



**NVIDIA®**

## **GL ES Content Development Post-Mortem on NVIDIA GPUs**

**Lars M. Bishop, NVIDIA Developer Technologies**

**Paul A. Hodgson, Denied Reality Limited**

# Agenda



- **Setting the Stage...**
- **Challenges and Solutions**
- **The Result**

# Setting the Stage



- The overall goal of the project
- The platform
- The team(s)



# The Goal (October 2005)



- To show new, playable, native (C/C++) OpenGL ES mini-game that showcased the 3D power of the GoForce 5500
  - Target high frame rate at VGA resolution
  - Focus on “how’d they do that” per-pixel effects
  - “No excuses required, no explanation needed” quality
- To show early 3D demo *at the GoForce 5500 launch!*
  - 3GSM 2006, February 13-16 (Barcelona)
- To show the playable mini-game at E3 2006

# The Platform



## ● World-class 3D

- HW Geometry pipeline
- 16/32bpp textures and color buffers
- Programmable pixel shading
- QCIF, QVGA, VGA, XGA screen sizes!

## ● Integrated multimedia features

- HW video decode (video textures!)
- HW video encode (videoconferencing)
- HW camera support (live camera into a texture!)
- HW audio support



# The Team(s): Denied Reality



- **Denied Reality, Ltd. (D.R.)**

- ~3 programmers
- ~2 artists
- ~0 sleep...

- **History**

- Extensive cross platform experience on PC, console and handheld/mobile
- Implementation and optimisation from pure software to full hardware solutions
- Numerous titles for both original and household brand IP
- TnT group responsible for innovative company-wide technology and fire fighting

# The Teams(s): NVIDIA



- **Developer Relations team: “DevRel”**
- **Developer Technologies team: “DevTech”**
- **Driver team: “Handheld SW”**
- **Systems Engineering Team: “SysEng”**



# The Timeline



- Initial discussions commenced in Sept 2005
- Development started in October 2005
- Decision to show a non-playable version at the GoForce 5500 launch (Feb, 2006) was made in December!
- Stable, good-looking demo was shown as a part of our demo suite at the GoForce 5500 launch



# Challenges and Solutions



- **Pre-release hardware and drivers**
- **Multiple development platforms**
- **The Usual Culprits**
  - **Tight schedule**
  - **Performance goals**

# Pre-release Drivers



- **Challenge: Drivers, like the hardware, were not final**
- **True of just about any pre-release 3D HW**
- **Drivers were not yet fully-featured**
- **Driver performance was not fully optimized**
- **In a few cases, the optimal way to feed the driver changed during development**



# Pre-release Drivers



- **Solution 1: NVIDIA Handheld DevTech**
- **A human interface between D.R. and NVIDIA teams**
- **Packaged and tracked D.R.'s issue reports for SW**
  - **Often worked out repro cases so that D.R. and the driver team didn't have to.**
- **Provided new driver builds when appropriate**
  - **Determined workarounds for issues that took longer to solve**
- **Provided guidance to driver teams as to which features were needed earliest**



# Pre-release Drivers



- **Solution 2: D.R. engine's flexible data model**
- **Made it easy to benchmark demo with different rendering primitives**
- **Made it easier to change an effect as features became available**
- **No downtime waiting for a specific feature**

# Multiple Development Platforms



- **Challenge: Several development platforms came online during demo development**
- **A GoForce 4800-based system initially (ARM9)**
- **A similar GoForce 5500-based system came next**
- **Final demo HW was a faster-CPU GoForce 5500 system (ARM11)**



# Multiple Development Platforms



- **Solution 1: NVIDIA Handheld DevTech SDK**
- **Provided documentation on HW and SW setup**
- **Provided feature demos and libraries that compiled for all target hardware**
- **Provided a standard structure for new toolchains and target file systems**



# Multiple Development Platforms



- **Solution 2: D.R.'s wisdom/previous experience**
- **Had worked on the Gizmondo, which had a GoForce4500 as its GPU**
- **Had always kept a cross-platform engine in-house**
- **Engine allowed for parallel development on all of the NVIDIA platforms and even Win32 to avoid downtime**
- **This was important in the early days when development HW was scarce**

# Tight Schedule



- **Solution here was manifold**
- **Iteration and offsite testing**
  - Frequent builds from D.R. allowed NVIDIA DevTech to monitor performance, stability, features, etc
- **Communication**
  - Frequent communication between NVIDIA DevTech, driver team, and systems engineering made it easier for all of us to plan the rollout of new HW and drivers
- **A head start**
  - Not developing an engine from scratch was a necessity in this particular case



# Performance...



- **Went quite smoothly, actually...**
  - Low-level optimization was not a consuming focus
  - No NVIDIA/D.R. “perf panic” meetings!
- **Mainly fill bound on final demo HW**
  - Many pixel effects + VGA screen
- **But final development HW and later drivers helped**
- **And so did an experienced team at D.R.**
  - Always made performance a priority
  - Provided frequent performance profiles back to DevTech and HH SW (included various primitive/strip profiles)



# Demo!



# Effects: Wood



- DOT3 lighting and more in a single pass
- Ambient reduces “harshness” of pure DOT3 lighting
- $T_0$  is the normal map,  $T_1$  is the color map

$$\text{Color} = (\text{Saturate}(T_0 \cdot L) + \text{Ambient}) \times T_1$$

- Plenty of instruction/texture slots remaining for other tricks in one pass:
  - Several lights
  - “Curving” to make the bumps more apparent in bright lighting



# Effects: Terrain



- Single-pass shader blends several “geo-typical” textures
- With 2 textures,  $V_A$  defines blending between the textures
- $V_{RGB}$  is the lightmap, including 2x “overbright”

$$\text{Color} = T_0 \times V_A + T_1 \times (1 - V_A) \times V_{RGB} \times 2$$

- Even more textures (3 or 4) could be blended in a single pass on GoForce 5500 using another texture's colors for the blend components



# Effect Highlight: Water Reflections



- Includes blurry reflection with bumpiness and fresnel effects!
- Several passes are required for this complex effect
- Render and process the reflection
  - Render the reflection to a texture
  - Blur the reflection texture
  - Apply EMBM using a DSDT map
- Render the DSDT map
  - Generate the DSDT map from a dynamic normal map
  - Takes the view direction into account
  - Generates a Fresnel term as well as 2D bump offsets

# Missed the Cut (This time...)



## ● Bloom

- Can be expensive, and we had another GoForce 5500 launch demo that already featured it

## ● Fire

- Several options tried, but not enough time to do the likely best option (render-to-texture with “Game of Life” and vertical diffusion tricks)

## ● Depth of Field

- Should be possible using a pixel shader that reads depth, but haven’t had the chance to explore this yet



# Still to come



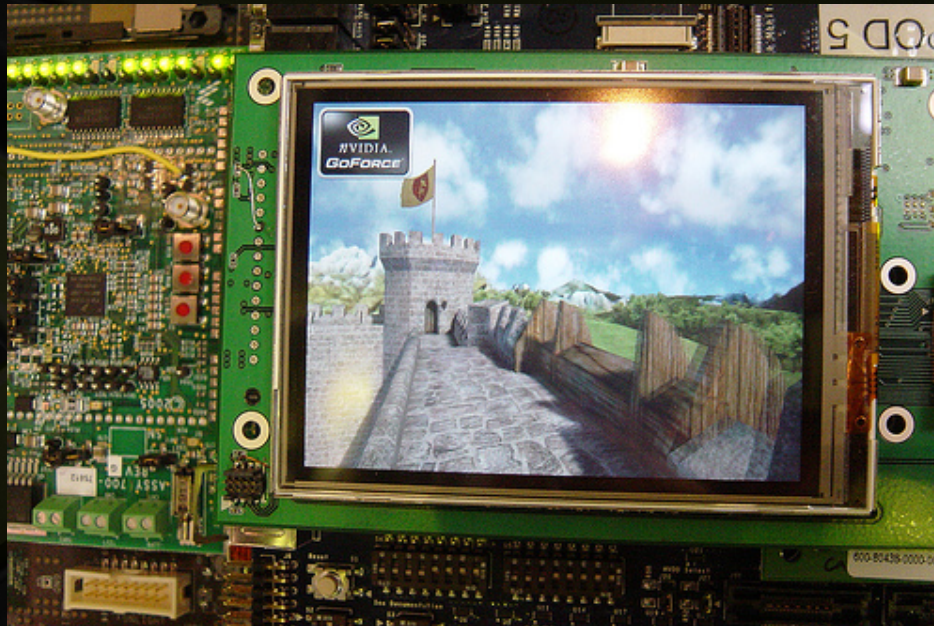
- **“Post-mortem? I’m not dead yet!”**
  - Mini-game is in active development now
- **Gameplay**
- **Audio**
- **Video textures?**
- **Camera-based input?**

# Wrap-up



- Thanks to Denied Reality, NVIDIA had an impressive and popular lead demo at the GoForce 5500 launch

Siege running on an MX31 with a GoForce5500 at 3GSM 2006



- We also had other successful demos from other developers, all of whom received support from NVIDIA's Handheld DevTech team.



# Shameless Plug: NVIDIA Handheld DevTech



- We're here to help you make your apps look and run great on NVIDIA's GoForce GPUs with:
  - Comprehensive handheld SDK; docs, demos, libraries, tools
  - Devkit setup support
  - Performance tuning assistance
  - Visual effects and integration ideas/assistance

**handset-dev@nvidia.com**

# Questions??



handset-dev@nvidia.com



PaulHodgson@deniedreality.co.uk





# The Source for GPU Programming

[developer.nvidia.com](http://developer.nvidia.com)

- Latest News
- Developer Events Calendar
- Technical Documentation
- Conference Presentations
- GPU Programming Guide
- Powerful Tools, SDKs and more ...



**nVIDIA**

Join our FREE registered developer program for early access to NVIDIA drivers, cutting edge tools, online support forums, and more.

[developer.nvidia.com](http://developer.nvidia.com)

©2004 NVIDIA Corporation. NVIDIA, and the NVIDIA logo are trademarks and/or registered trademarks of NVIDIA Corporation. Nalu is ©2004 NVIDIA Corporation. All rights reserved.