GDC 13 EUROPE

Using Gigapixel Landscape Textures in Dragon Commander: Lessons Learned

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About Larian Studios

- Divinity II (Dec. 2010)
  - RPG
  - PC & Xbox 360
  - Dragon fights were very popular!
- Dragon Commander (DC) (Aug. 2013)
  - RTS + Action
  - Lots of dragon fights


20
51
+37
30
+10
Bismark

Landscape Texturing in Divinity II

- Looked great on the ground

Landscape Texturing in Divinity II

- Lower quality when seen from the sky

Visible Tiling

Need more dramatic detail

Divinity II Approach

- Masked blending
  - Low resolution masks
  - Tiling detail textures

DC Requirements

- Needed something more visually unique
  - Less tiling when seen from the sky
  - More natural detail: erosion, rivers, cracks, …
- Blending approach not feasible
  - Needs many layers for variety
  - Needs high resolution source art to ensure uniqueness
    - Masks: height, slope, …
    - Textures: diffuse & normal
  - Needs complex blending modes

DC Prototype Solution

- Use uniquely baked texture data on the landscape
  - 64 tiles, 2048x2048 each
  - Equivalent to a 16384 x 16384 texture
  - Textures baked during production
- Statically load all the data
  - 512 MB (DXTn)
- Big, but the artists were happy ☺


Capped: 17 (58 ms) - Real: 18 (55 ms)
The Zealots
The Imperials
35 (3460)
0 / 550
New tutorial available: Movement and Selection
114

Prototype Issues

- Too much runtime memory use
  - 512MB per level landscape
- Too much disc storage
  - 512MB per level landscape

Solution 1: Back to layer blending?

Layer Blending

- Recreate production pipeline in shader:
  - 36 source textures per map
    - 18 diff + 18 norm
    - 1k x 1k: ~ 50 MB total (DXT)
  - 8 mask textures
    - height, erosion(s), normals, roads, walkable
    - 16k x 16k: ~1,3GB total
- Assuming 8k masks: still 391 MB run time memory use
- Complex blending shader accessing many textures

Static Loading

- 2 textures
  - diffuse + normal
  - 512MB run-time meory use (DXT)
- Trivial shader

Solution 2: Texture Streaming?

- A.k.a. don’t load it all at once
- Requirements
  - Low rendering overhead
  - Low memory footprint
  - Low disk storage
  - Future scalability

Solutions overview

Prototype

- Trivial shader accessing 2 textures
- 512 MB memory at run-time
- 512 MB memory on disc

Layer Blending

- Complex blending shader accessing many textures
- 360 MB memory at run-time
- 360 MB memory on disc

Streaming Final

- Relatively simple shader accessing 3 textures
- 60MB ~ 120MB run time memory use (depends on cache)
- ~130MB memory on disc

Texture Streaming

Charles Hollemeersch - Graphine

Background

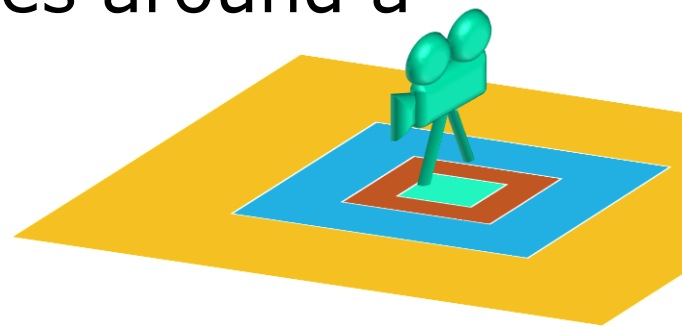
- Mipmap based
- Clipmapping
- Virtual texturing
- Dedicated hardware

Mipmap Based Streaming

- Stream textures one mipmap level at a time
- + Easy to implement
- + No special shader needed
- - Bad granularity
  - Big tiles
    - Seconds, not ms to process for highest mips
    - Memory not efficiently allocated maybe only small area needed
  - Small tiles
    - Batch overhead of splitting geometry

Clip Mapping

- Load fixed resolution rectangles around a certain point
  - + Supports large textures
  - + No need to split geometry
  - - Need roughly planar UVs
  - - Special set-up in shader
  - - Streaming gets more compicated



Clip Mapping in Games

- Difficult to decide a single high resolution area to load

Which area should we load at the highest resolution?

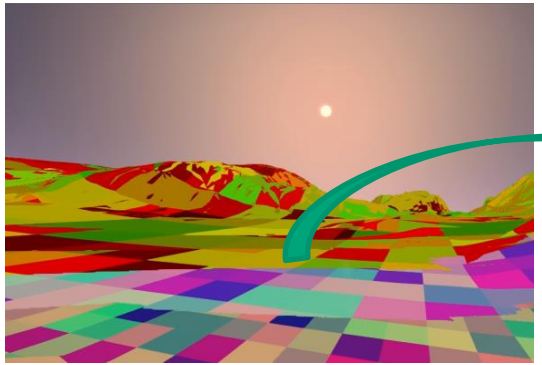
Clip Mapping in Games: Example

Virtual Texturing

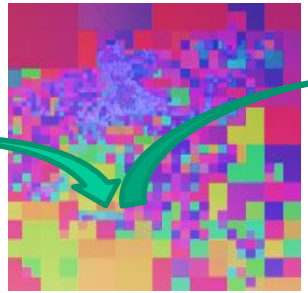
- Stream arbitrary set of tiles based on actual visibility
- + WYSIWYL (a.k.a. what you see is what you load)
- + No special geometry or uv requirements
- + Tiles are small and can be processed fast
- - Most complex to implement
- - More complex shader

Virtual Texturing Overview

Calculated Tile Identifiers and Mip Levels

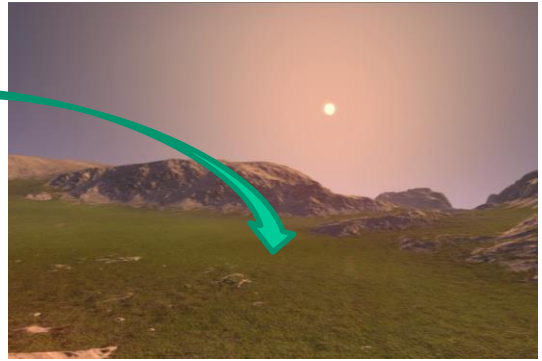


Translation Texture



Cache Texture

Rendered Result



Virtual Texturing in Games

- Has been used in a few high-end titles

Tiled Resources

- Hardware tiled-texture support
- Simlified texture filtering
- Announced at //Build/ 2013
- Confirmed on DirectX 11.2 and Xbox One
- PS4 Partially Resident Textures
- Can be used to implement flexible streaming
  - Clipmapping
  - Virtual Texturing
  - …

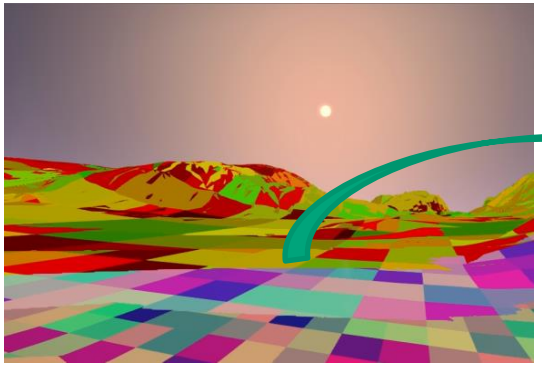
Tiled Resources II

- Still need streaming system to drive hardware
  - Decide what to load
  - Streaming data from disc
  - Compression
- More info in our //Build/ talk
  - http://msdn.microsoft.com/en-us/library/dn312084(v=vs.85).aspx
- Not used in Dragon Commander: DX9

Tiled Resources: Hardware

Indirection step is now hardware accelerated

Calculated Tile Identifiers and Mip Levels



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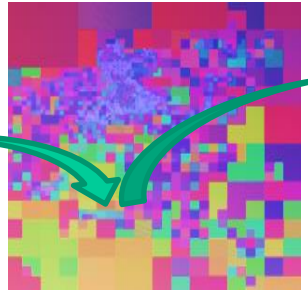

Cache Texture

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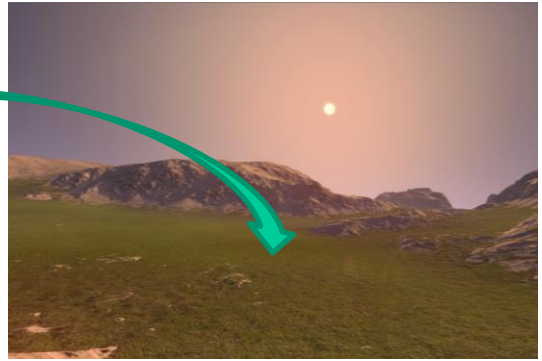
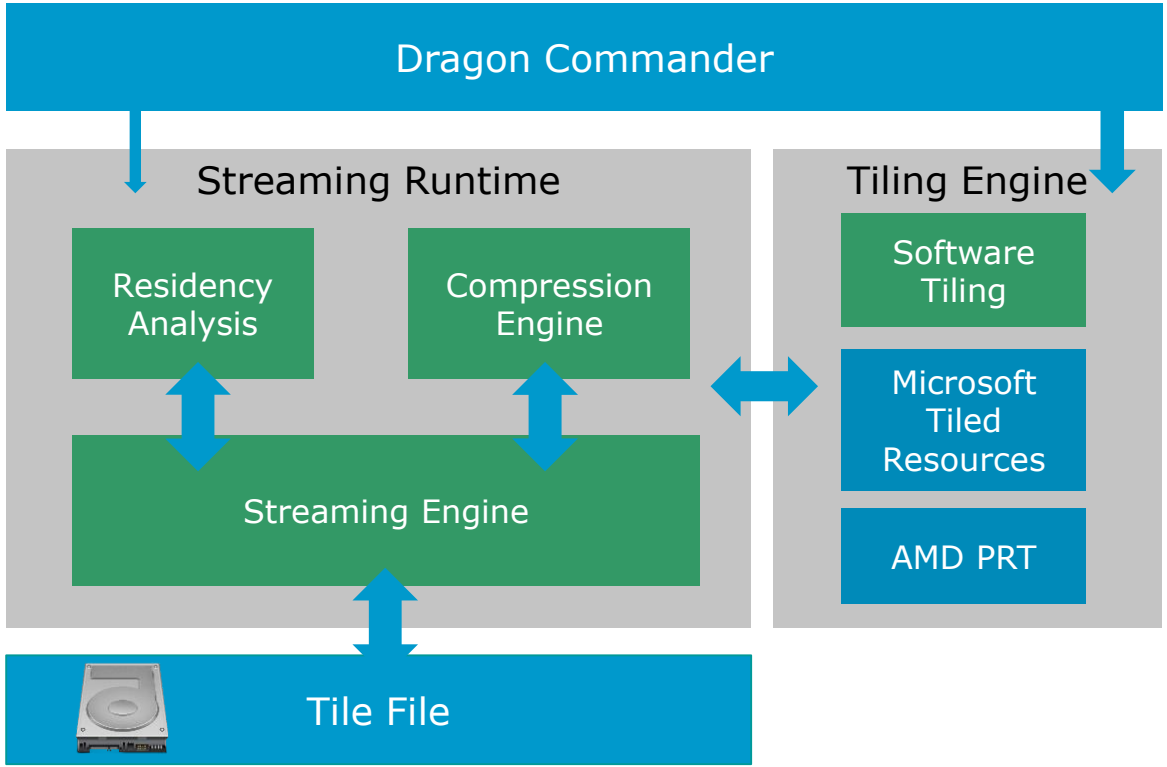


Virtual Texturing in Dragon Commander

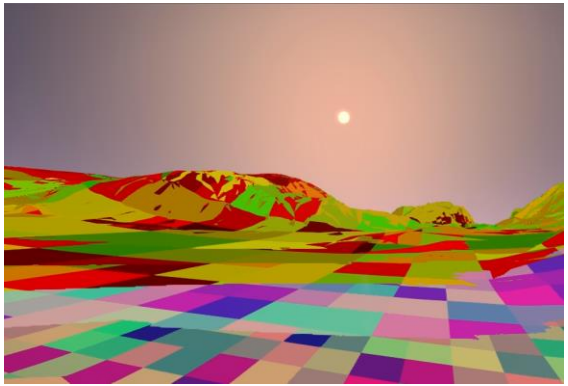
Streaming Runtime Overview



Software Tiling on DX9

- Difficult to get right in all cases
  - Tile border filtering
  - Mipmap filtering
- Been described in detail elsewhere
  - J.M.P. van Waveren - id Tech 5 Challenges
  - Charles Hollemeersch et al – Accelerating Virtual Texturing using CUDA

Residency Analysis in DC



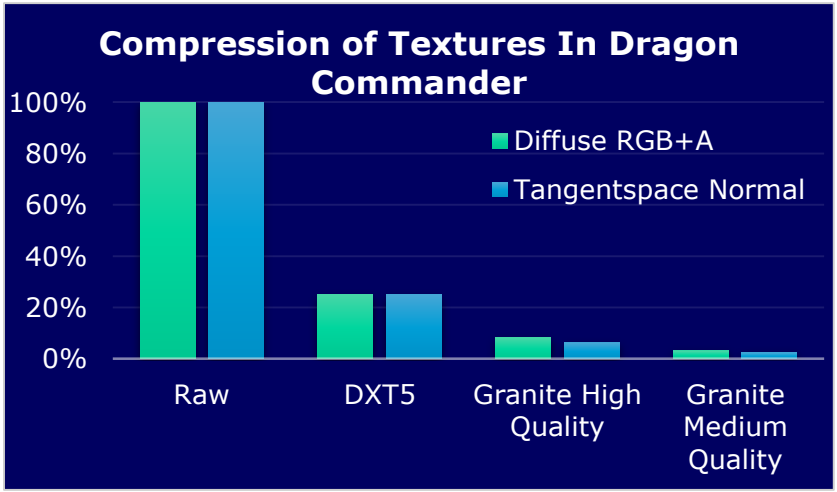
- Decide what tiles to load
  - Try not to load unnecessary tiles
    - Mipmap level never accessed
    - Occluded by other geometry
- Low resolution render of the scene
  - Asynchronous read back to the CPU for analysis
- Only render landscape
  - Main occluder in DC scenes

Need for compression

- DXTn compression: 512 MB/Level
  - DXT5: 16k x 16k Normals + mipmaps
  - DXT1: 16k x 16k Color + mipmaps
- 54 levels in game:
  - 28 Gigabyte
- We needed something better than plain DXTn on disc

Compression

- Graphine compression
  - quantized, block-based
  - predictive
  - adaptive: color + normals
  - support for alpha



- Supports fast transcoding from this format to DXT for optimal storage on GPU

Compression: Example

Compression: Example

fixed 6:1

quantisable ~20:1

Compression in Dragon Commander

- 4.6x compression over DXT (18x vs raw)
- Made the game ~ 1/3rd smaller
  - 6GB level textures
  - Ship on 2 DVDs
  - Download faster

VT Engine Integration

- VT textures are first class citizens
  - Fully integrated in engine resource system and shader node editor, not a special case shader
  - Can use VT on all objects if we want (RAGE style)
  - Currently only used on the landscape
- Integrated in tool chain
  - Compression (16k) adds 45 seconds

Multi-threading

- Asset loading thread
  - Regular assets load through this thread, used at load time
  - Main thread renders loading animations
  - Resource creation invoked on main thread (DX9)
- Texture streaming thread
  - Active at run-time streams compressed pages from disc
  - Mainly sleeping blocked on disc IO
- Texture transcoding thead
  - Convert tiles from compressed format to DXT

Memory use

- 128 MB of system cache memory
- 96 MB of GPU texture memory (-82%)
- Less on low-quality settings

Performance

- Fast even on low-end systems
  - Minimum spec GeForce 8800 (>96% PC Gamers)
- Transcoding of tiles takes up 10-15% of a single core
- Tiles usually available in 2-4 frames
  - Gracefully falls back to lower resolution if data is unavailable
  - No visible popping

Texture Streaming

Swen Vincke - Larian Studios

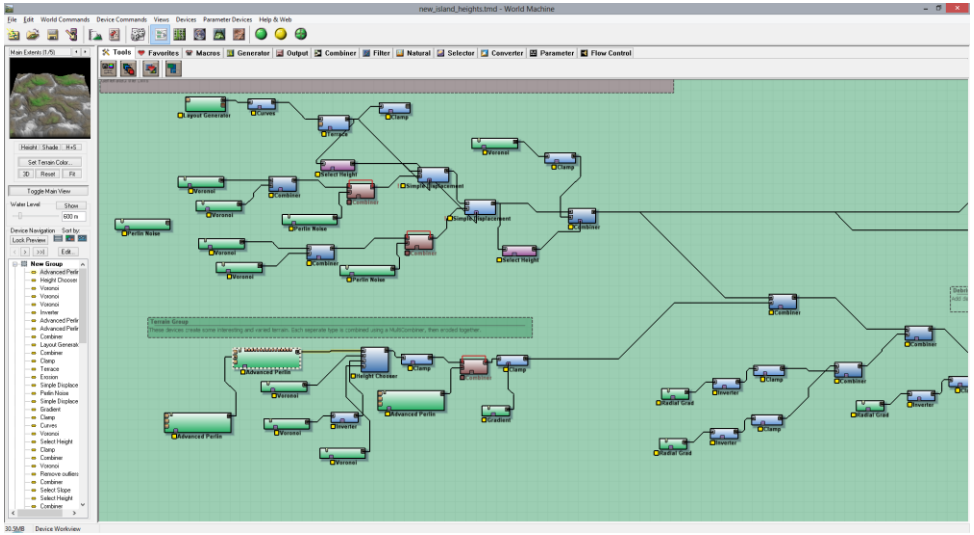
Conclusions on VT

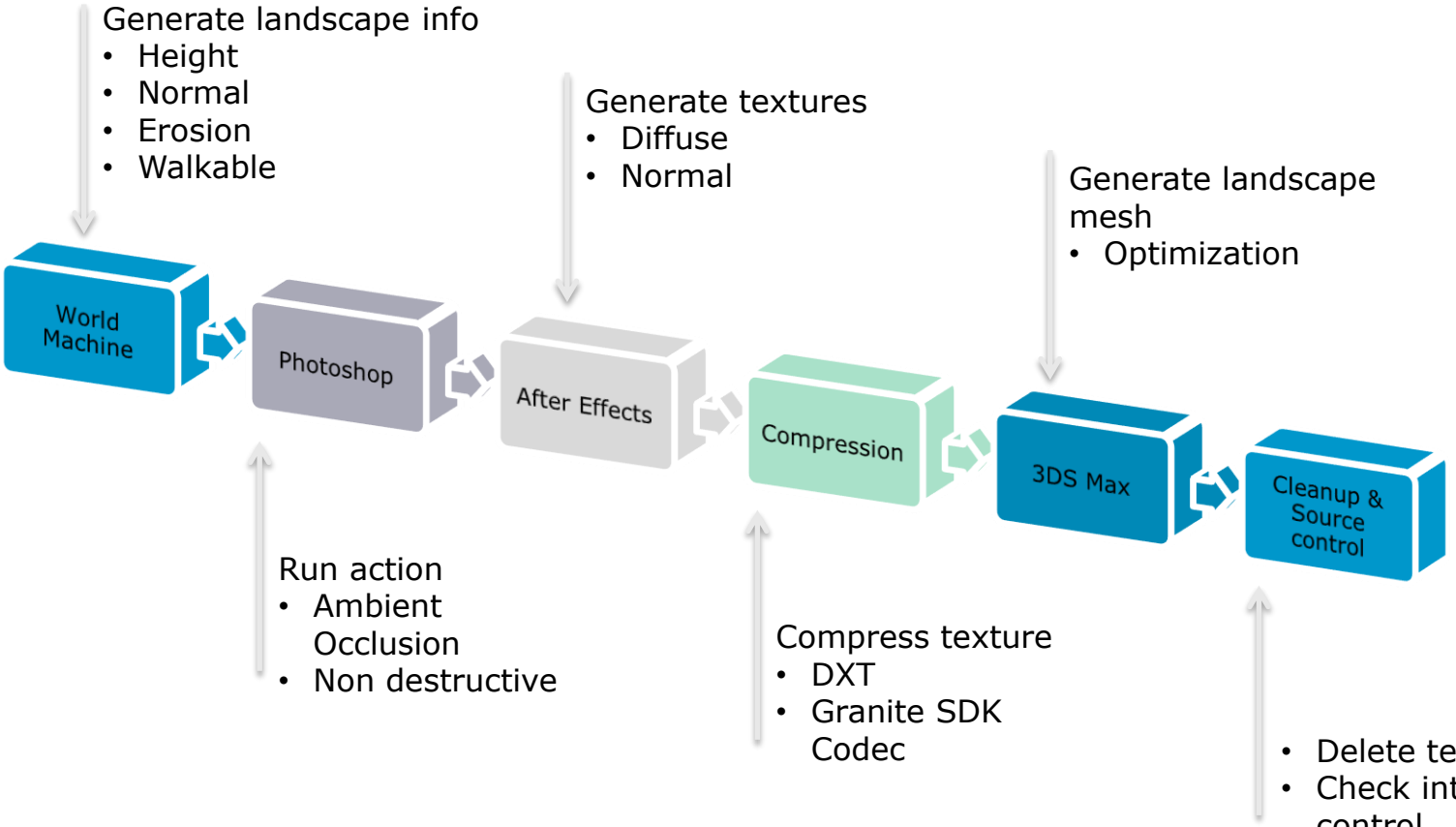
- Removed limit on texture detail
- Reduced storage per map
  - 28GB -> 6GB
  - ~1/3 size reduction overall
- Low runtime memory use
- Easy to integrate in production pipeline

Why we chose to use Granite SDK by Graphine

- Granite SDK: middleware package for advanced streaming and compression
- Easy to integrate
- Years of expertize on streaming and compression
- No codecs to write & optimize
- Future proof: Engine is tiled resources ready

Baking Workflow




Generate landscape info
• Height
• Normal
• Erosion
• Walkable
Generate textures
• Diffuse
• Normal
Generate landscape mesh
• Optimization
World Machine
Photoshop
After Effects
Compression
3DS Max
Cleanup & Source control
Run action
• Ambient Occlusion
• Non destructive
Compress texture
• DXT
• Granite SDK Codec
• Delete temp. data
• Check into source control

Build Server

- Automatically builds landscapes overnight
- Python script controlling all DCC apps
  - Maxscript
  - After effects java script
- Runs through: http://www.cruisecontrolnet.org/

Pipeline problems

- Iteration times to long
  - 2~3 hours for full resolution bakes
- Not enough local control
  - Wanted to add small stamps around bases, forests…
  - Fine control for road layout
- Integrate interactive painting tools in the game editor in the future

Conclusions

Final Conclusions

- Texture streaming allowed us to use less memory at run-time
- On-disc compression allowed us to pack more content in the same download size
- Using middleware gave us high-end technology quickly
- More interactive tools are needed

Questions ?