ABOUT RED
EVOLUTION OF RED

- Jim Jannard founded the company, and has had a lifelong interest in imagery. RED is his brainchild.

- RED is a technology company (both sensor and camera technology). RED is committed to obsolescence obsolete, by way of loyalty programs.

- Sensor Timeline
  MYSTERIUM > MYSTERIUM-X > DRAGON > DRAGON VV > HELIUM > MONSTRO VV > GEMINI

- Evolution of Brains
  DSMC > DSMC2

- RED is committed to the DSMC2 through 2020, securing customers investment in products.
REAL-TIME HIGH RESOLUTION WORKFLOW IS NOW A REALITY
REAL-TIME 8K WORKFLOW WITH R3D SDK

WHAT WE’LL BE COVERING

- The goal: to achieve playback of 8K footage at 24 FPS
- How big is an 8K frame?
- REDCODE RAW compression format
- The three stages of decompressing a frame
- Then there’s demosaic
- How much work can we move to the GPU?
- How do we schedule it?
- What about rendering?
- Eureka! 24 FPS on a 2080
- So, how do you use it?
- REDCINE-X: RED’s free editing software
- REDLINE: Command-line transcoding tool
- Who else uses it?
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THE GOAL: TO ACHIEVE PLAYBACK OF 8K FOOTAGE AT 24 FPS

- Most camera footage is shot at 23.976 FPS
- Our goal was to play 8K footage in real time on a single GPU
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HOW BIG IS AN 8K FRAME?

- An 8K FF frame is 8192 pixels wide by 4320 pixels high
- That’s 35,389,440 pixels in a single frame
- Each pixel is 4 bytes wide
- That’s 141,557,760 bytes of data for each frame
- If we’re outputting to 8-bit BGRA then that’s another 141,557,760 bytes
- At 24 FPS that’s 3,397,386,204 bytes of data to move each second
- How do we move that much data? Compression

141,557,760 bytes/frame
3,397,386,204 bytes/second
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REDCODE RAW COMPRESSION FORMAT

- Wavelet compression
- Smaller resolutions can be easily extracted and decoded (processing decreases by 75% per resolution removed)
- 16-bit pixels (DCT algorithms typically handle 8 or 10-bit pixels)
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THE THREE STAGES OF DECOMPRESSING A FRAME

- REDCODE RAW is a proprietary wavelet compression codec.
- REDCODE RAW involves three stages of compression:
  - Wavelet transform - separate the image into approximation and detail coefficients
  - Tier 1 - block encode the wavelet coefficients using an entropy encoder
  - Tier 2 - encode the blocks into a bit stream
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THE THREE STAGES OF DECOMPRESSING A FRAME

- To decompress the image, we run the three stages in reverse.
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THEN THERE’S DEMOSAIC

- The raw image is in the form of a Bayer array.
- Demosaicing is the process of converting the raw Bayer data into an RGB image of the same resolution.
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HOW MUCH WORK CAN WE MOVE TO THE GPU?

- Tier-2 decode
  - Stream based encoding, it can’t be partitioned
  - Has to run on the CPU

- Tier-1 decode
  - Block based, it can be partitioned
  - Can be run on the GPU

- Inverse wavelet transform
  - Straightforward to implement on the GPU

- Demosaic
  - Already implemented on the GPU
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HOW MUCH WORK CAN WE MOVE TO THE GPU?

- Challenges
  - The Tier-2 decode produces a large amount of data that we need to move to the GPU.
  - The Tier-1 decode is computationally demanding - it contains a large number of loops and conditional blocks that are not optimal for GPU processing.
    - High divergence
    - Low occupancy
  - Even though we already had an implementation of demosaic on the GPU, we had to look for ways we could optimize it.
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HOW DO WE SCHEDULE IT?

- Overlap the Tier-2 decode on the CPU with the Tier-1 decode on the GPU
- Run multiple CUDA streams to fully saturate the GPU
  - Four streams seems to be the optimal number

Trace of decode & demosaic pipeline
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WHAT ABOUT RENDERING?

- We use OpenGL to render the frames to the screen.
- CUDA/OpenGL interop allows us to move the frame directly from CUDA memory to an OpenGL texture.
  - cudaGraphicsMapResources()
  - cudaGraphicsRegisterImage()
- We need to synchronize OpenGL with the decode kernels.
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EUREKA! 24+ FPS ON A 2080.

- Benefits
  - 8K real-time 24 fps or greater playback performance.
  - Up to 10x faster transcoding depending on the format and content.
  - Improved efficiencies and better quality control within the content review process.
  - Creative freedom using flexible RAW R3D files, rather than semi-baked proxy files.
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SO, HOW DO YOU USE IT?

- Fully asynchronous API

```c
Status status = RED_CUDA->processAsync(CUDA_DEVICE_ID, stream, cudaJob, err);
cudaJob->completeAsync();
```

- Use multiple CUDA streams
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SO, HOW DO YOU USE IT?

- Memory management - provide your own memory manager

```cpp
R3DSDK::EXT_CUDA_API api;
api.cudaFree = SimpleMemoryPool::cudaFree;
api.cudaFreeArray = SimpleMemoryPool::cudaFreeArray;
api.cudaFreeHost = SimpleMemoryPool::cudaFreeHost;
api.cudaHostAlloc = SimpleMemoryPool::cudaHostAlloc;
api.cudaMalloc = SimpleMemoryPool::cudaMalloc;
api.cudaMallocArray = SimpleMemoryPool::cudaMallocArray;
api.cudaMallocHost = SimpleMemoryPool::cudaMallocHost;

//CREATE THE REDCuda CLASS
return new R3DSDK::REDCuda(api);
```
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REDCINE-X PRO: RED’S FREE EDITING SOFTWARE

- Available on Windows
- Supports projects and timelines
- Supports color grading
- Supports transcoding to many different formats
- Decode acceleration not available on Mac
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REDLINE: RED’S FREE COMMAND LINE TRANSCODE UTILITY

- Available on:
  - Windows
  - Linux
  - Mac (decode acceleration not available on Mac)

- Able to transcode to:
  - Apple ProRes
  - H.264
  - Mpeg
  - H.263
  - AVID DNX
  - AVI
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WHO ELSE USES IT?

R3D SDK Integrators include:

- Adobe - Adobe Premiere Pro
- Blackmagic Design - DaVinci Resolve
- Apple - Final Cut Pro
- Autodesk - Flame
- AVID - Media Composer
- Colorfront - Transkoder
- Industrial Light & Magic
- Assimilate - Scratch
- Foundry - Nuke
- Baselight - FilmLight
- SGO - Mistika
- Fotokem
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QUESTIONS?