Texture Streaming

Everything you care to know and more.

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The Basics

The concept is simple: load the top mip level of textures as the camera gets close to them.

If everything is working properly, they'll be loaded before they are actually needed. If not, there can be a slight pop as the top mip level appears.

The Goal

The goal, of course, is to be able to have more memory for textures.

How much more? On Resistance the shader budget was 150 Megs per level. On RCF we used 250 to 300 Megs – so nearly double.

What Textures Are Streamed

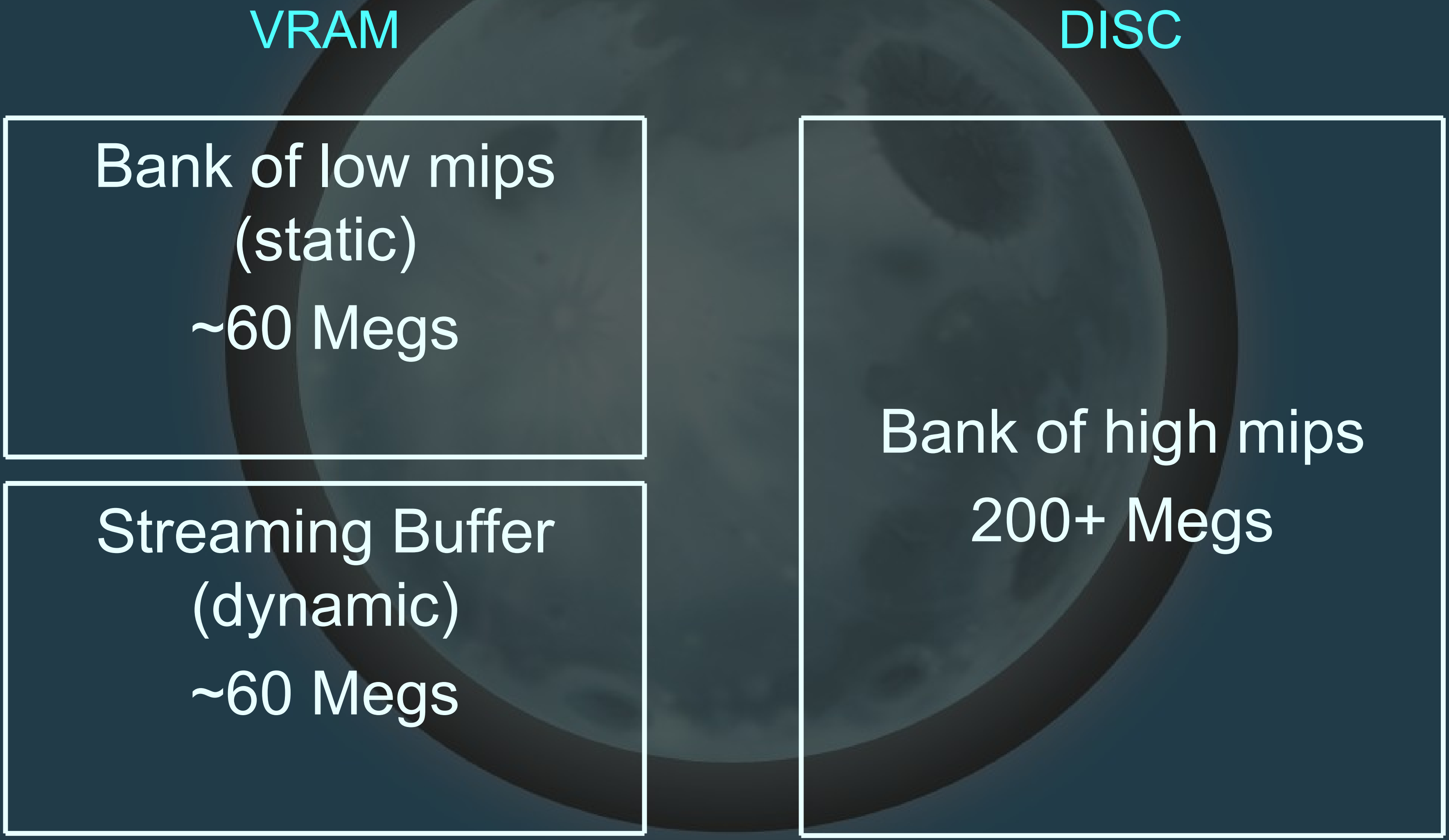
All shader textures are streamed. This includes:

- color maps
- normal maps
- gloss, parallax, incandescence maps
- detail maps

All other kinds of textures are not streamed:

- light maps
- blend maps
- effects textures

Memory Layout



VRAM

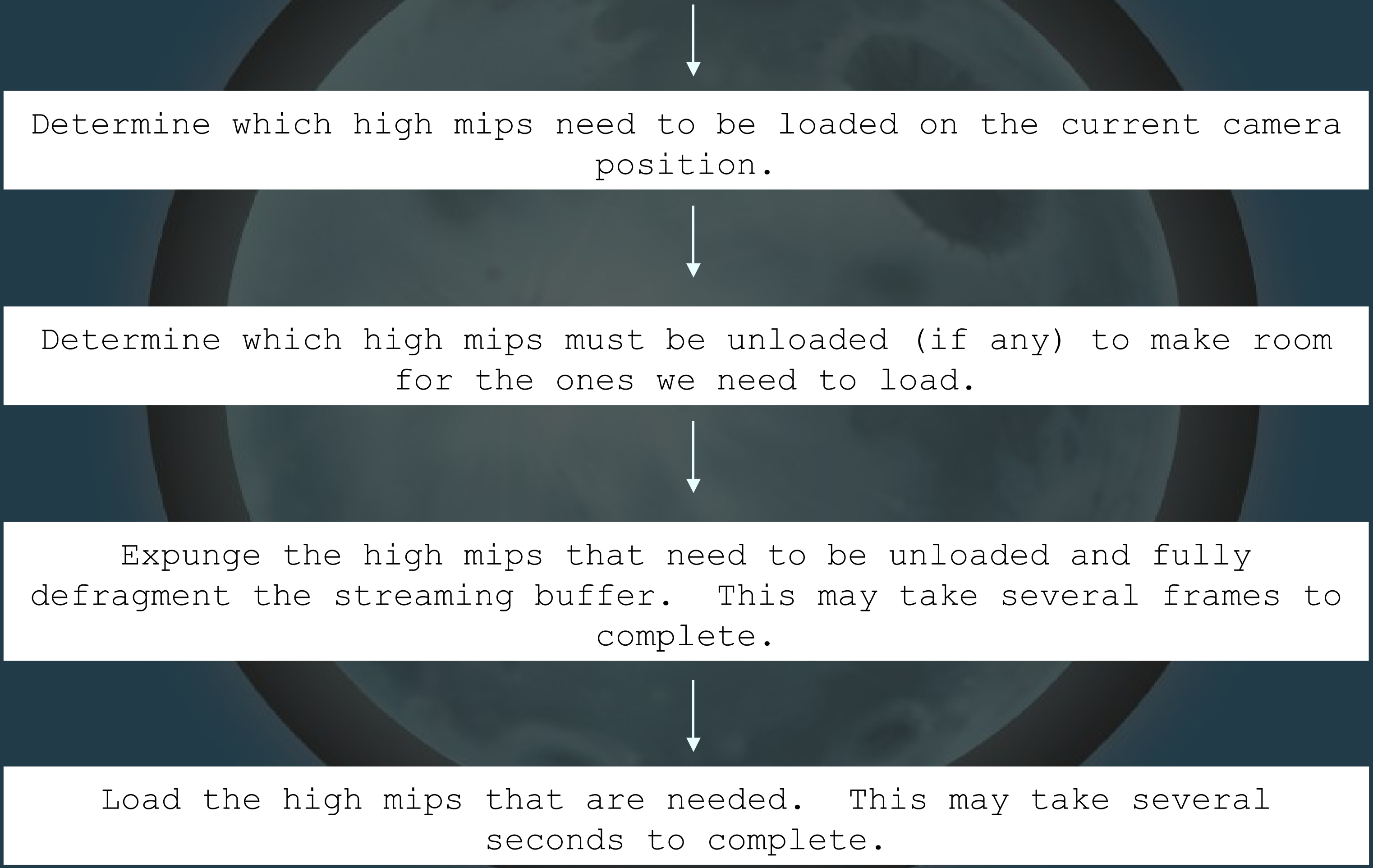
Bank of low mips
(static)
~60 Megs

Streaming Buffer
(dynamic)
~60 Megs

DISC

Bank of high mips
200+ Megs

Game Update



Determine which high mips need to be loaded on the current camera position.

Determine which high mips must be unloaded (if any) to make room for the ones we need to load.

Expunge the high mips that need to be unloaded and fully defragment the streaming buffer. This may take several frames to complete.

Load the high mips that are needed. This may take several seconds to complete.

1) Determining Which Mips Are Needed

- The tools analyze the geometry of each asset and compute some helper data indicating how close you need to be before each texture’s high mip is needed. This calculation is an approximation – the real math is incredibly complex.
- The render shells also compute some helper data each frame indicating how close any camera got to each asset.
- The texture streaming itself hardly has to do any work. It compares the actual distances versus the threshold distances (and adds a fudge distance so the mips have time to load).
- Then the mips that need to be loaded are sorted so the ones that are furthest inside their threshold are loaded first.

2) Determining Which Mips To Unload

- The code will only unload mips that are no longer needed if it needs to make room for new mips. This is pretty typical behavior for a cache in order to reduce re-loading.
- Each mip in memory keeps a stale timer, so the mips that haven’t been needed for the longest are selected to be unloaded first.

3) Unloading Mips And Defragmenting

- After the set of high mips is expunged, the entire high mip buffer is fully defragmented. This is done to keep the streaming logic simpler, and to make sure we can always use the full size of the buffer.
- Because the high mip buffer is in vram, the defragmentation has to be done by the RSX. This adds a bit of complexity because the RSX runs a frame behind the CPU. And there are some weird cases that need to be handled because RSX commands are not always guaranteed to be executed (like on some game mode transitions, or when the push buffer overflows).

4) Loading The High Mips

- In order to play nicely with other systems that stream from the disc, the loads from disc can be done with several different priorities. The high level game logic determines which mode to use.
- Because the RSX requires that all mip levels of a texture must be contiguous in memory, we not only have to load in the high mip from disc but we also have to copy the low mips from the resident bank to the memory just after it. Again this is done by the RSX.

Issue: BluRay or HDD

Obviously, it’d be great to stream the high mips from HDD. That way we’d get high bandwidth and we wouldn’t conflict with the other things that need to stream from BluRay like dialogue, music, cinematics and background loading. But when could we copy 200+ Megs to the HDD for every level?

Our solution for RCF (thanks to Giac and FIOS):

- When the level starts up, we start streaming from BluRay using the lowest possible priority.
- At the same time, we use background loading to copy the high mip file from BluRay to the sys cache on the HDD.
- Once this copy is complete, we switch texture streaming to the highest priority. Typically this happens about a minute into the level.