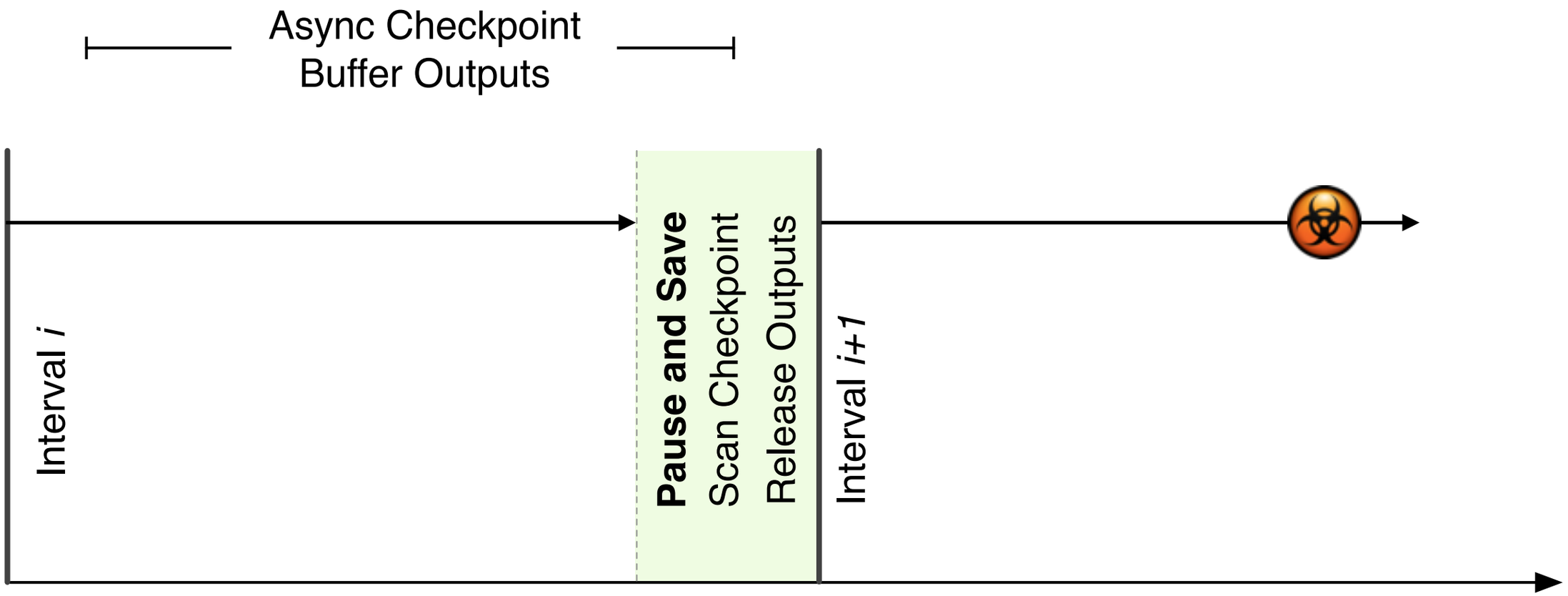

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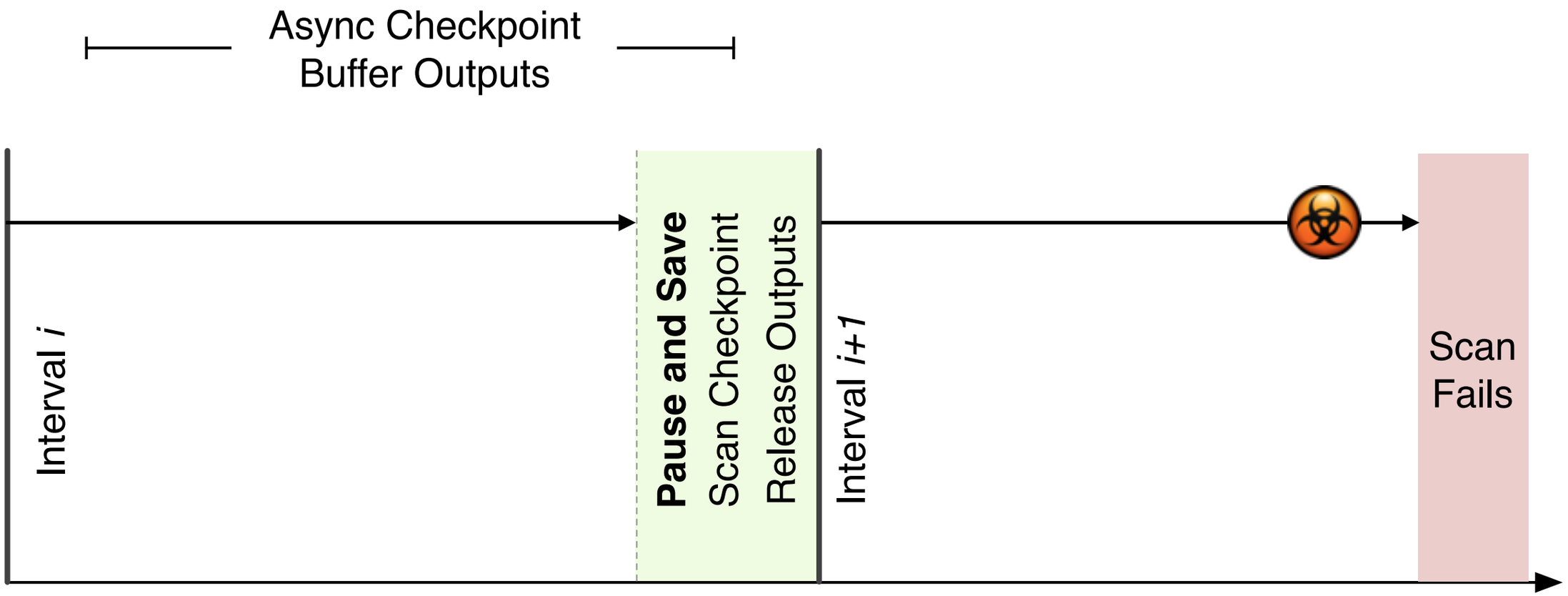

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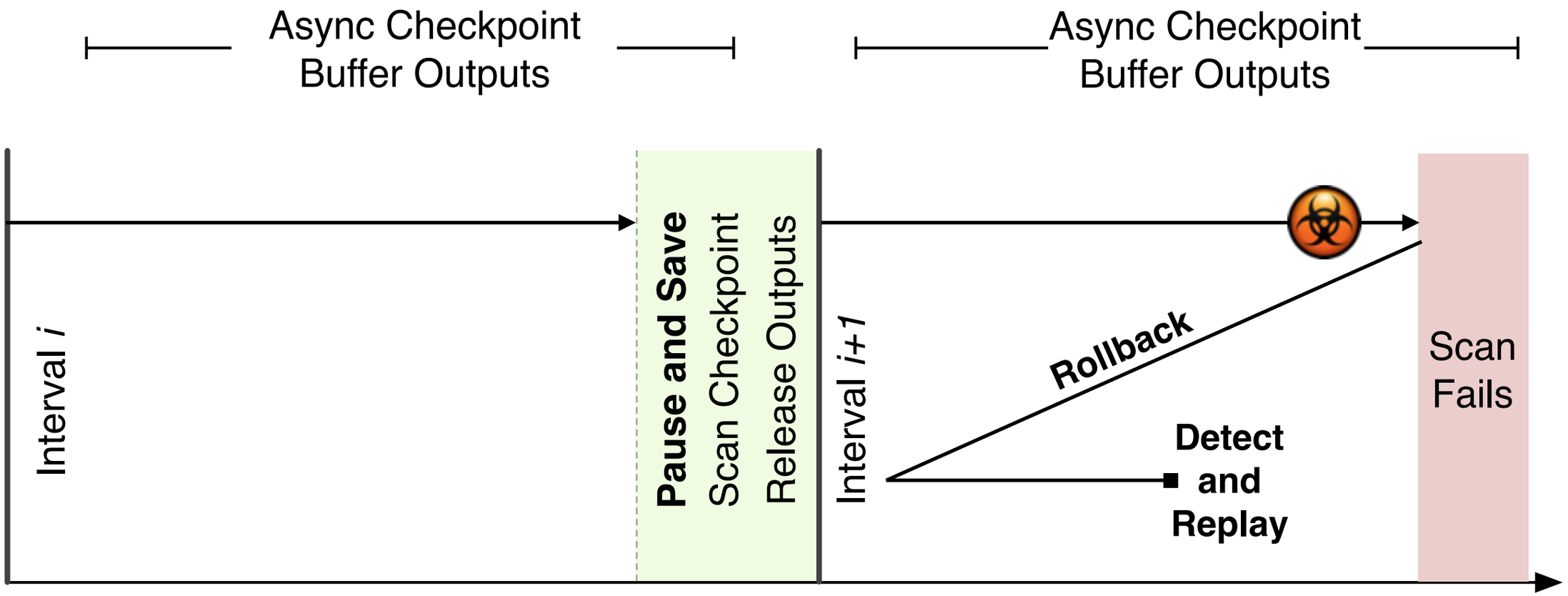

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Attack Detection and Response

- **Forensic analysis:** Do analysis that cannot be done on runtime.

- **Rollback and Replay:** Useful when using breakpoints that trigger errors such as buffer overflow.

- **Honeypot mode:** Resume and run in a sandbox.

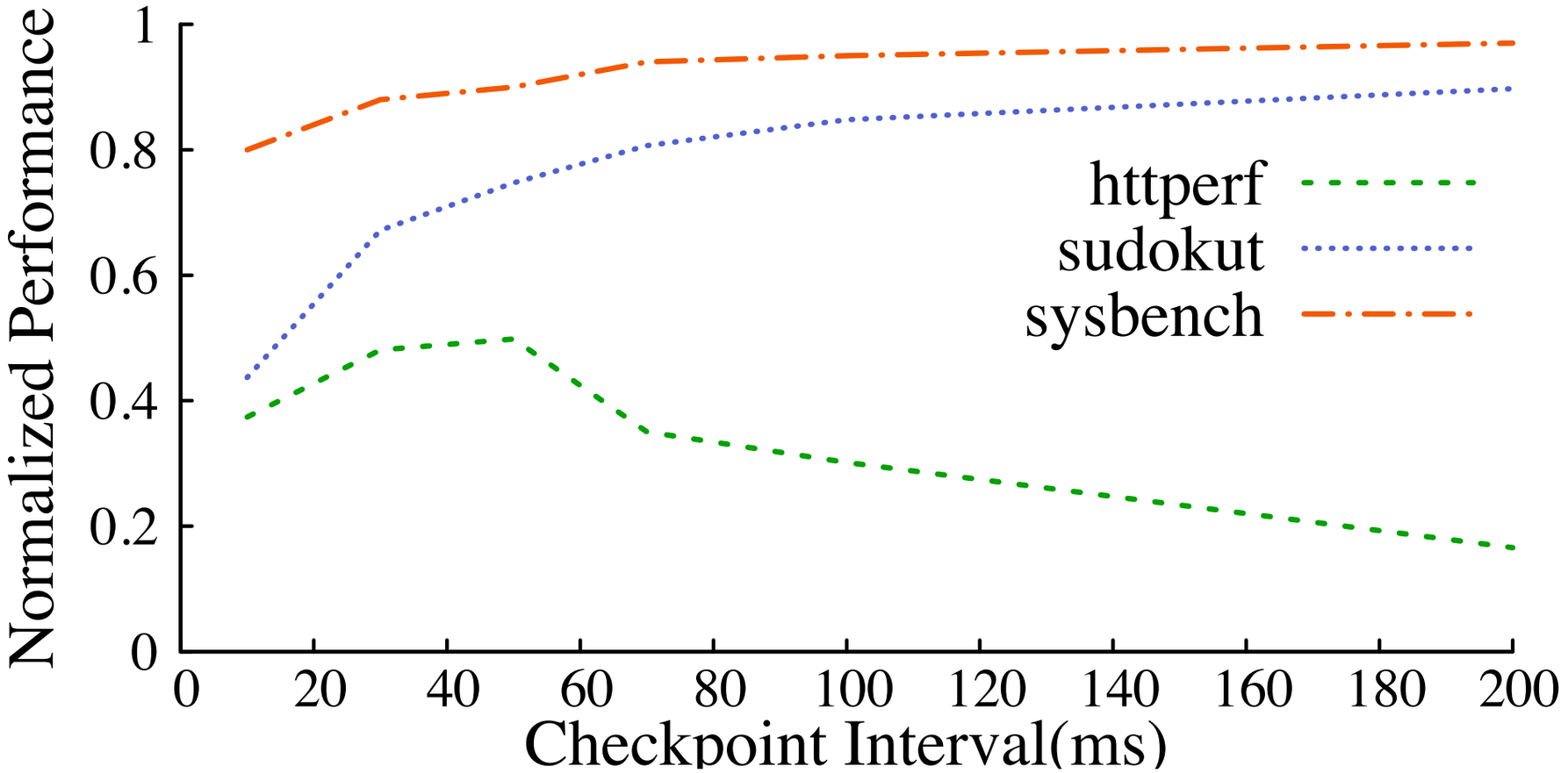
Prototype Evaluation

- Prototype of ScaaS using Xen 4.5.2
- 1Gbps link between Primary and Scanner host.
- Checkpointing using Remus.
- VM introspection using libVMI.

Types of Scans

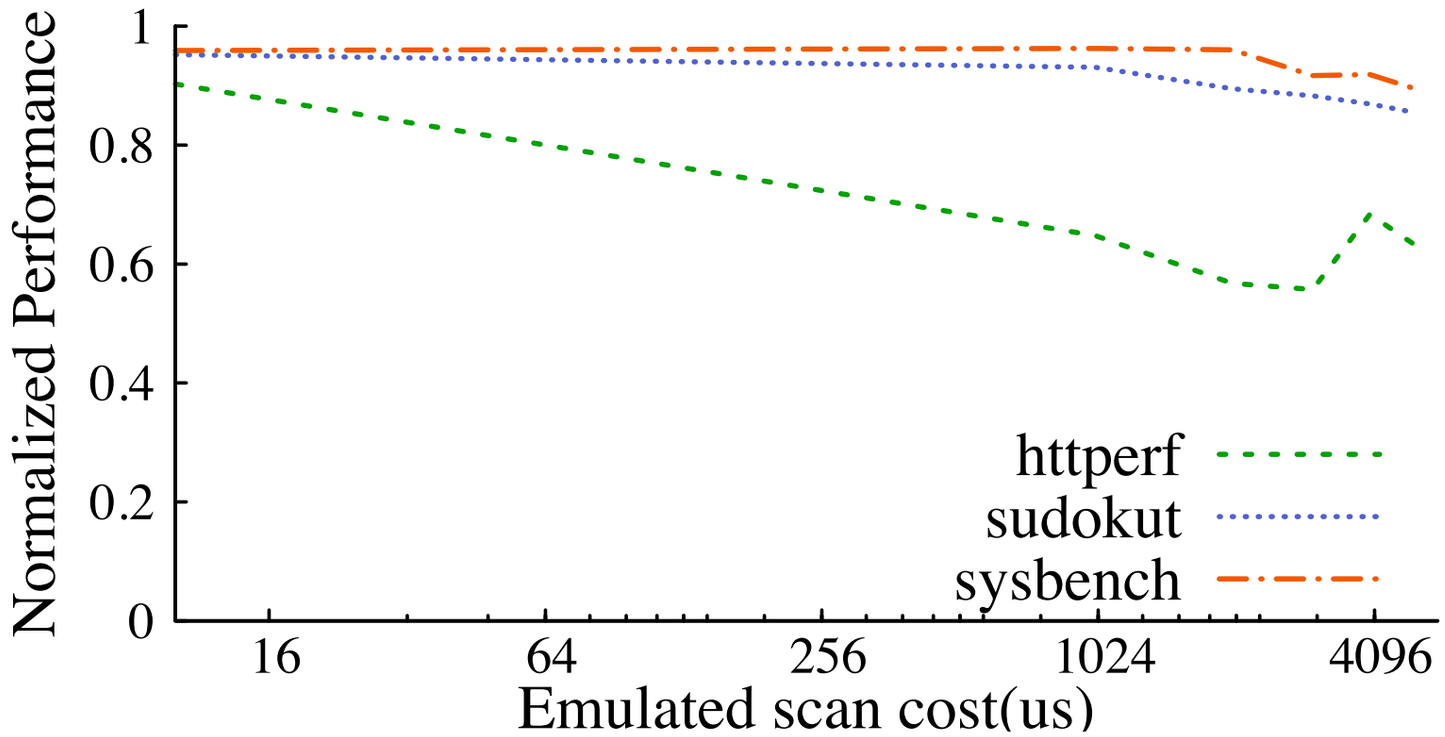
- **Process Black/White List Enforcer**:
    - Determines current running processes in a VM.Triggers errors depending on whether a target process is running or not.
- **Memory Fingerprinter:**
    - Hashes the memory pages to compare against known good states. eg: sys call table, that doesn’t change that often.

Checkpoint overhead



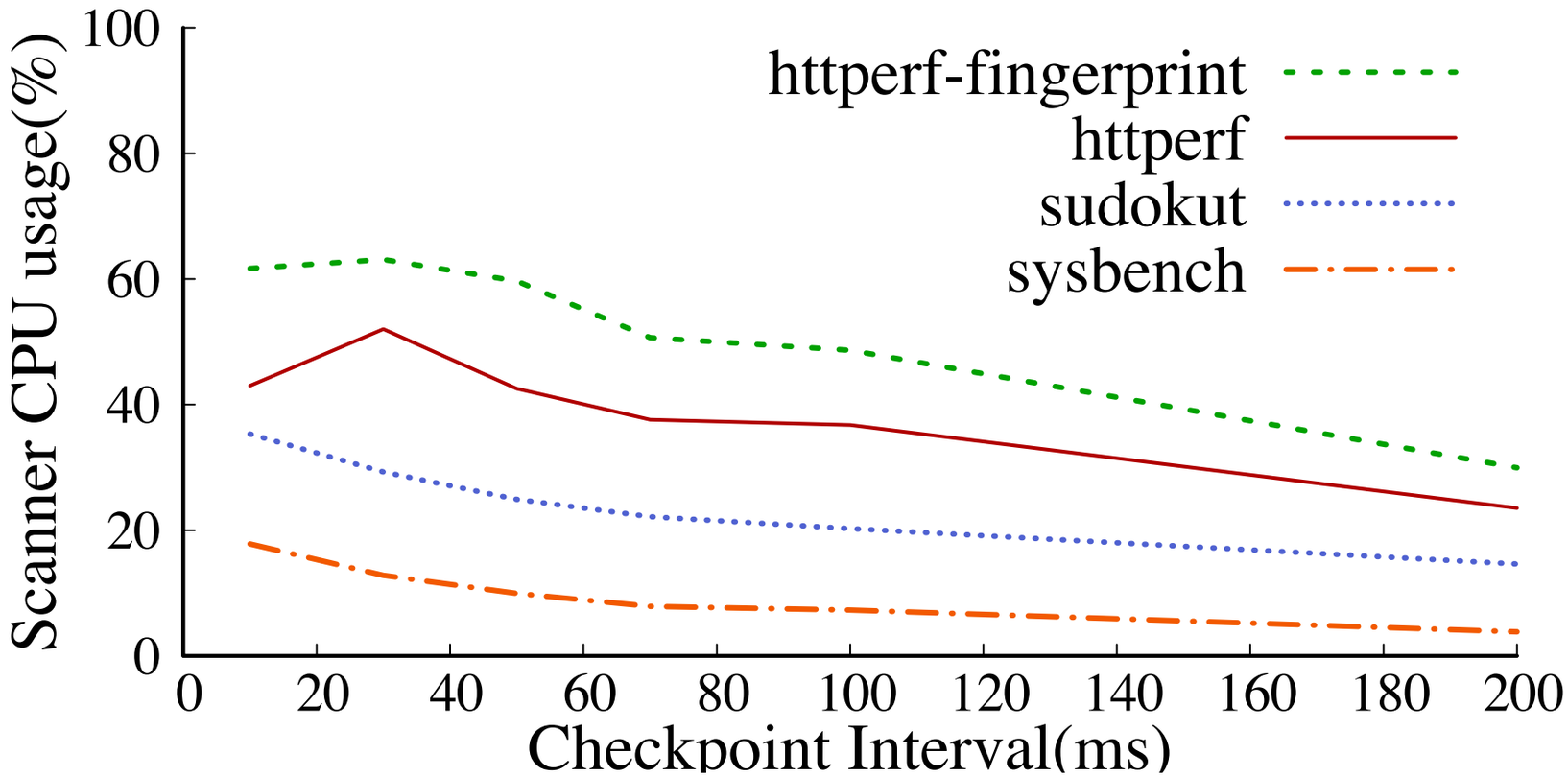
- Benchmarks vs. different checkpoint intervals
- CPU intensive benchmarks perform well with longer intervals
- httperf is a latency sensitive benchmark
  - Longer the interval worse the performance.

Emulated Scan cost



- Performance change of application w.r.t. emulated scan costs.
- Normalized wrt to zero-cost scan
- httperf costs worsens with scan cost
  - as it has to hold buffer data for longer periods

CPU usage at scanner host



- Fingerprinter causes high overhead initially but becomes negligible as checkpointing interval increase.

Conclusion

- ScaaS: Framework for security Scanning as a Service.
- Tool for attack detection and forensic analysis on memory.
  - examining memory checkpoints for an attack.
  - highly scalable and fast.

Discussion

- What types of attacks can we detect?
- Do we need to keep a history of checkpoints? Why? How?
- What is a reasonable cost for ScaaS?