Karlsruhe Institute of Technology

GPUswap: Enabling Oversubscription of GPU Memory through Transparent Swapping

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Motivation

- GPUs are widespread in computing
  - Unprecedented performance for some applications
  - Very energy efficient
- GPUs are moving to the cloud
  - Cost effective through oversubscription
- Can safely share computational power
  - Even have fairness to some degree
- But what about memory?

Sharing GPU Memory – FCFS

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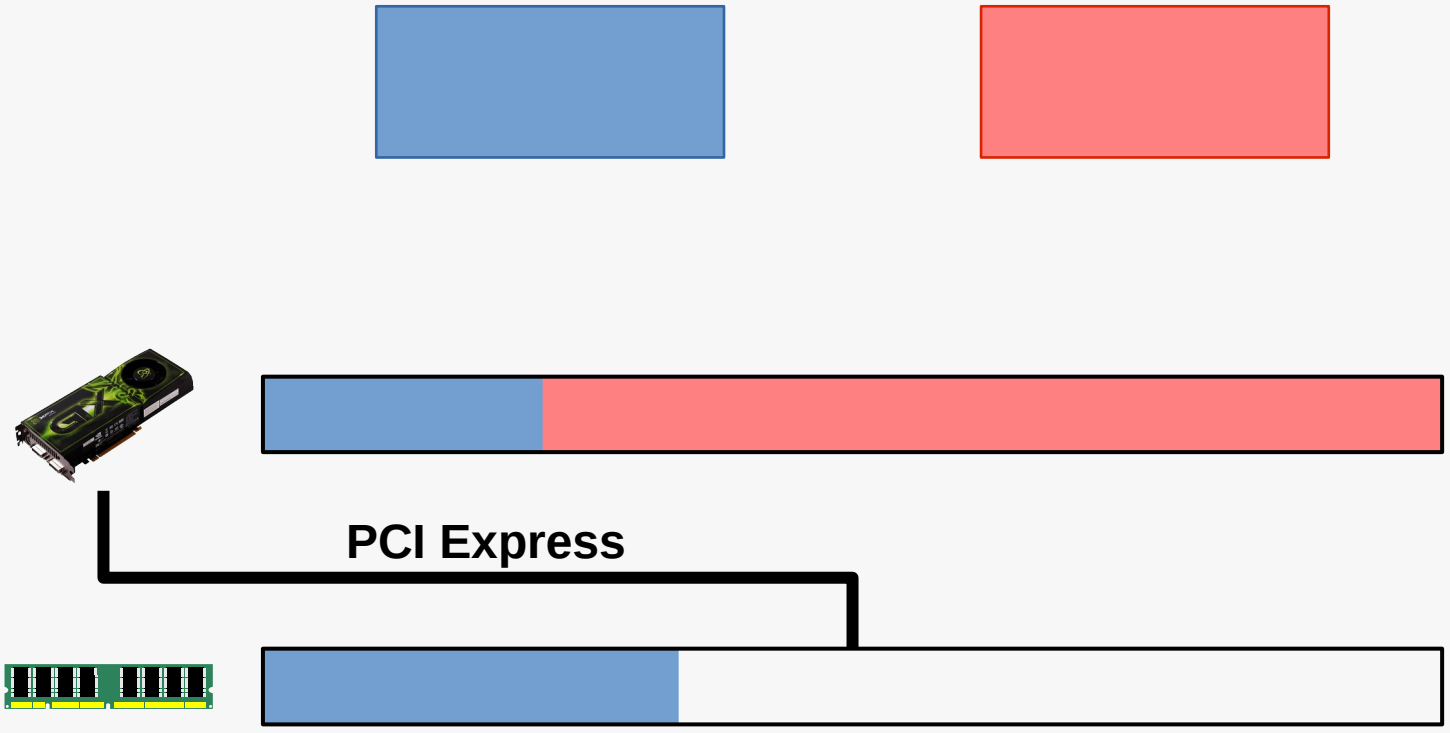
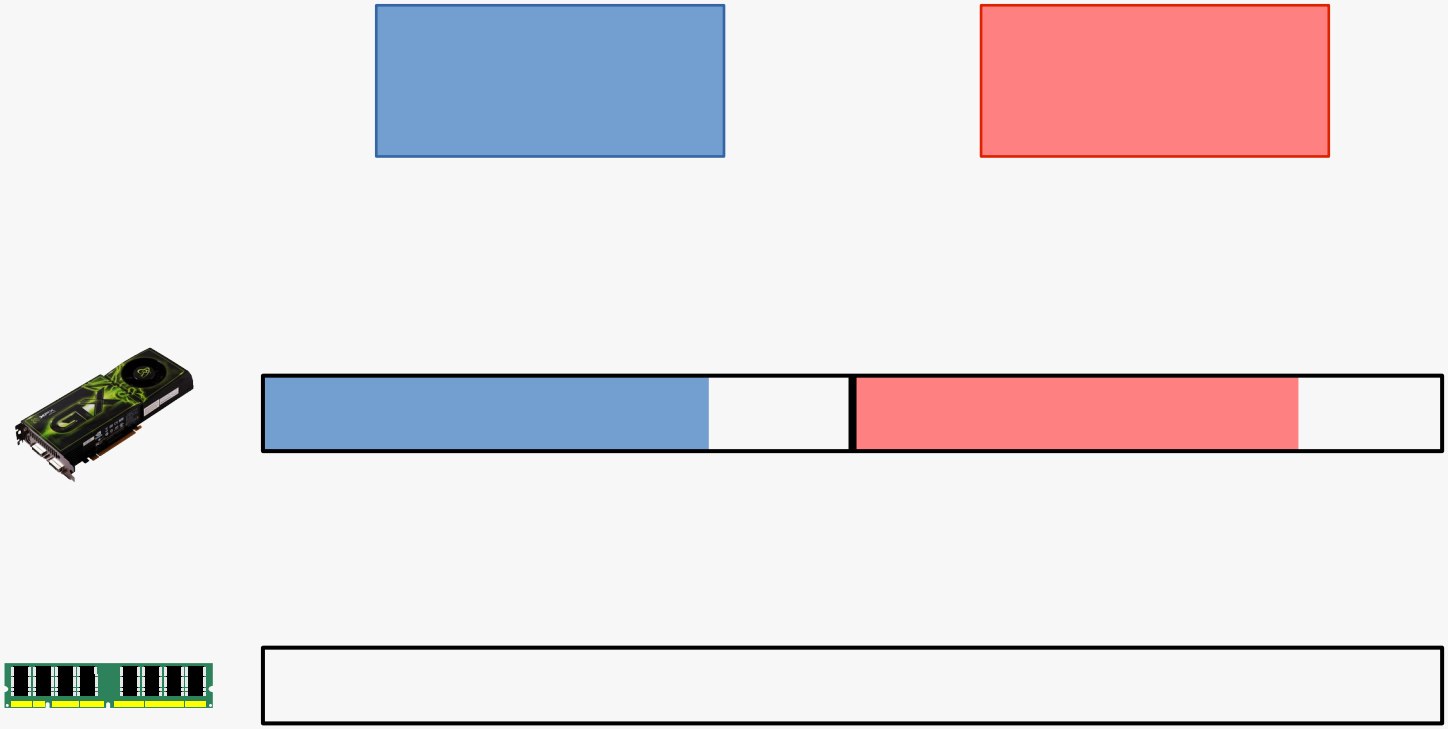


⇒ **Need to ensure fair allocation of fast GPU memory**

Sharing GPU Memory – The Naïve Way



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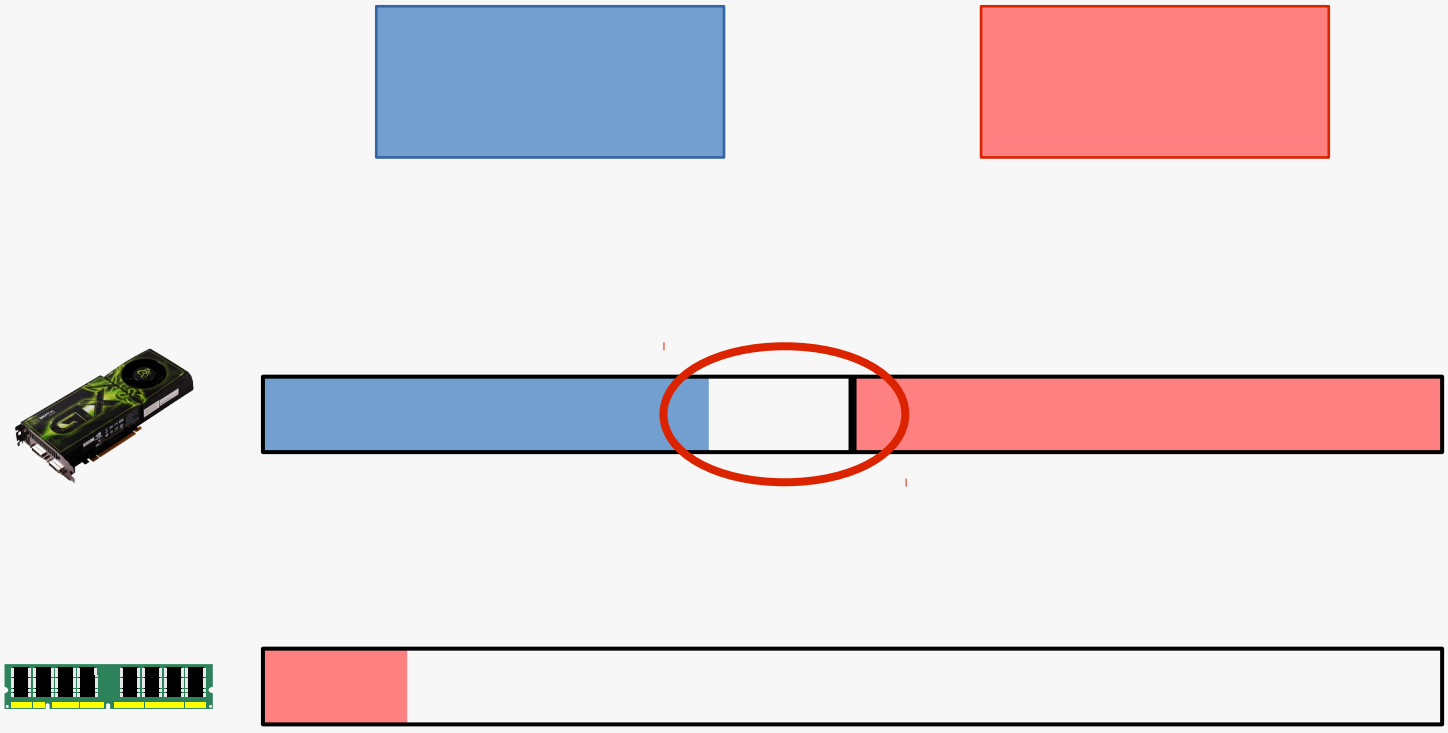
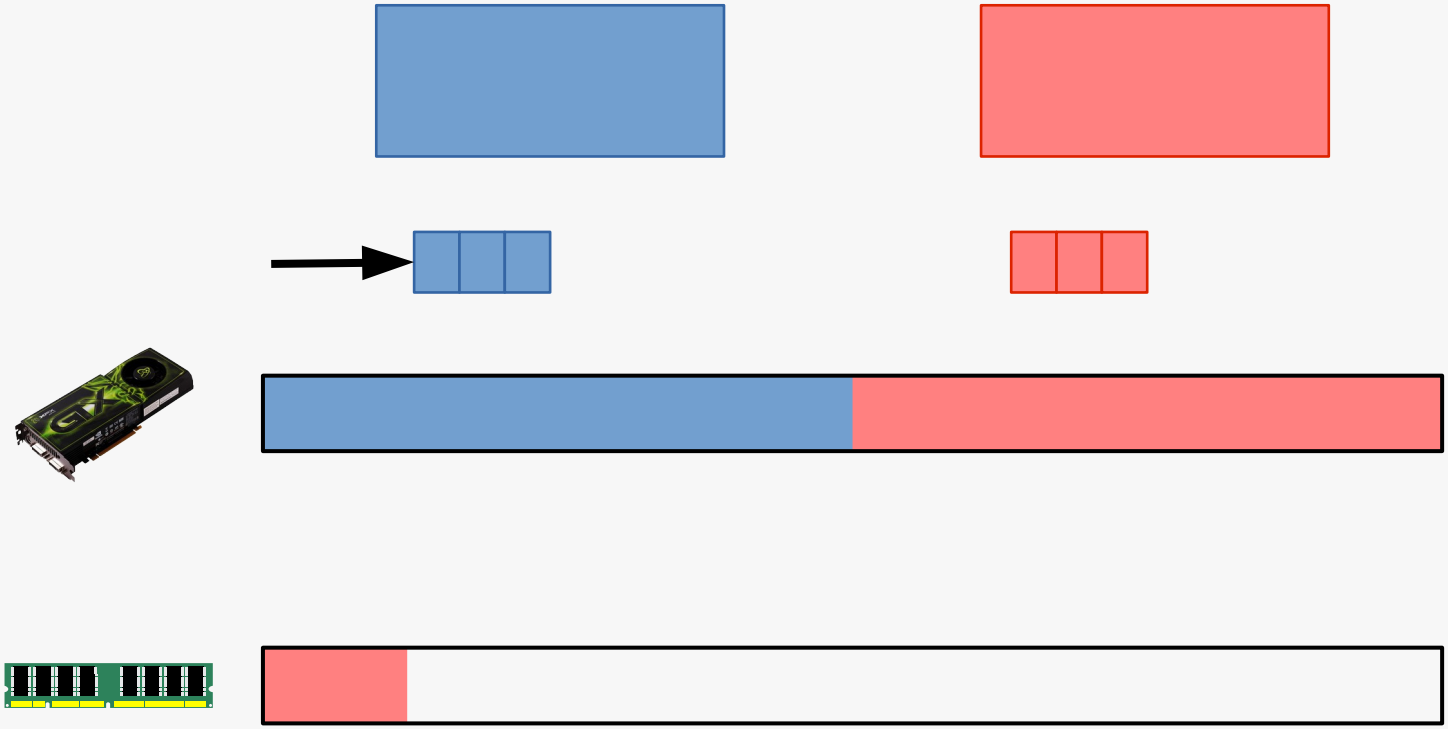


⇒ **Need to maintain good utilization of fast GPU memory**

Sharing GPU Memory – Gdev (USENIX ATC '12)



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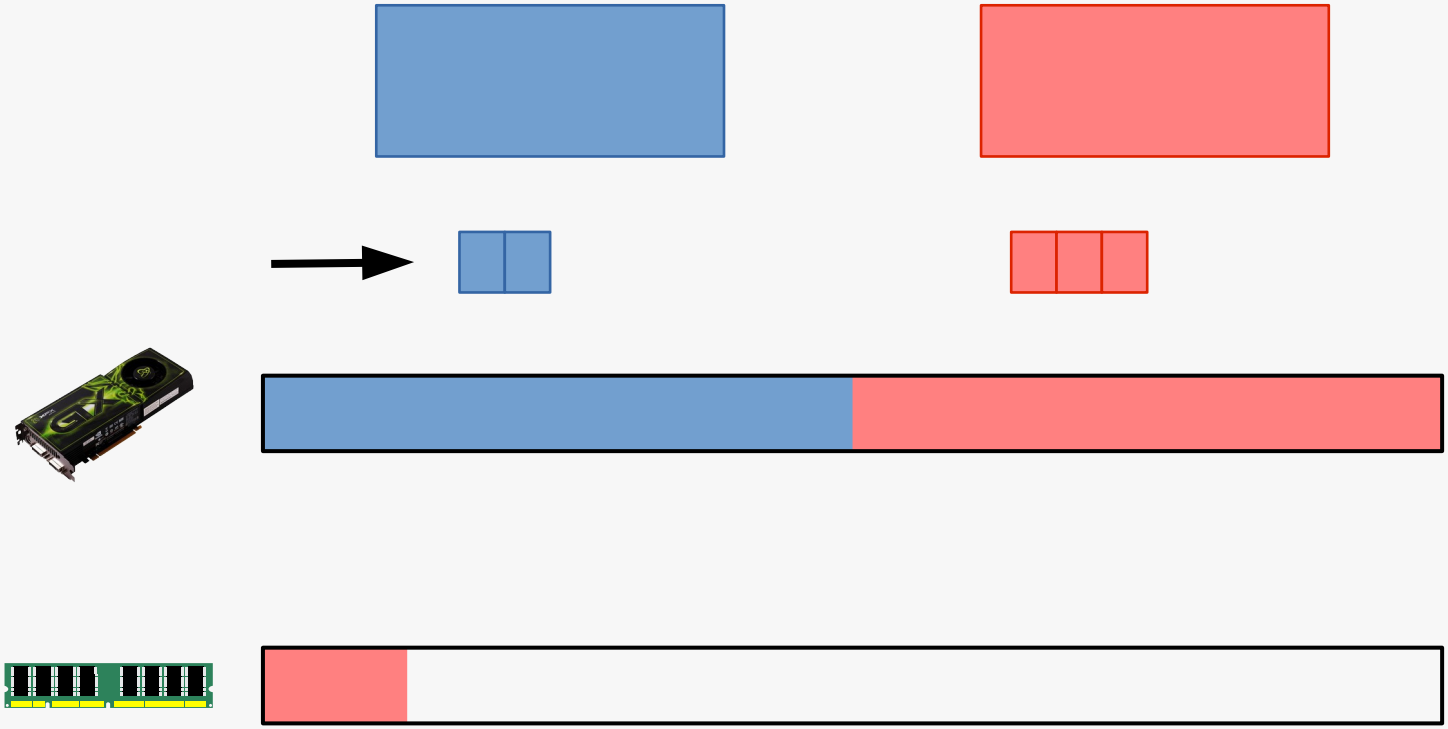

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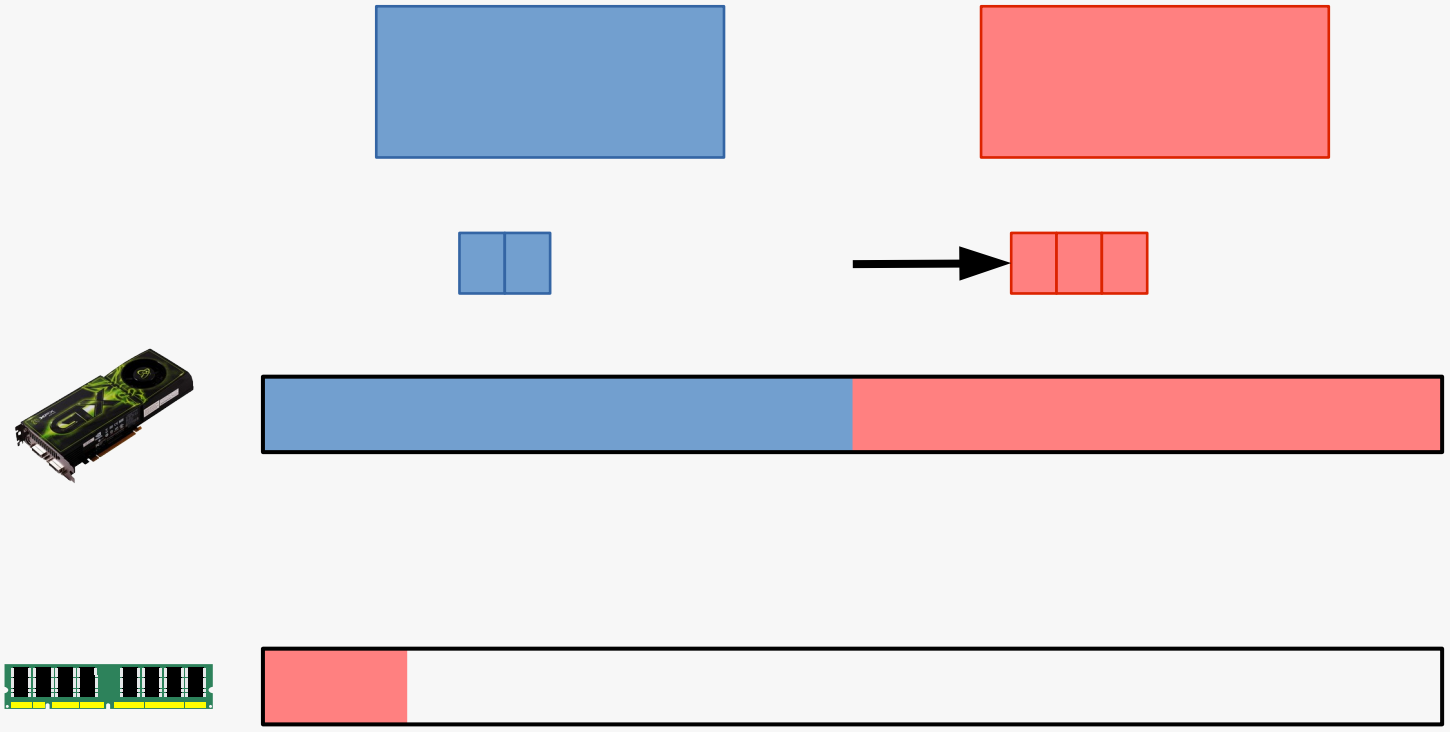

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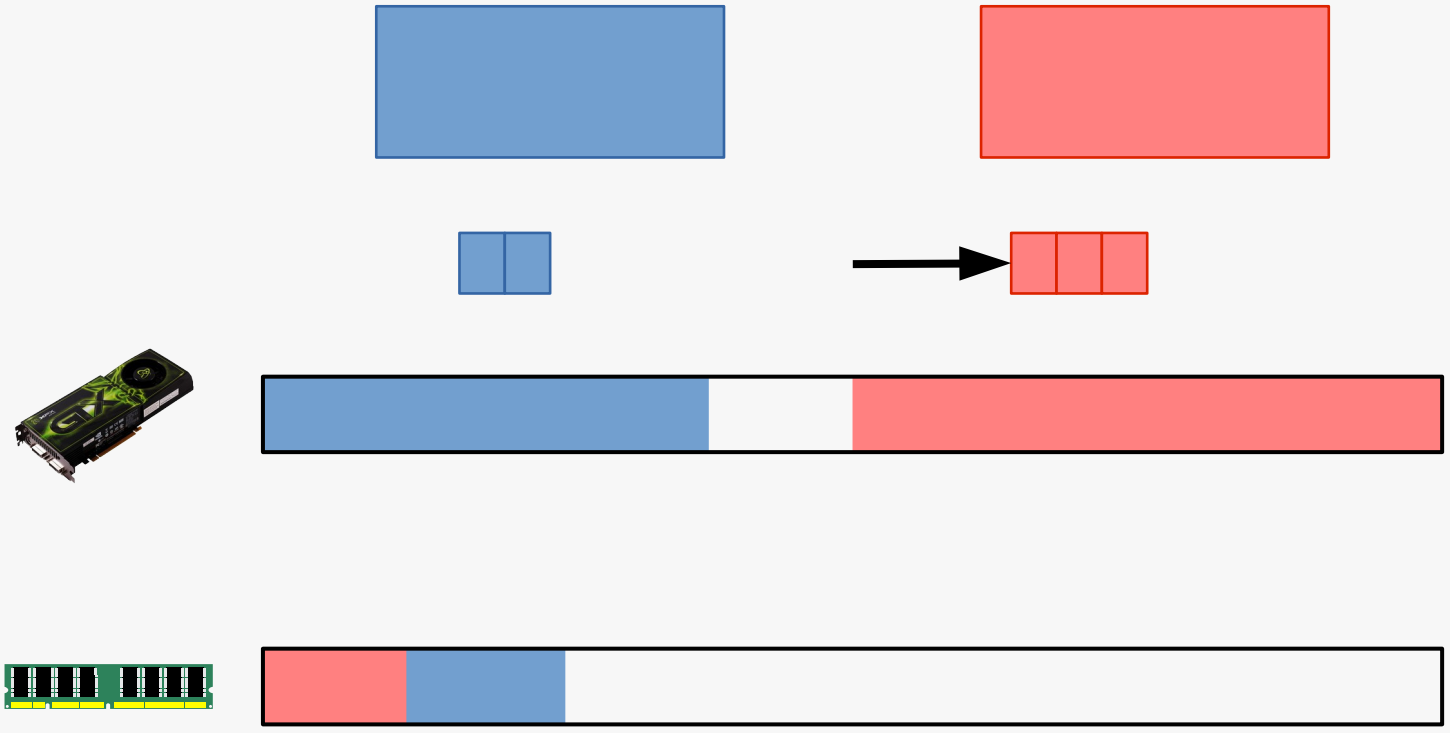

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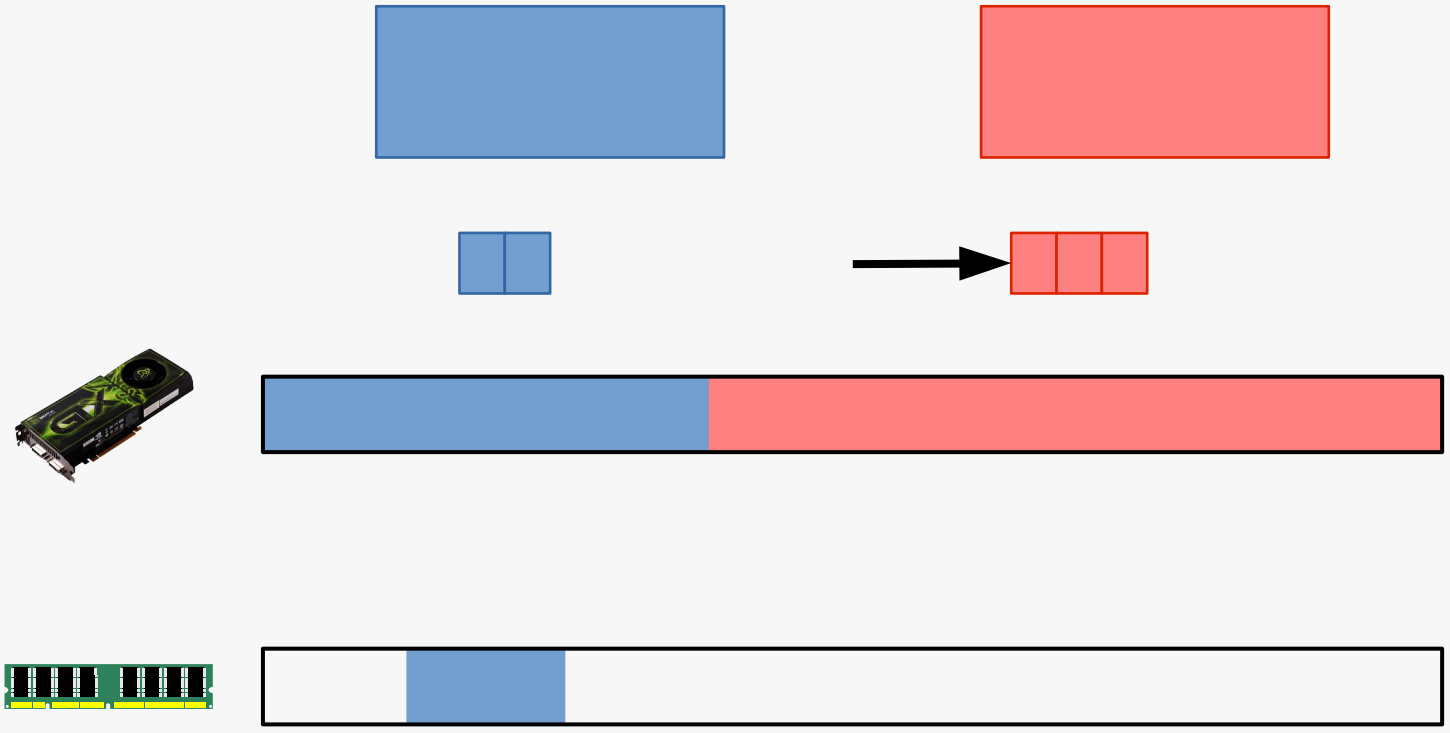

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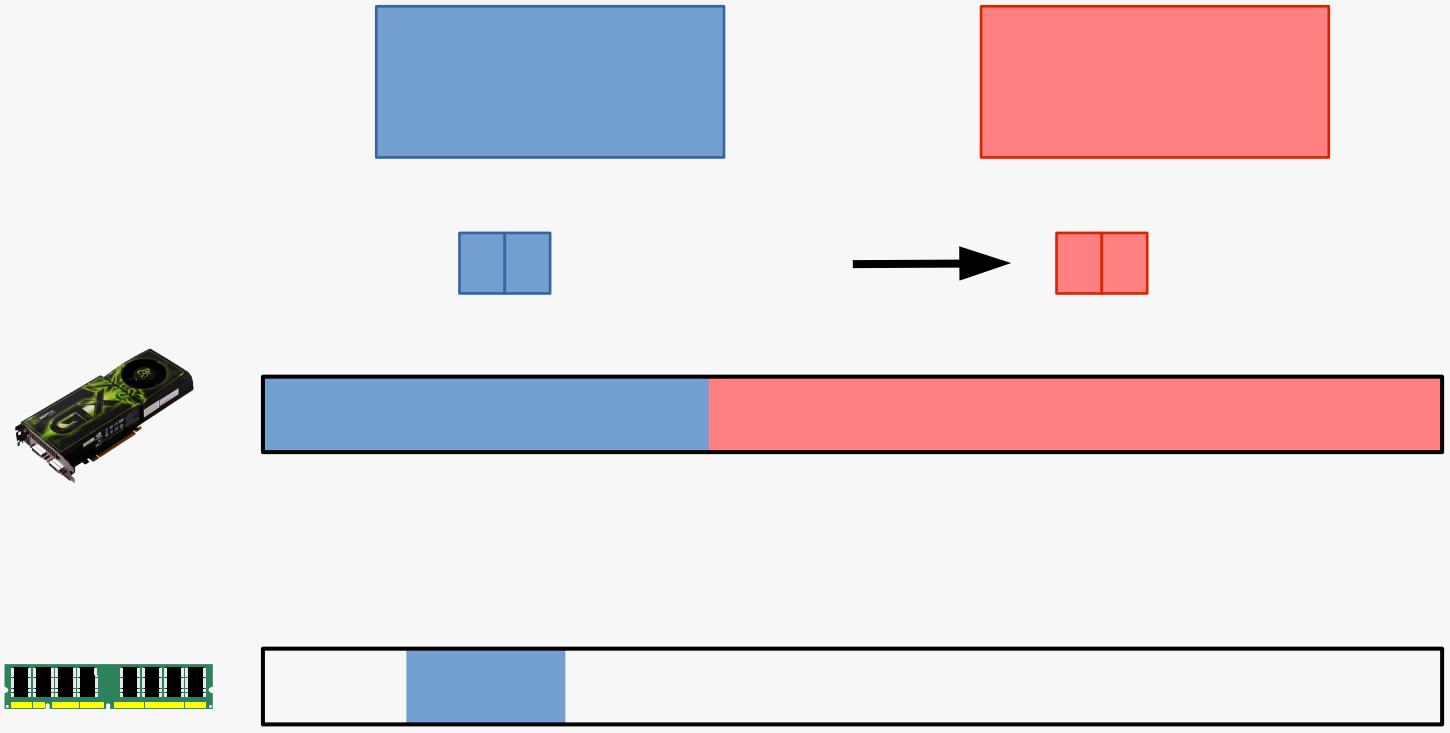
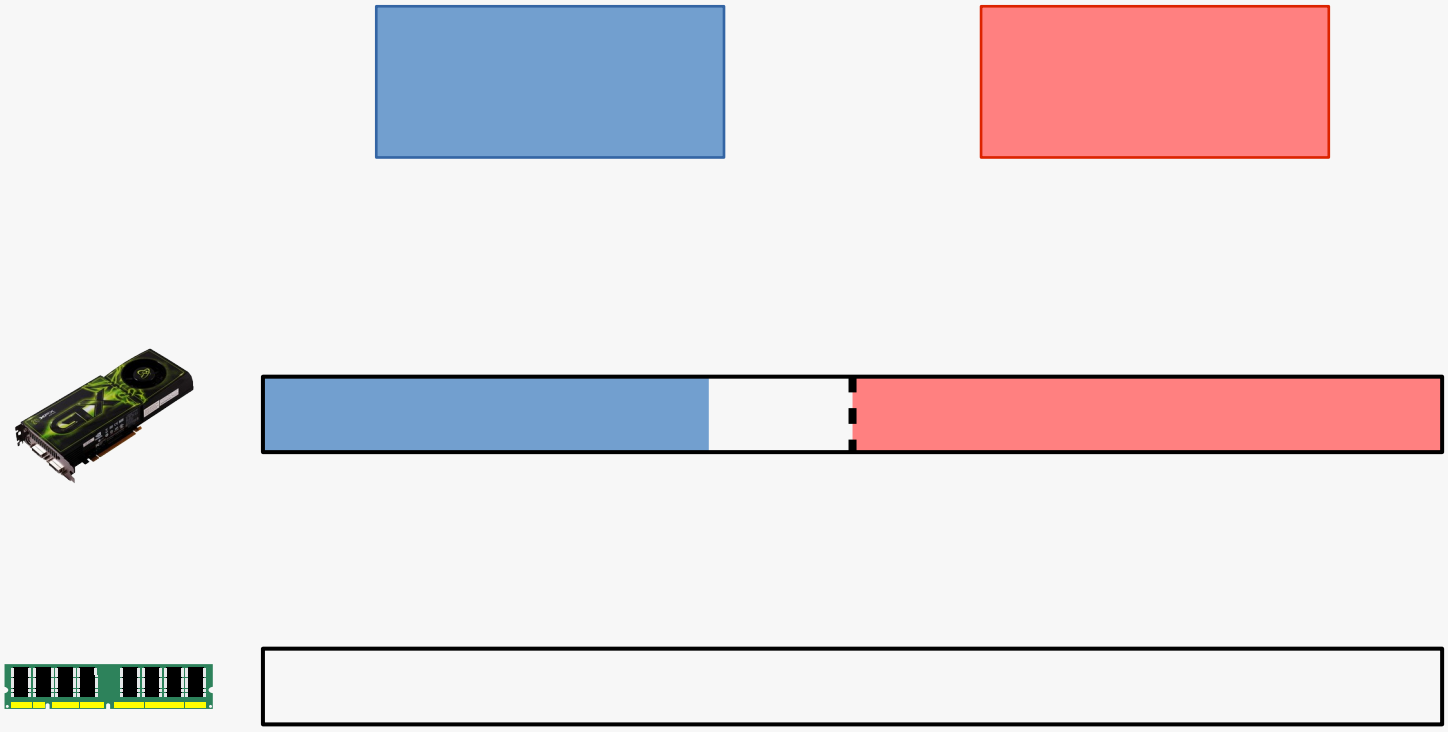


⇒ Need to avoid software scheduling overhead in the common case

Goals of GPU Memory Sharing

- Fairness
  - Same share of memory for each application
- Performance
  - High utilization of GPU memory
  - Optimize for common case: No overhead if no over-utilization!

Sharing GPU Memory – Our Approach



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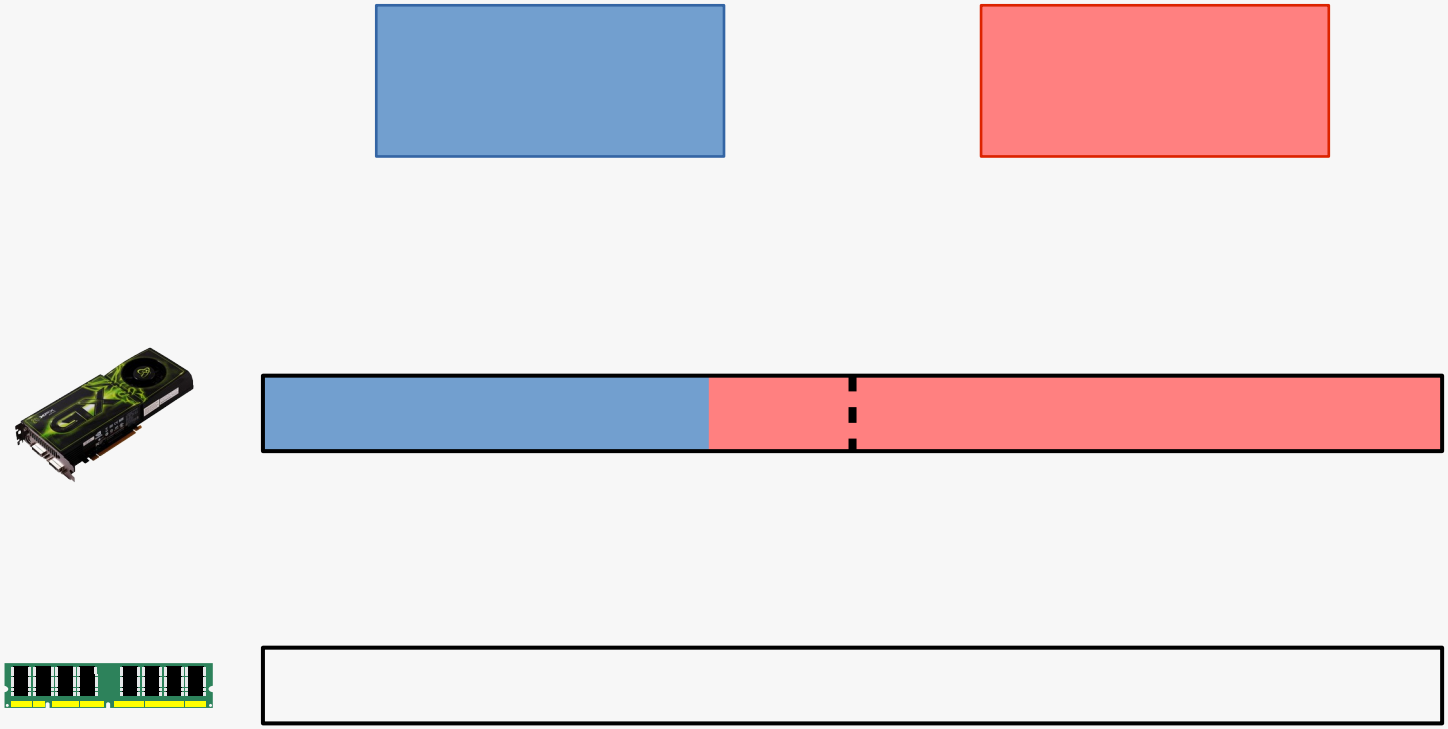

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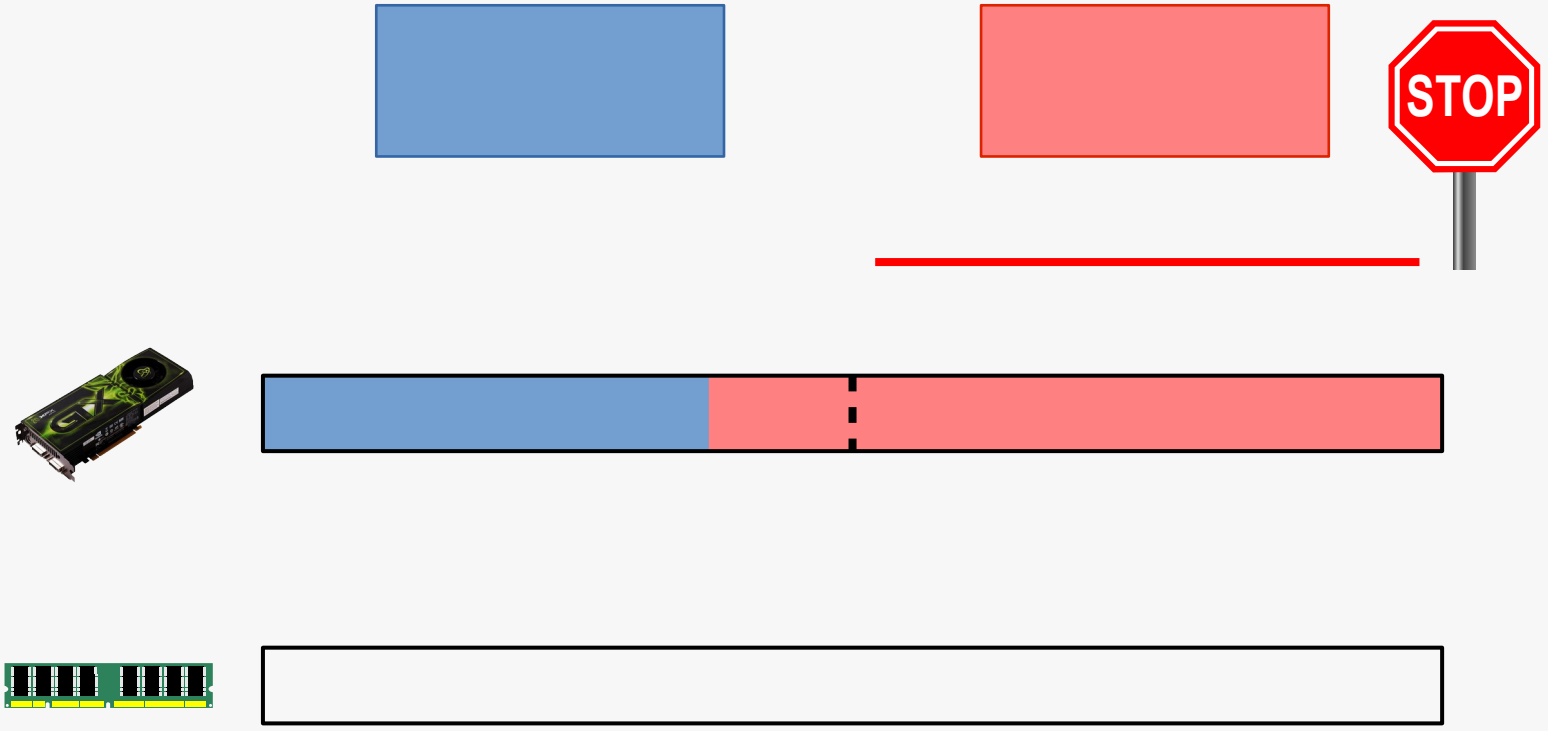

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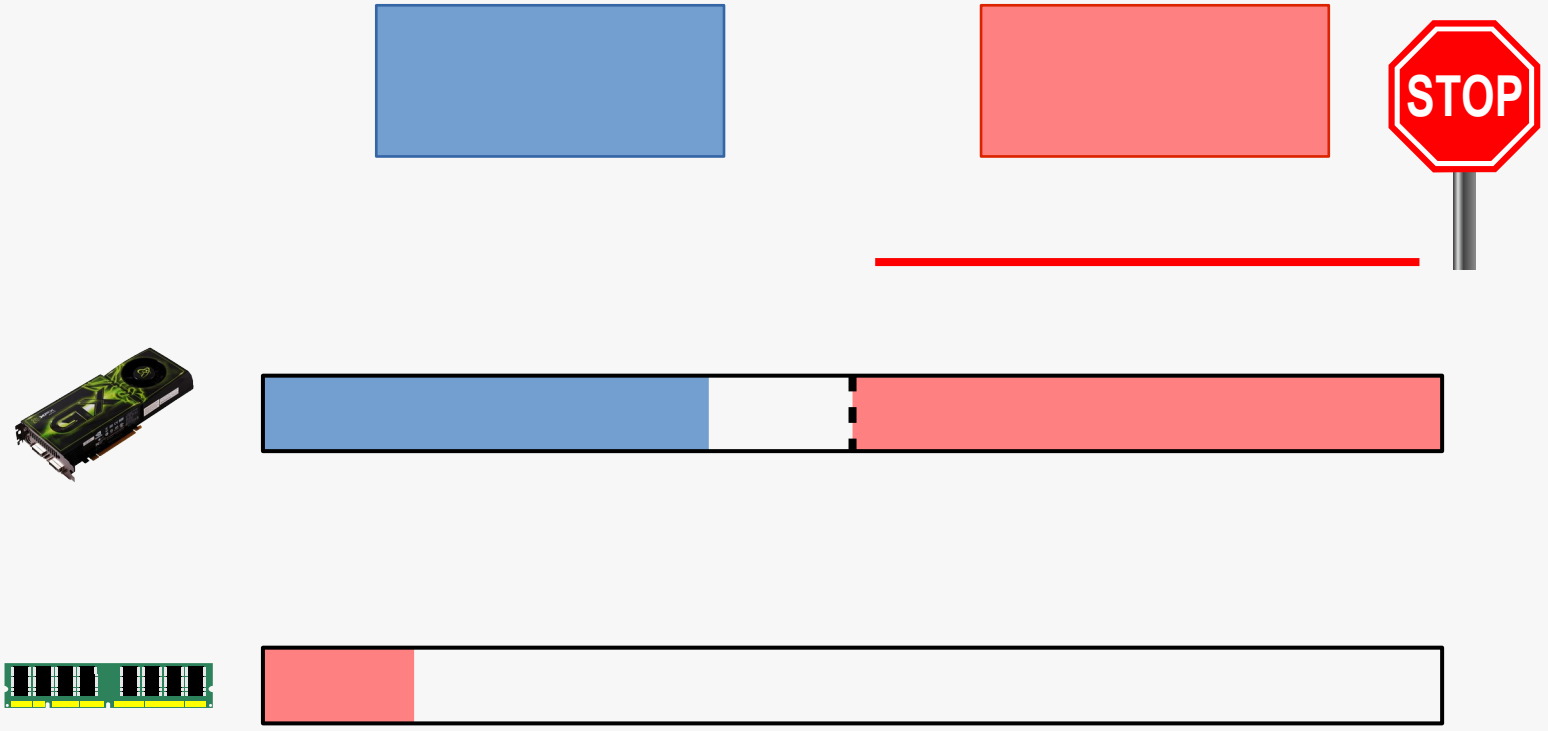
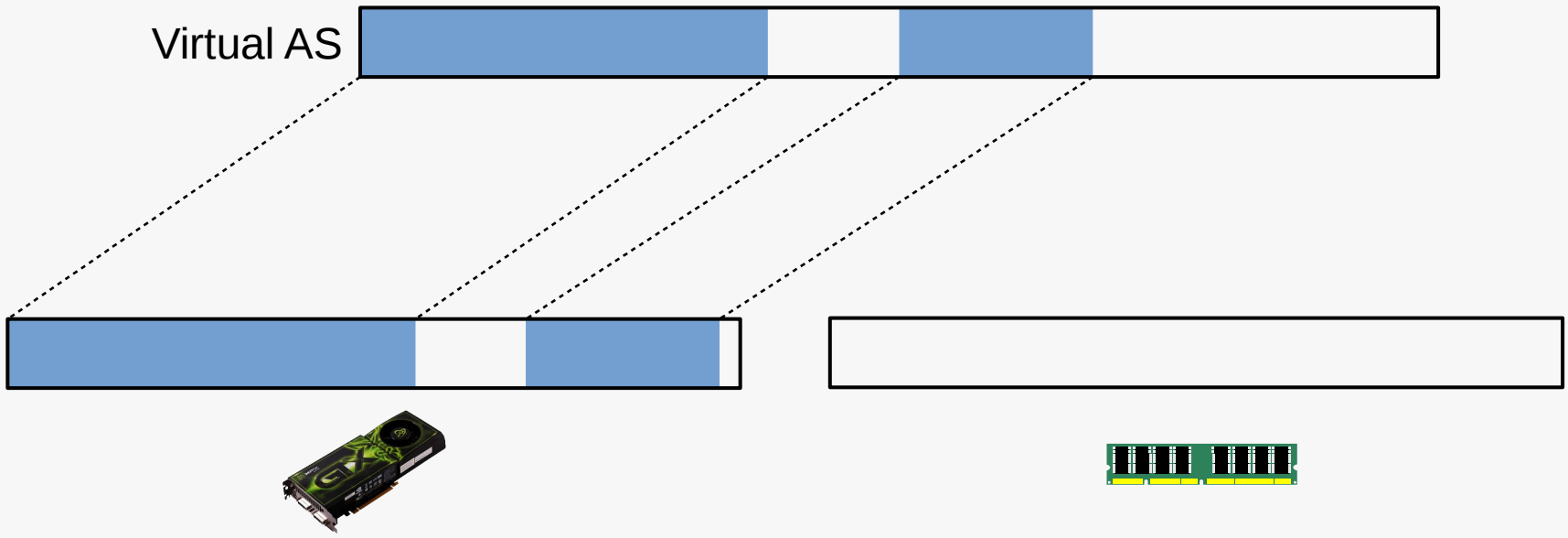


Sharing GPU Memory – Our Approach

⇒ Fairness AND good utilization

⇒ No software scheduling

Implementation – Memory Relocation



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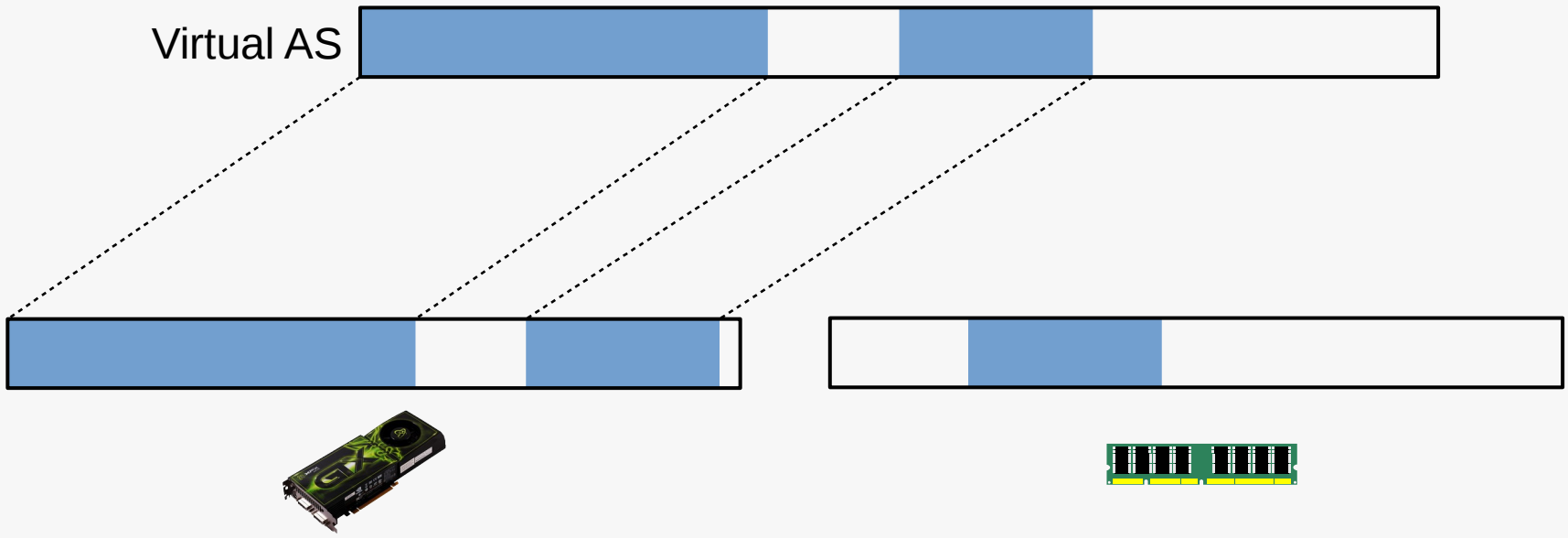

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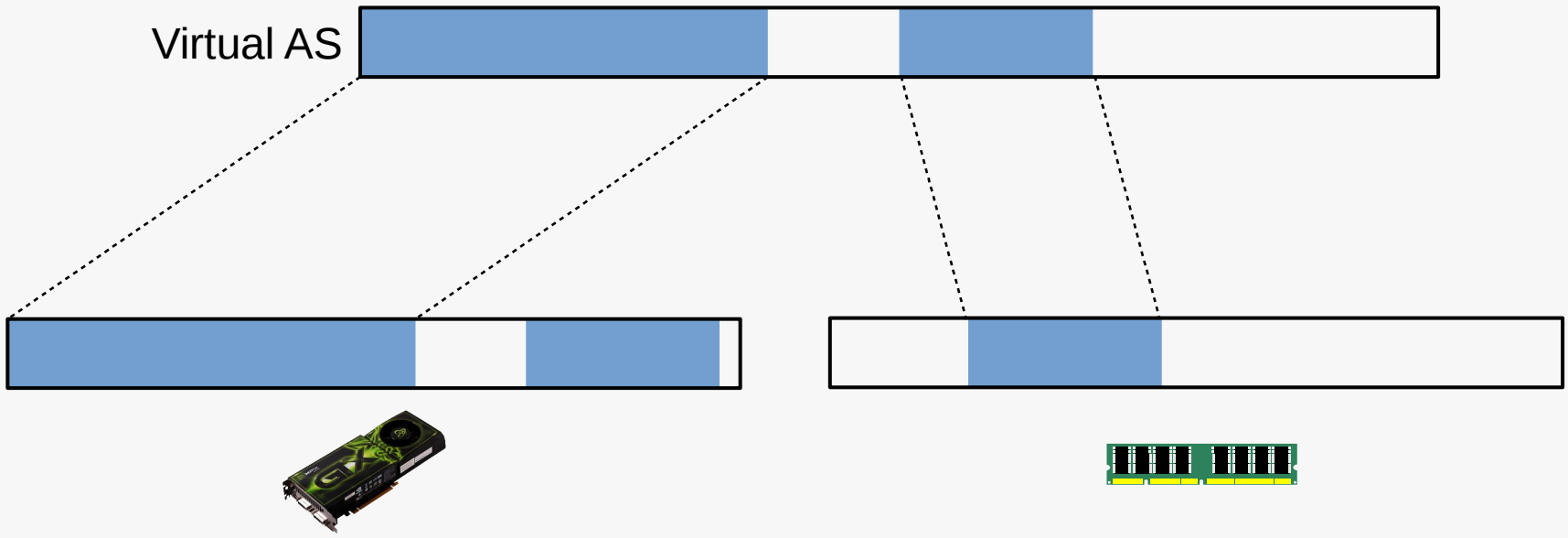

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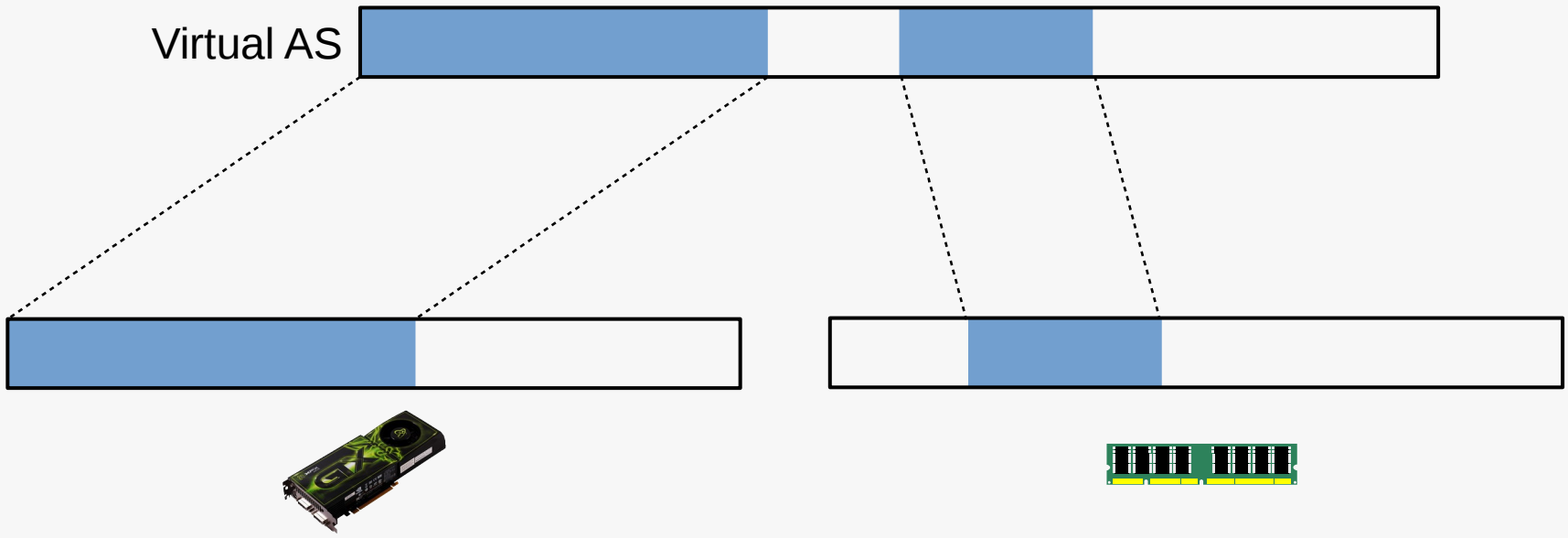
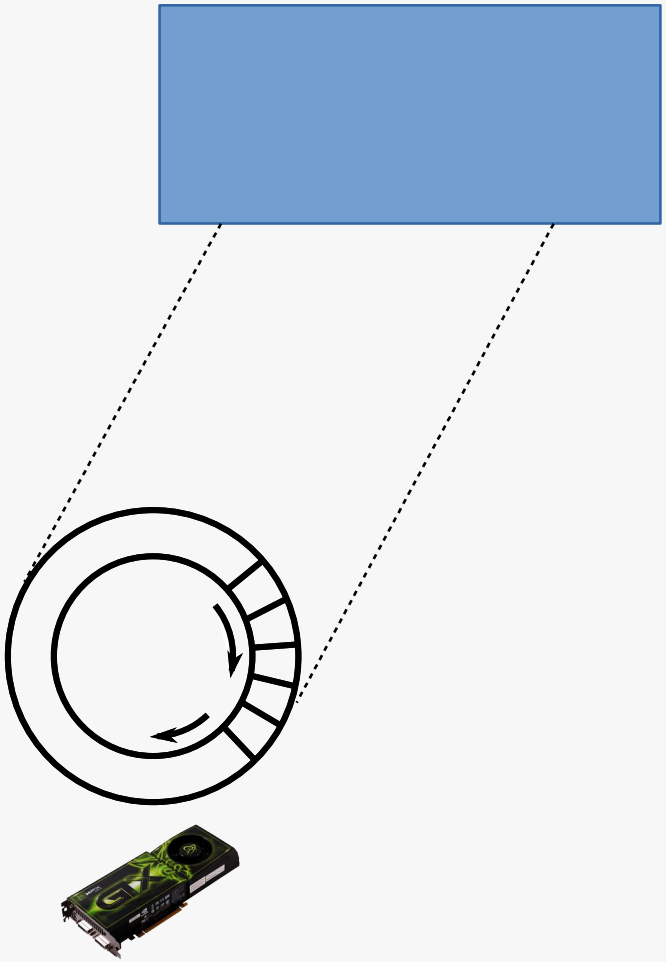


Implementation – Suspending Applications



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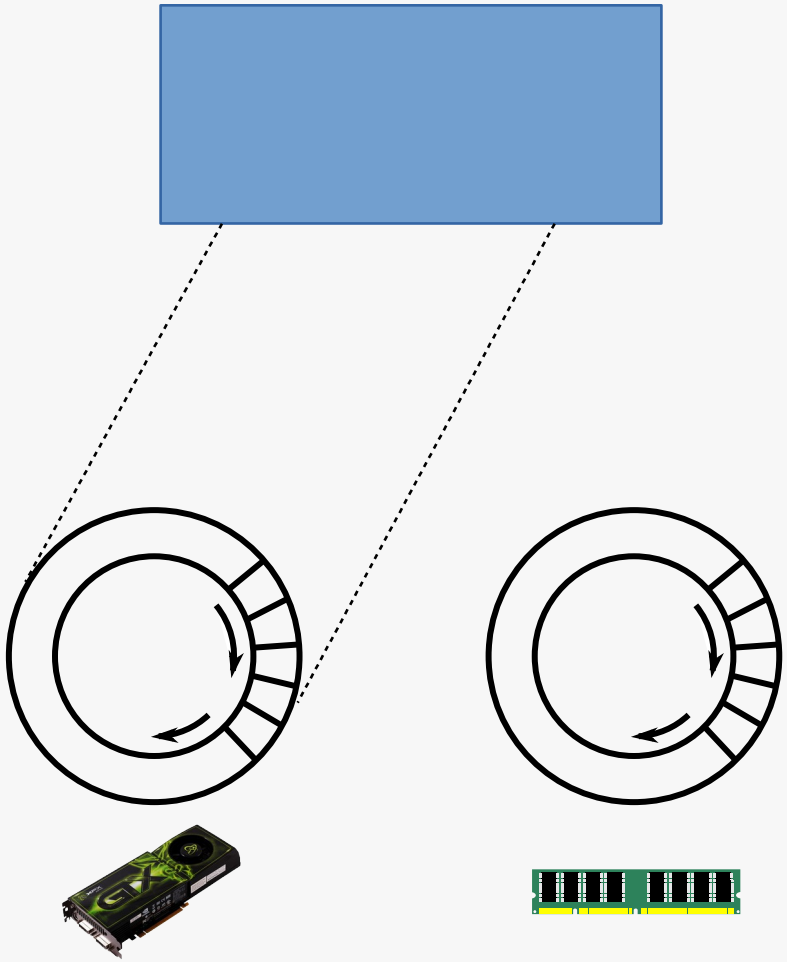

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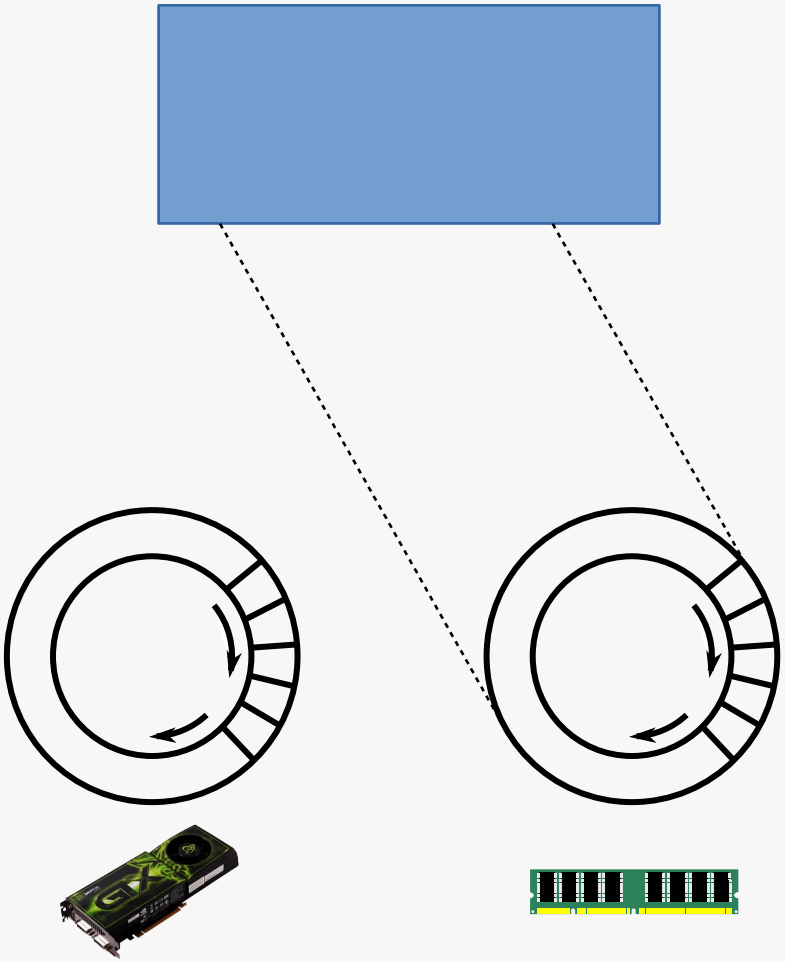

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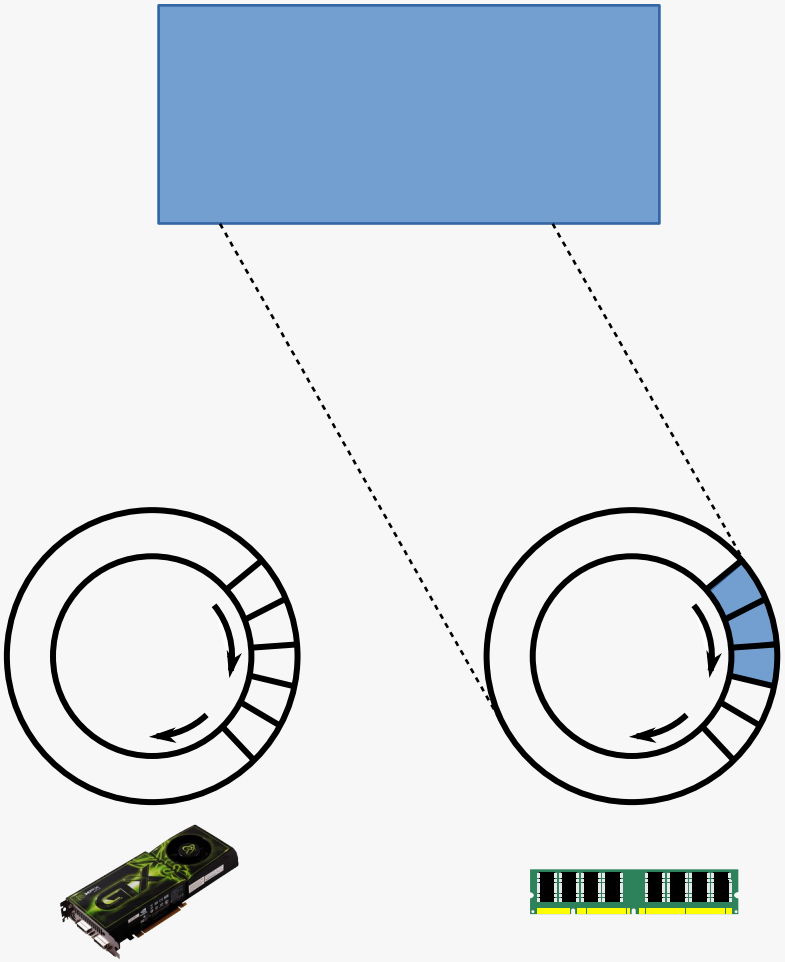

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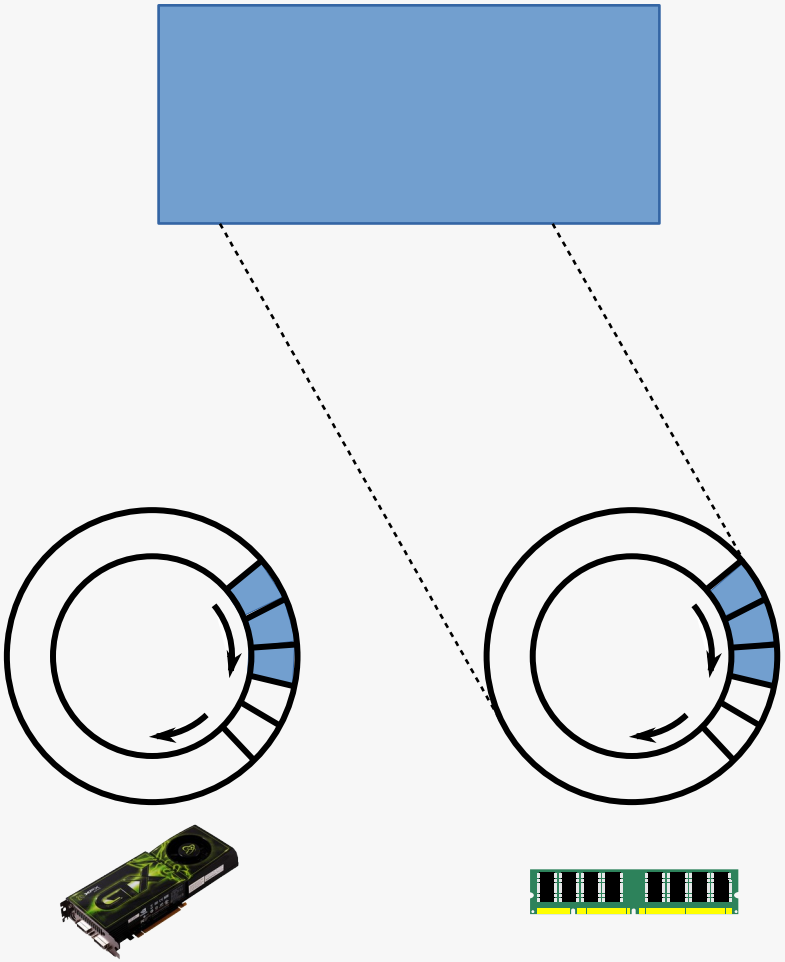

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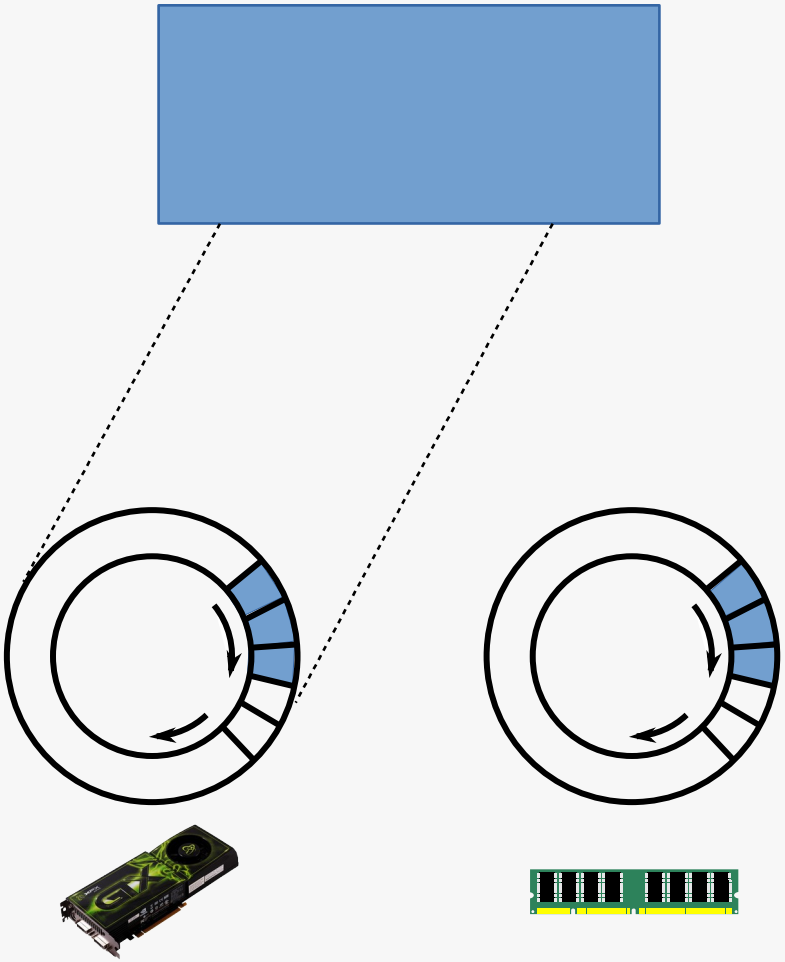


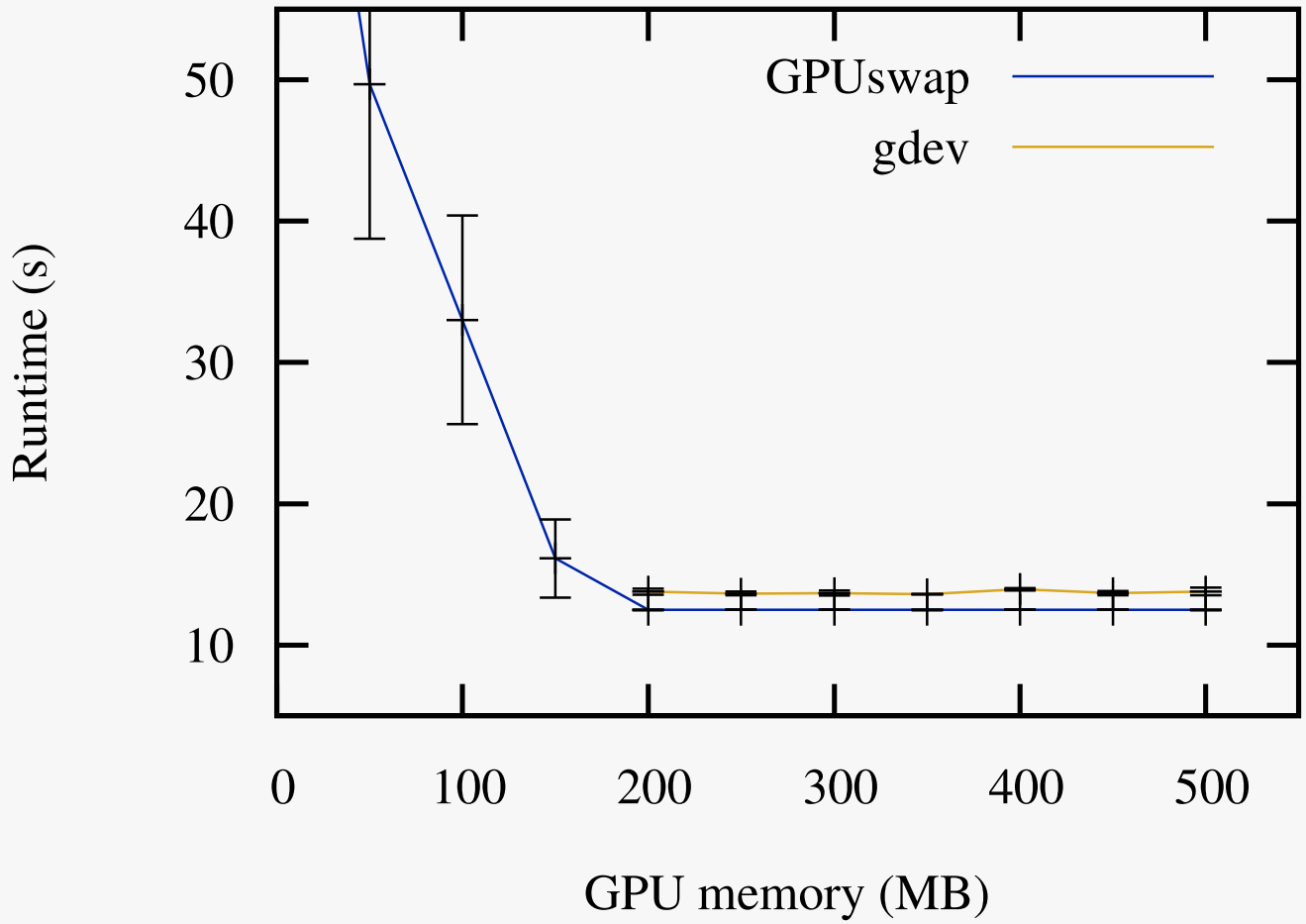
Swapping Policy

- Choose app with most GPU memory („The Victim“)
  - Achieves fairness
- Choose chunk of memory from victim‘s AS

- How do we find the right chunk?

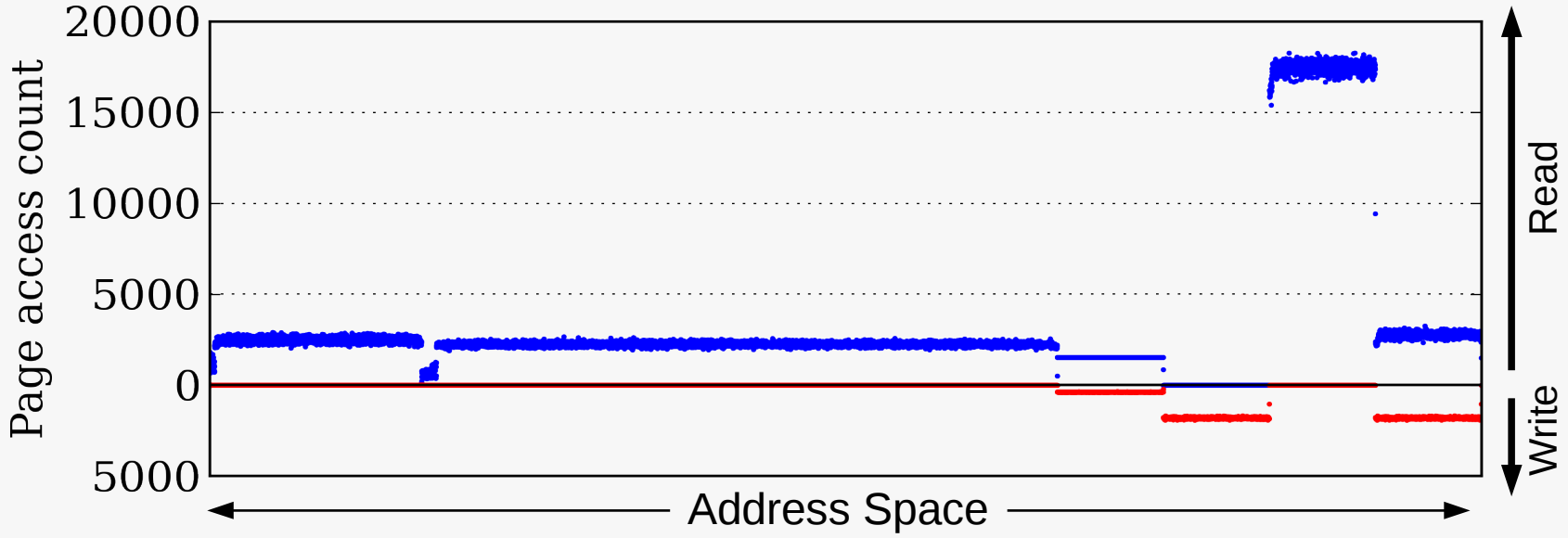
- Original implementation: Random

Results: Runtime Overhead (lud)



Hot and Cold Pages (BFS)

- Use GPU performance counters
- Measure number of accesses per page

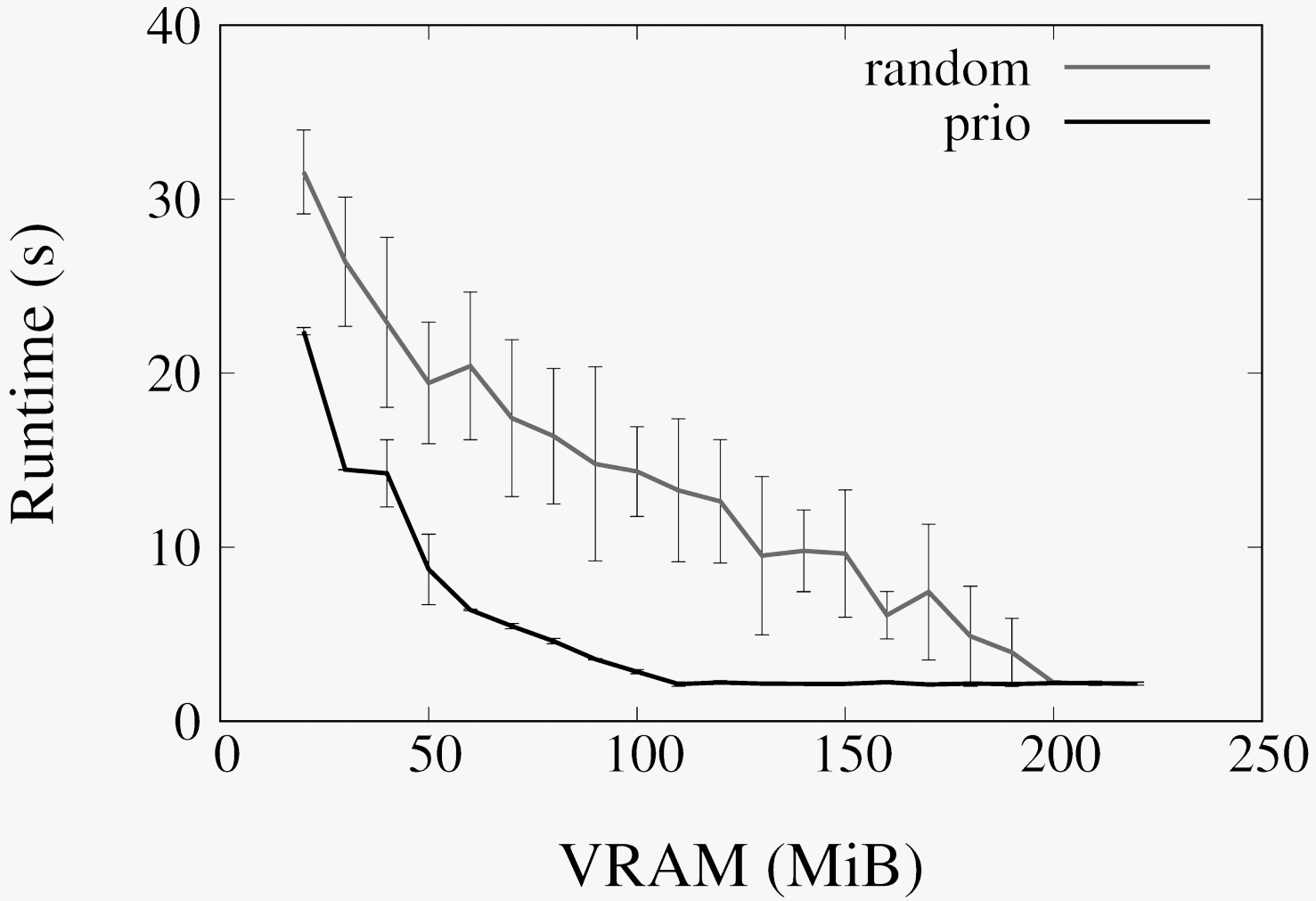


Swapping Policy Mark II

- Idea: Assign a priority to each buffer
  - Profile application
  - Buffers with more accesses per page get higher priority

- Policy:
  - Choose victim (application with most GPU memory)
  - Choose buffer with lowest priority from victim‘s AS
  - Pick chunk from that buffer randomly

Results: Buffer priorities (BFS)



GPUswap

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Credits

- GPU clip art: © Calvin Souto, 2008, GFDL