Predicting Performance

Where to begin?

You're done writing code, now what?

Does it work?

Is it fast?

What does fast mean?

60x faster than the CPU is pretty good

- What are you leaving on the table?
- How close is it to theoretical?

Predicting Performance

It is very useful to predict theoretical performance when working on shaders

Spreadsheets are quite useful for this

- Compute theoretical performance
- Compute pixels per clock, etc
- Easy to see how close an implementation is to peak performance

Quite easy with CAL/Brook+ since you can get the ISA even if you use a high-level language

Breaking down GPGPU performance

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ALU

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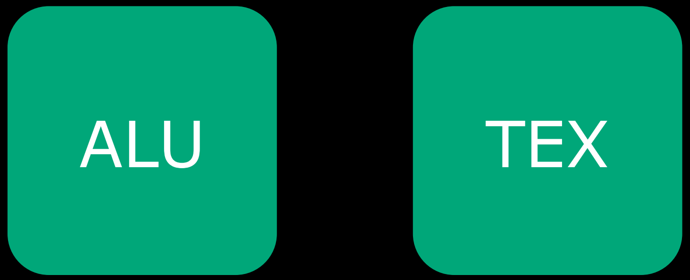

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AMD Smarter Choice

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ALU TEX MEM

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# of ALU, TEX, and Write operations

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What do we need to find out?

Calculating Theoretical Performance

Radeon X1900XT (R580)

- 8:48:16:16 (VER:ALU:TEX:ROP)
- 256 bit memory bus
- 625 MHz Engine / 750 Mhz Memory Clocks

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- 1 ALU Shader

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$$= 0.07ms$$

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$$\frac{(\#pixels)x(\#TEX\ instructions)}{(TEX/clk)x(3D\ engine\ speed} = \frac{(1920x1088)x(1)}{(16)x(625Mhz)}$$

$$= \quad 0.21ms$$

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- Memory Performance - 1 Byte in 1 Byte out (Copy)

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$$= 0.085\ ms$$

Calculating Theoretical Performance

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Overall Theoretical Performance

- max(ALU,TEX,Memory)
  - each operation happens in parallel
- max(0.07, 0.21, 0.085)
- 0.21 ms - Texture bound
  - Texture units is the limitation

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Remember, this is only a starting point!

- ALU and TEX calculation is reasonable
  - Actually usually very close
- Memory assumes peak
  - depends on access pattern, etc
- Conditional operations can complicate things

Decoder Ring

GPU	Engine Clock	Memory Clock	Memory Width	ALUs	TEX	ROPs
R600 HD2900	750	850	512	64	16	16
R610 HD2600	700	1100	64	8	4	4
R630 HD2400	800	1100	128	24	8	4
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How long would a 1 ALU shader that outputs 1 byte take on R610? What's the bottleneck?

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How long would a 2 ALU shader that outputs 1 byte take on R610? What's the bottleneck?

AMD Smarter Choice

The Value of System / Remote Memory

Radial Correction

System Requirements:

- Capture video from one or more cameras.
- Transfer images to GPU
- Convert bayer-pattern images to RGB images
- Remove lens distortions
- Return to host for further processing

System needs to use limited power

- Mobile GPU

Want to minimize correction time

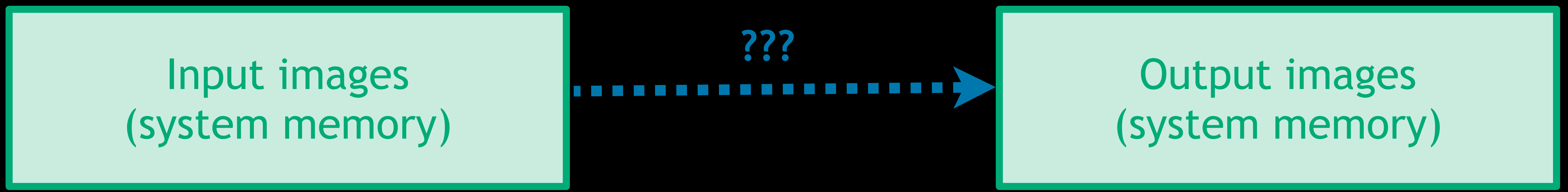
- Images further processed in a large real-time system

Naive Implementation

Input images
(system memory)

Output images
(system memory)

Naive Implementation



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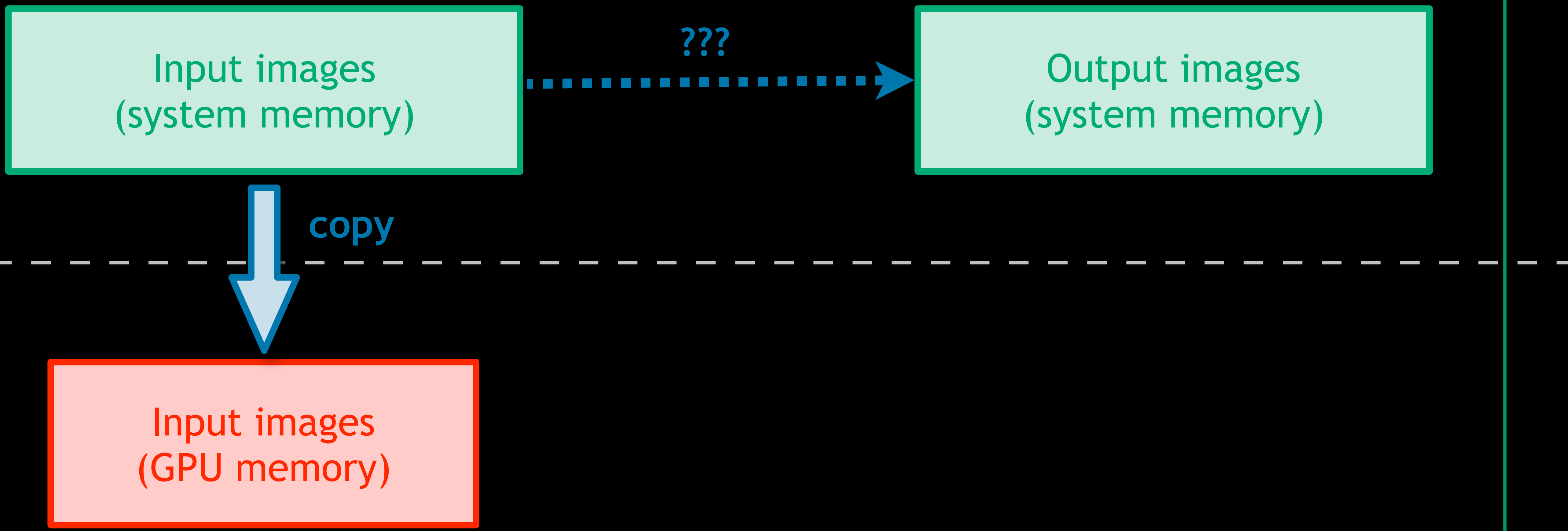

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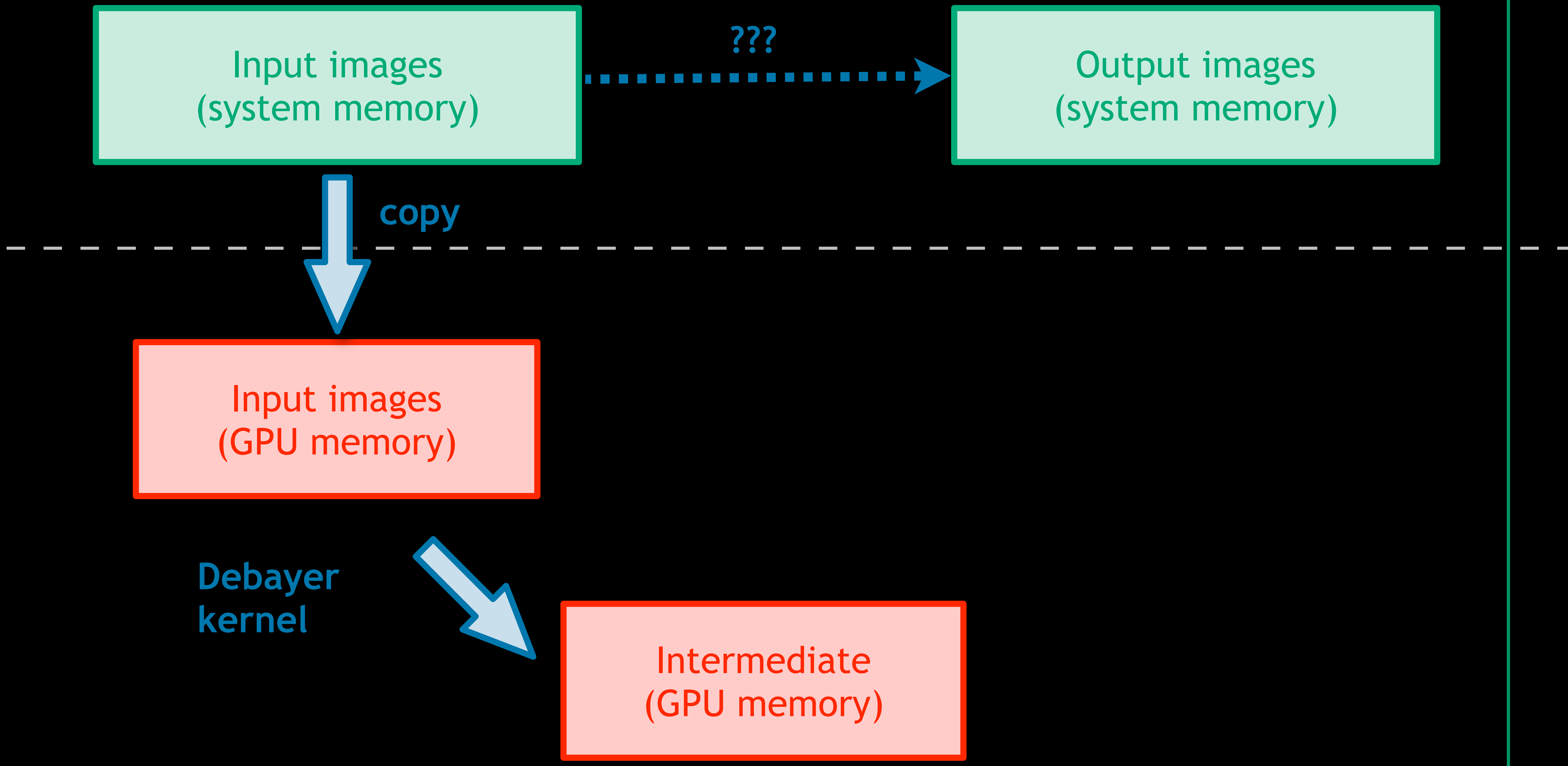

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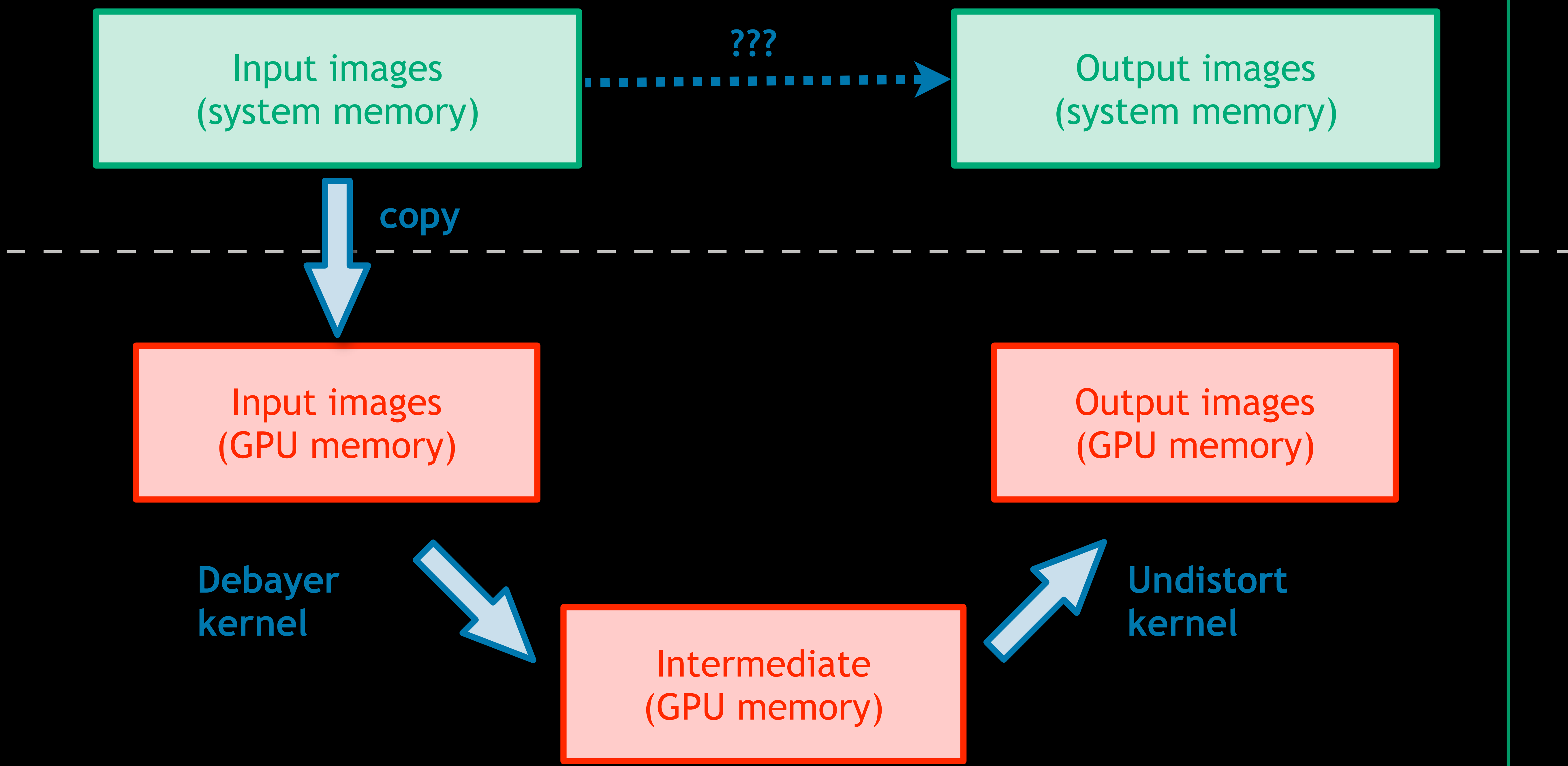

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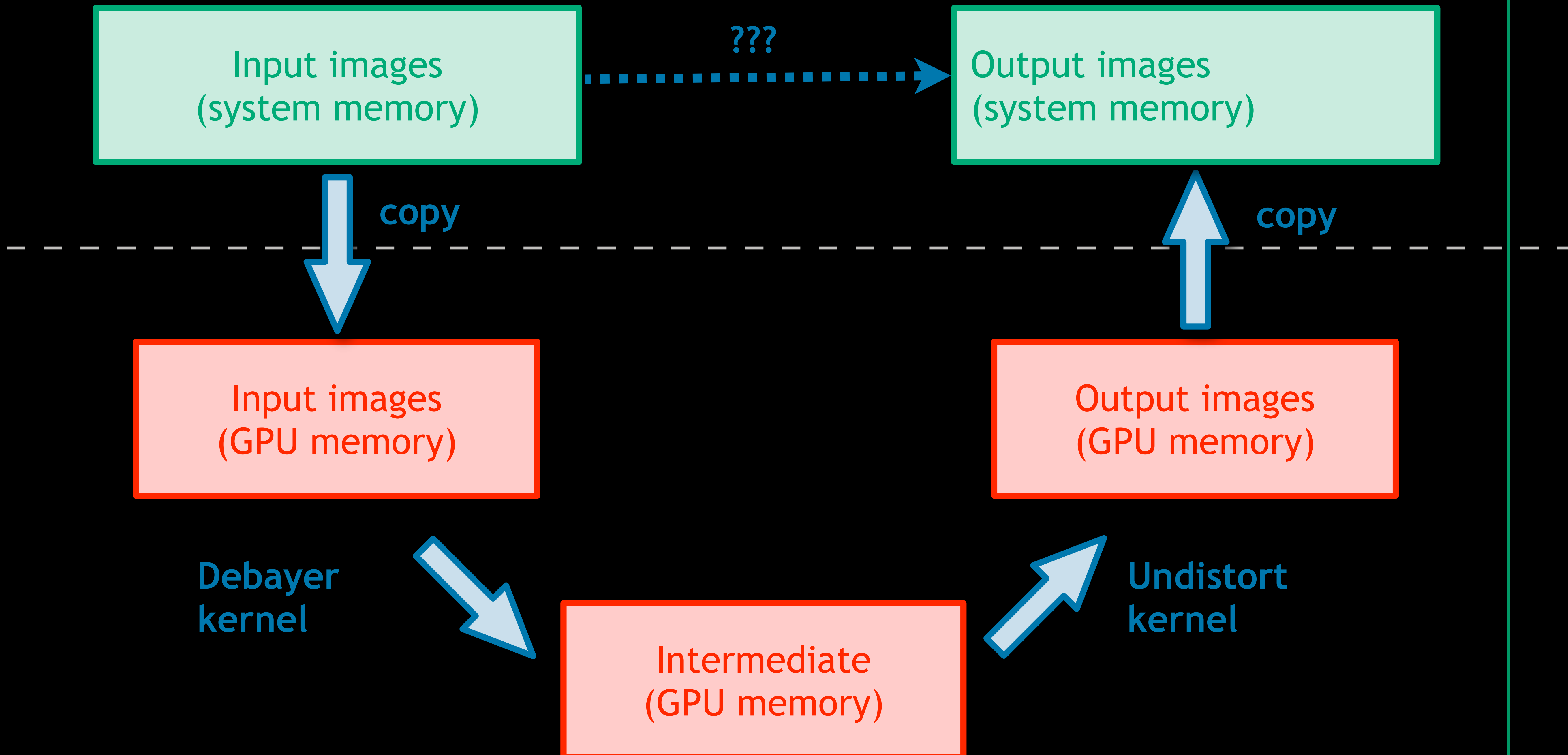

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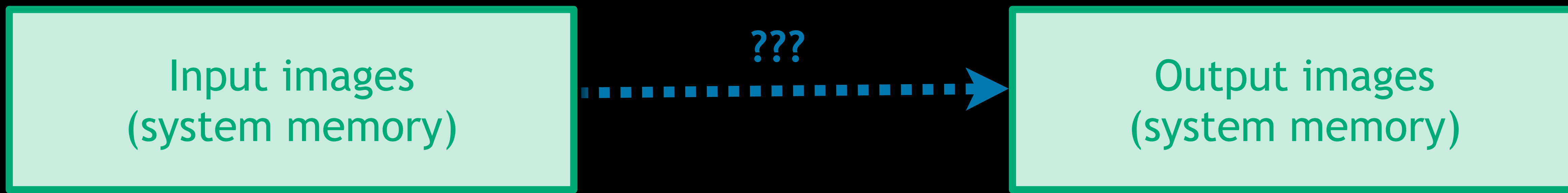

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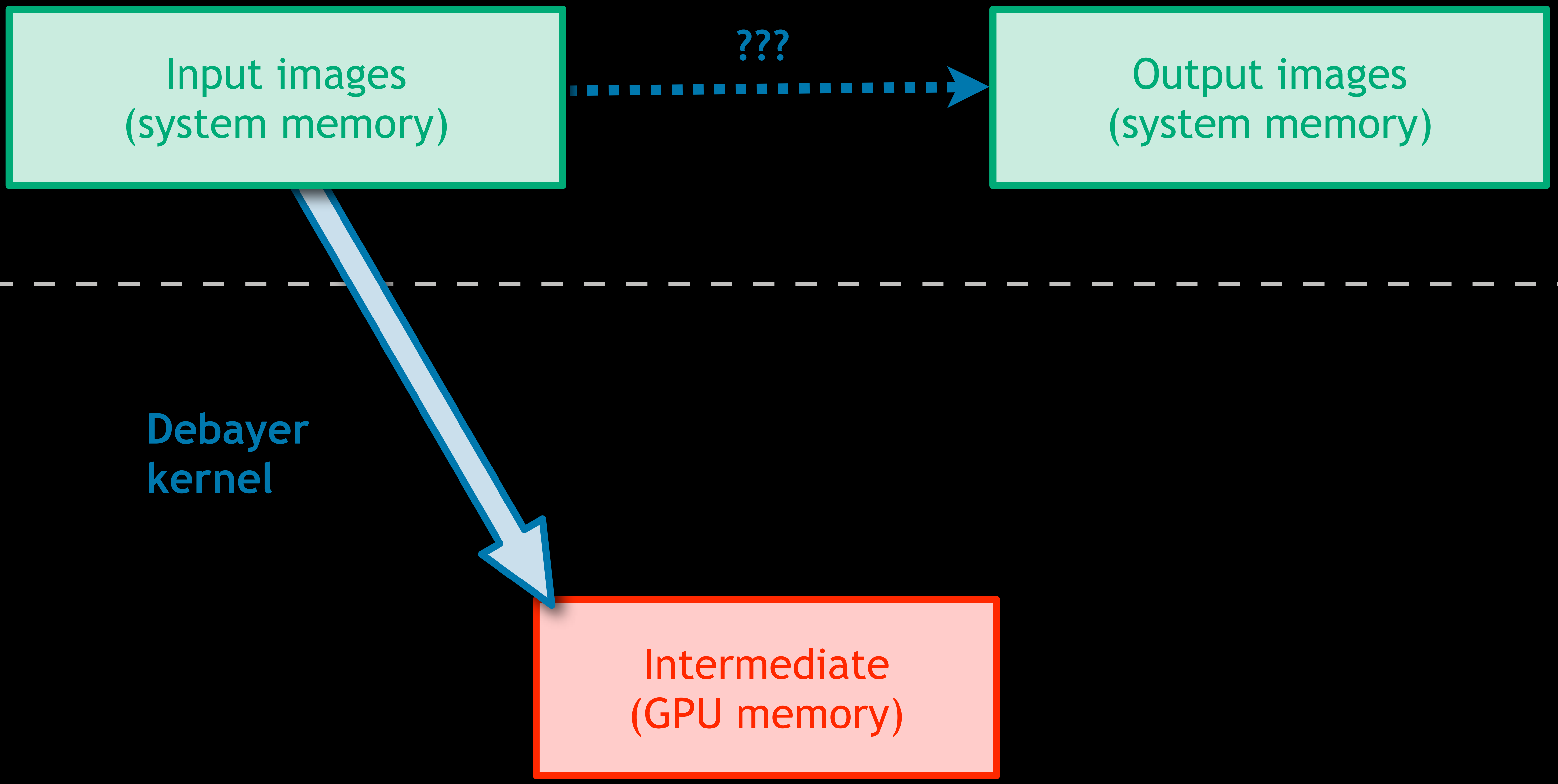

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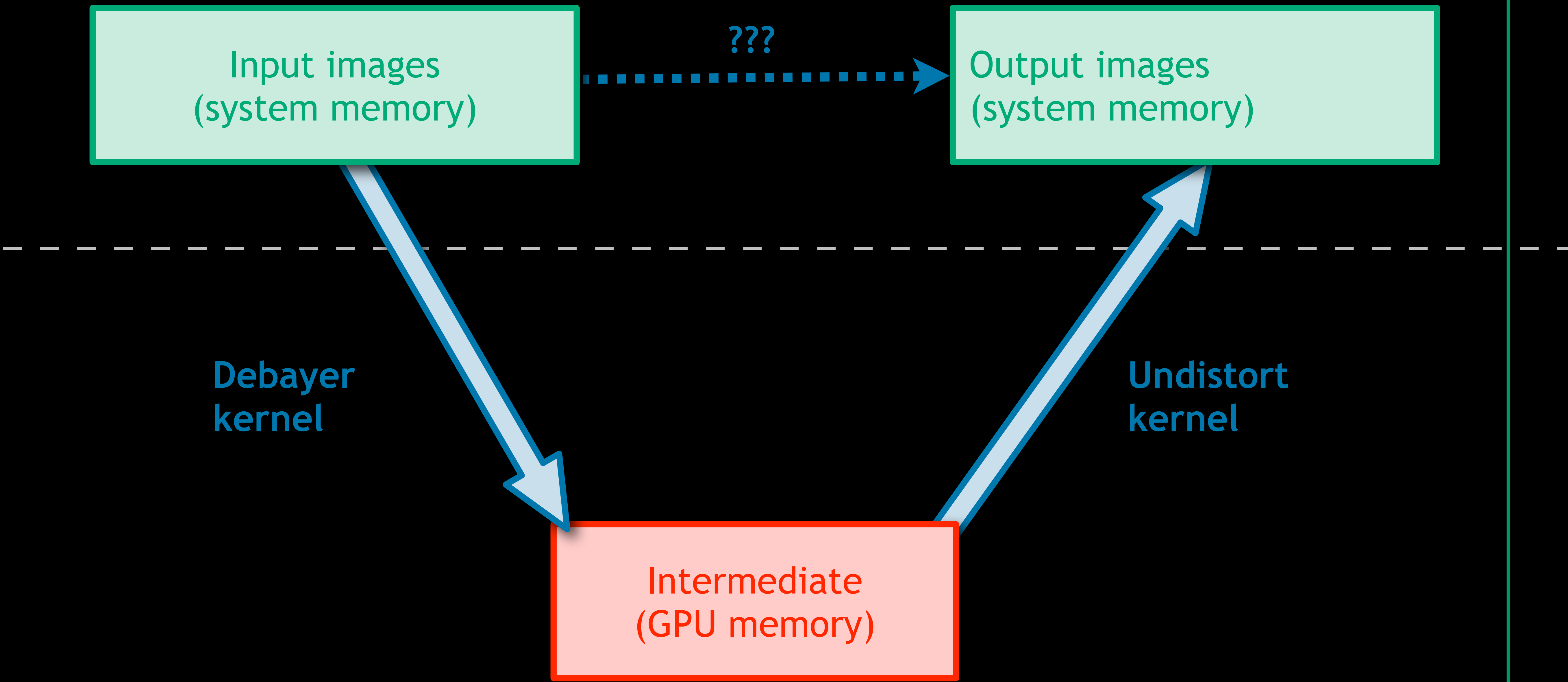

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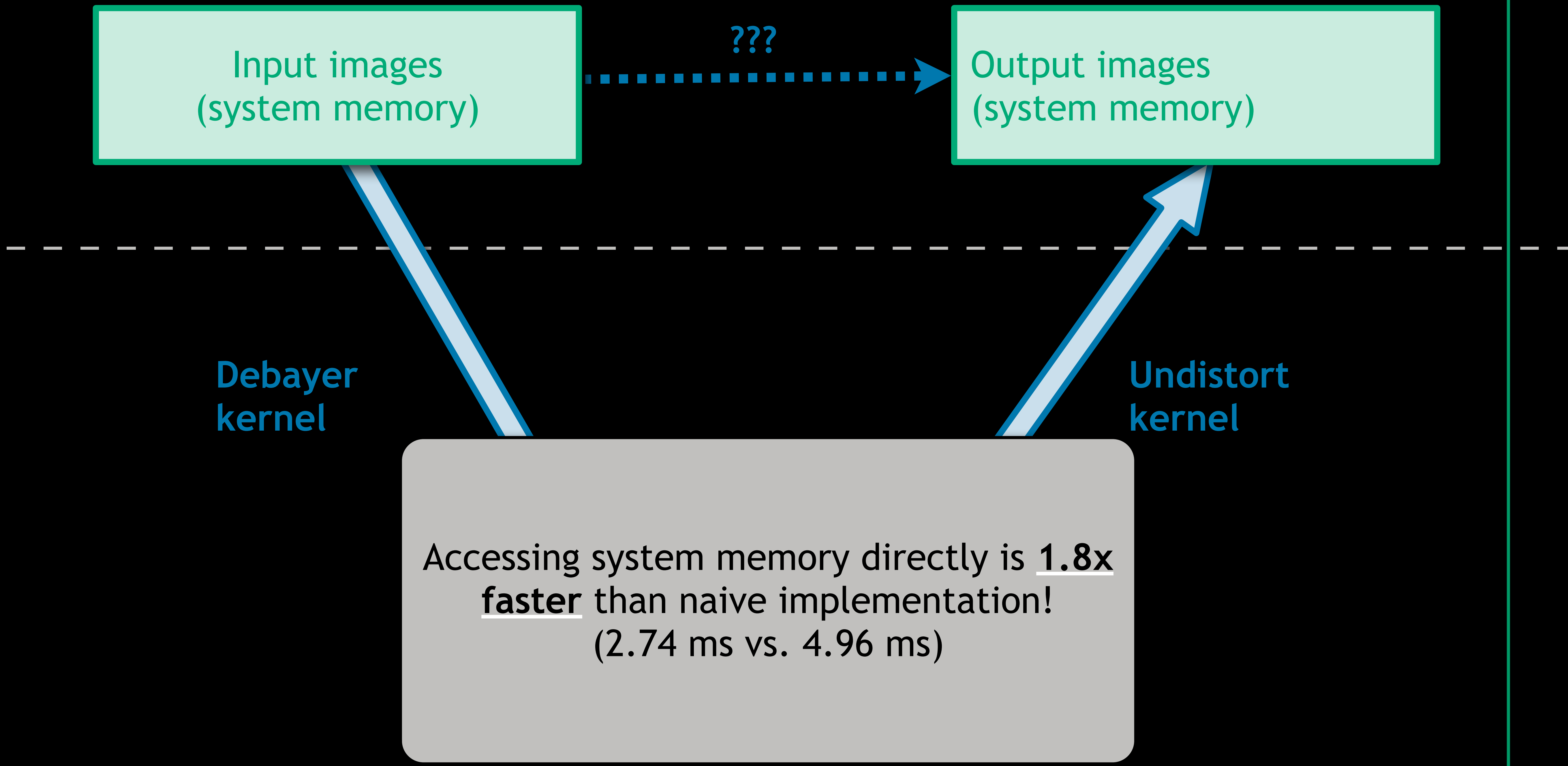

Caveat: System Memory

Performance is chipset dependent

Rasterizers optimized for texture cache performance when rendering graphics

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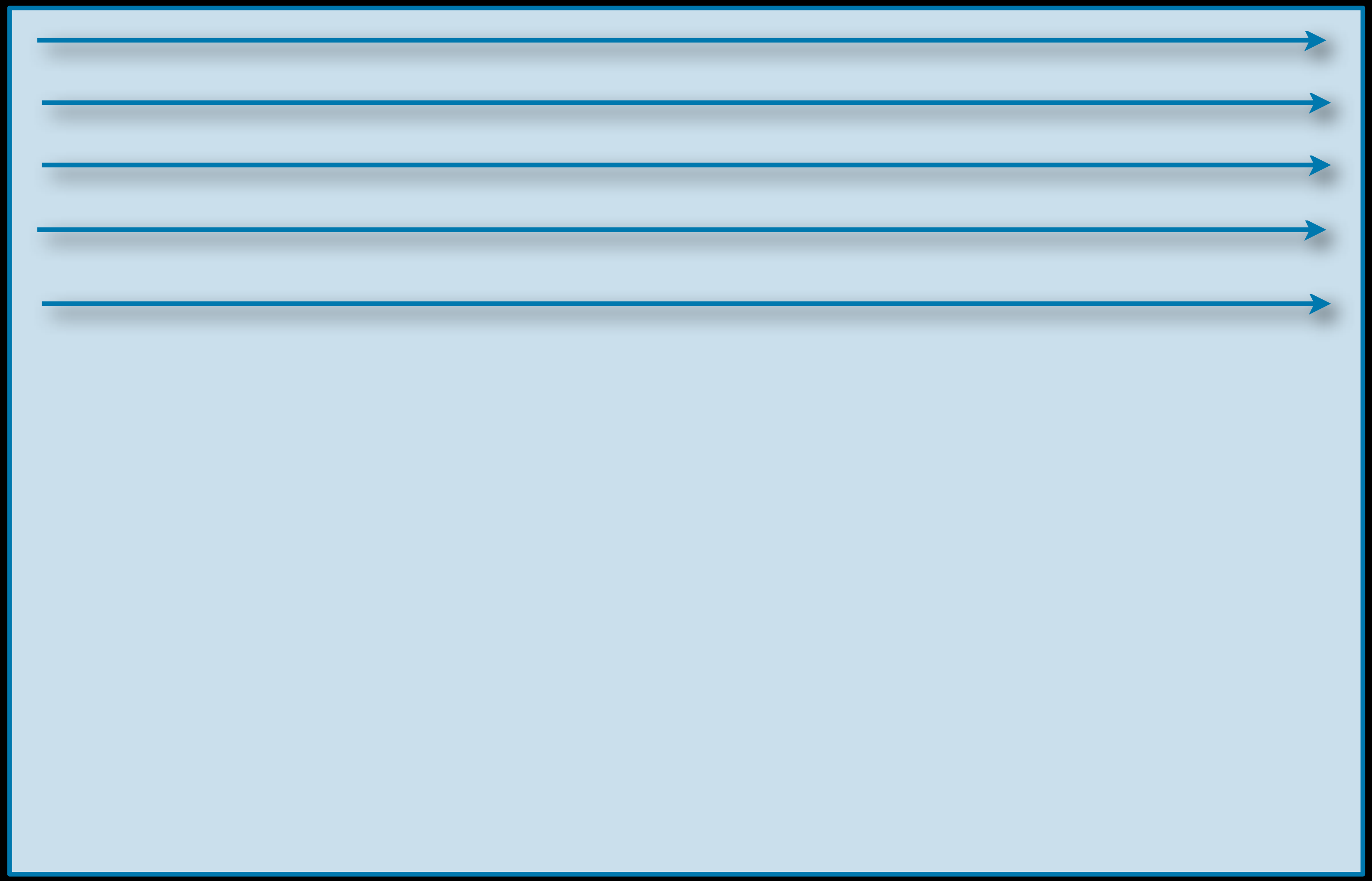

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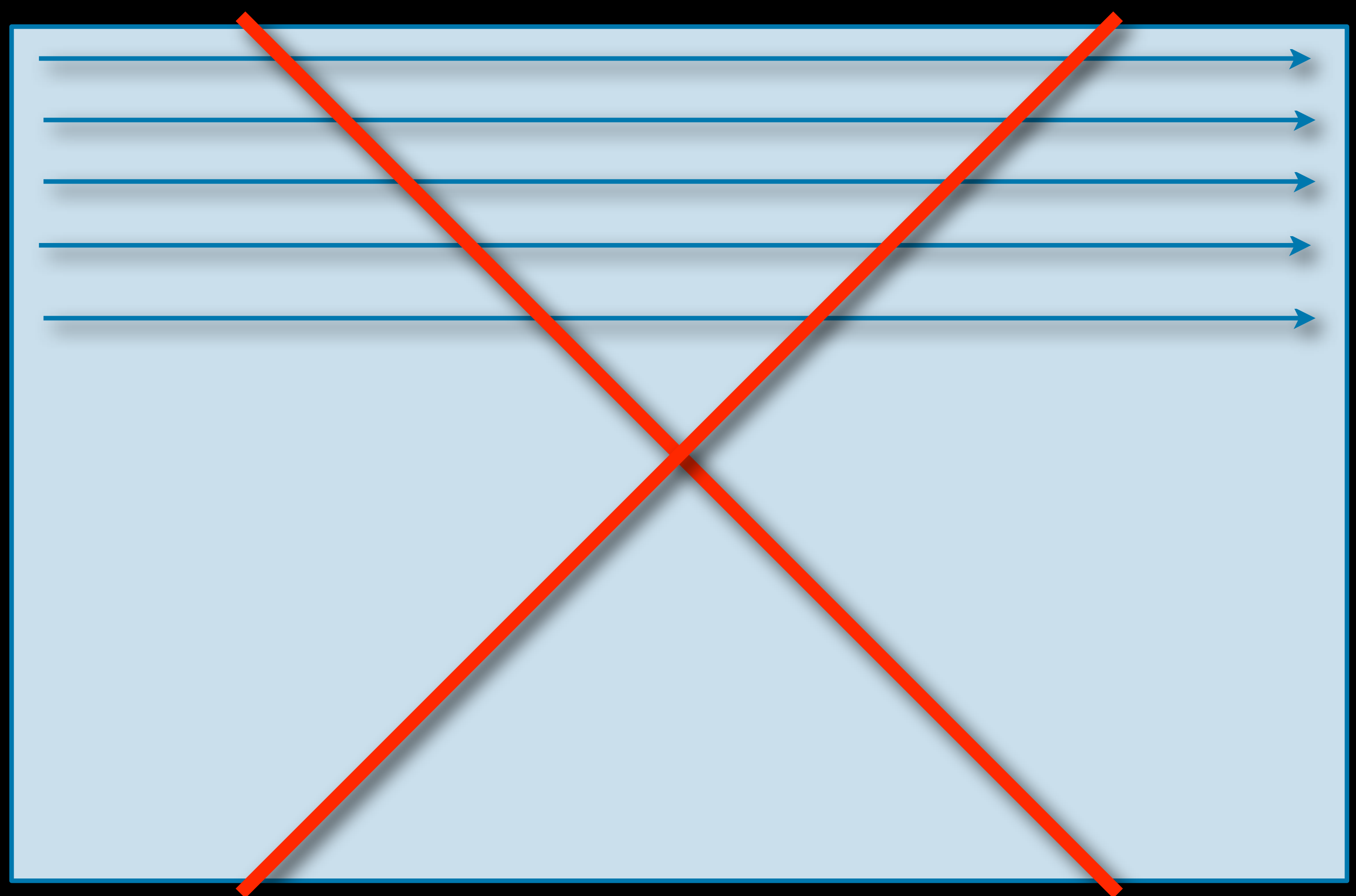

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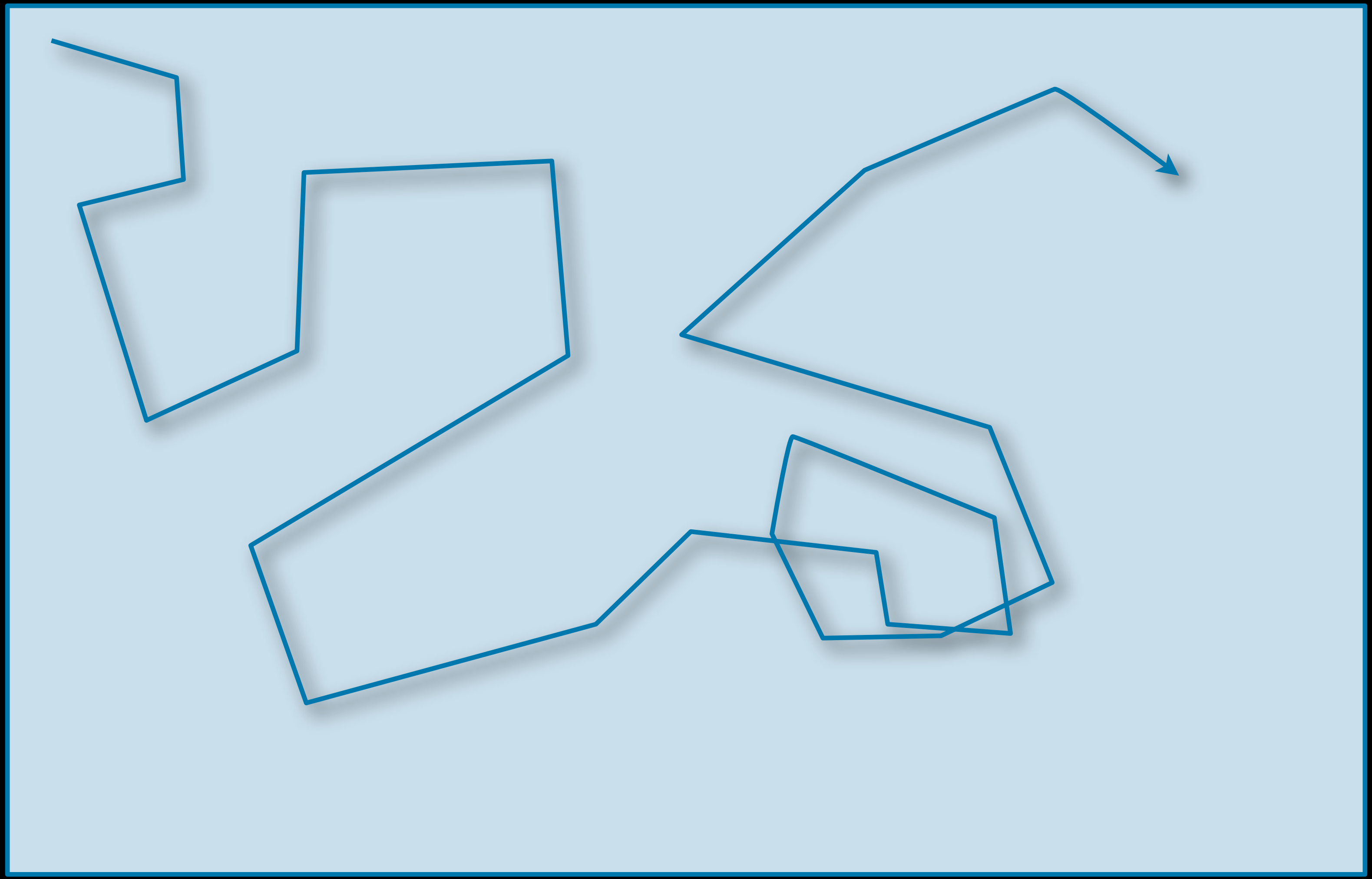

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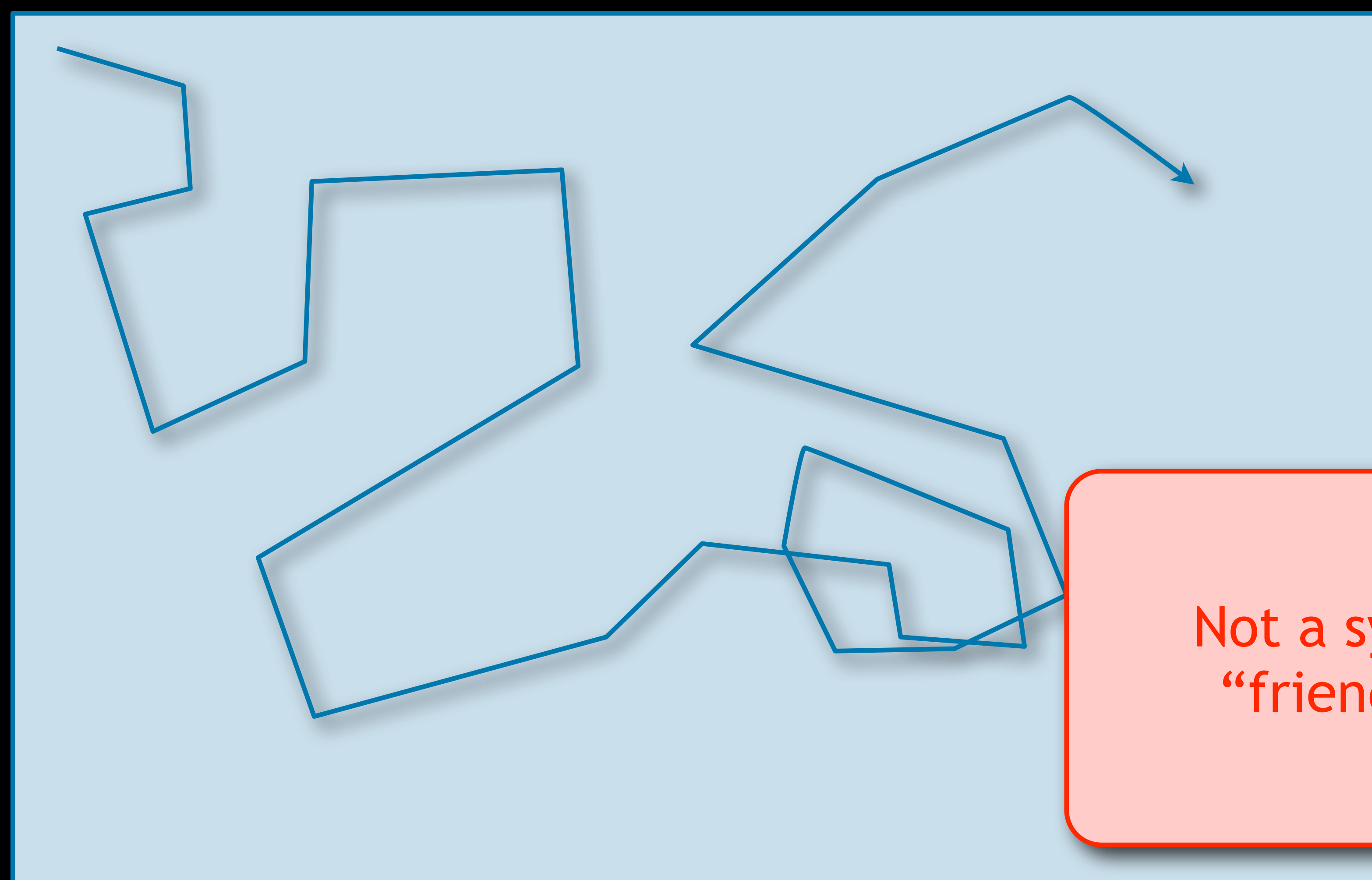

Not a system memory "friendly" traversal

“Forcing” Raster pattern

“Force” the rasterizer to be more friendly with system memory traversal

- Use strips of geometry (CTM can directly *stamp* quads)

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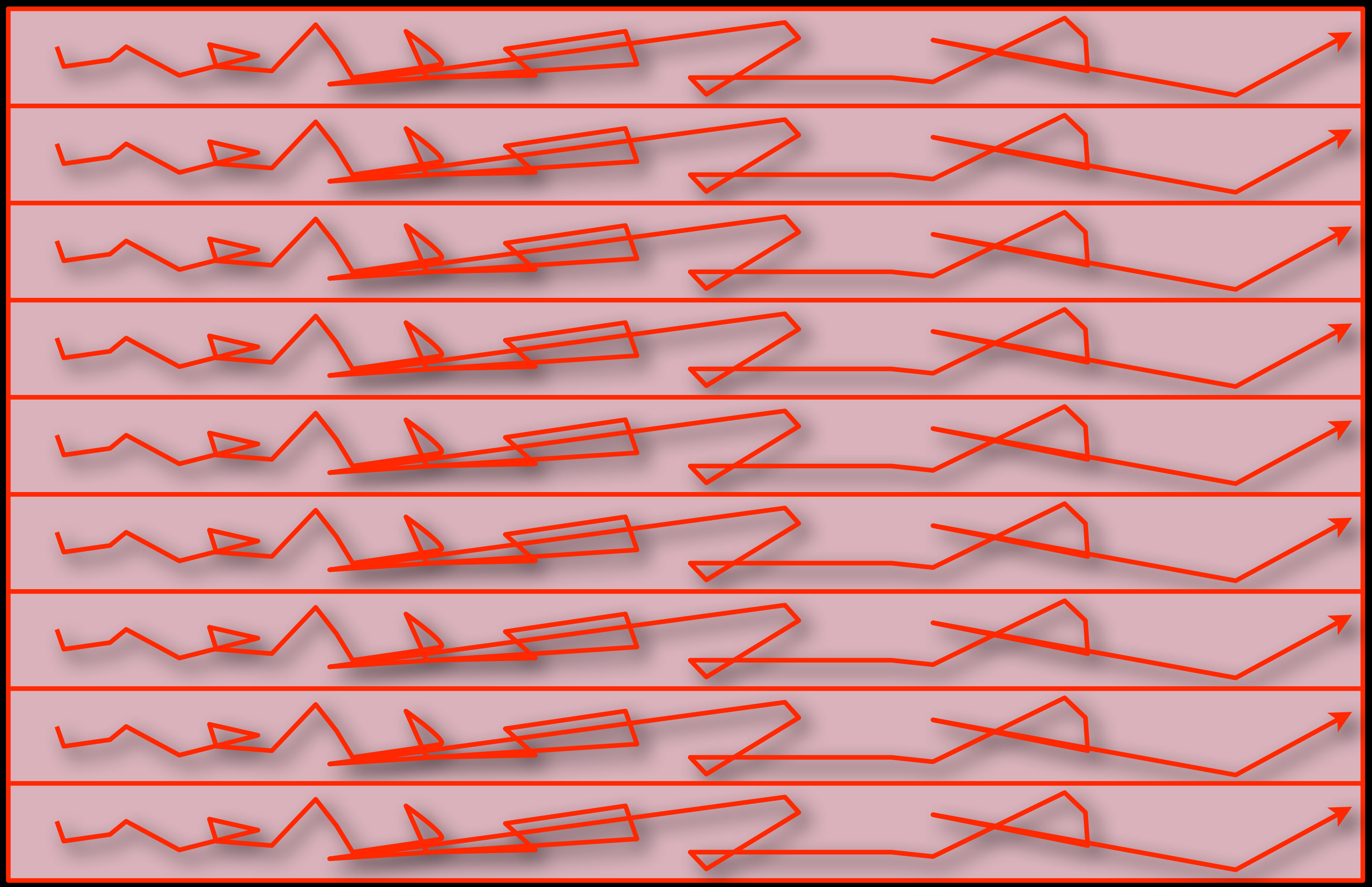

Effect of "Forcing" Raster pattern

AMD
Smarter Choice

2048x2048 float32x4 "copy" shader

- Reads input in local GPU memory, writes to system memory
- RD580 with an R580

Full screen quad time = 45.51 ms

- ~1.5 GB/sec *readback*

"Raster-Blocks" time = 26.53 ms

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Technique could also be used to optimize shaders with non-standard to local memory accesses

Need to be aware of how threads are assigned to wavefronts / warps / vectors

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1.7x faster

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