To see speaker notes, hover over dialog bubble.

How To Go From PC to Cross Platform Development Without Killing Your Studio

Elan Ruskin

Valve

We Are a PC Shop That Recently Added Console.

- Some of this talk may seem *elementary* to console-exclusive developers …
- … but each one of these issues has burned an actual project.
- Experienced console devs will still find useful info here.

This Is a High-Level Talk

This Talk is Based On:

- Our work at Valve
- My work elsewhere
- Interviews with others throughout industry

What Landmines Await A PC Developer Going To Console?

Consoles are like PCs...

A PC

+

Closed Platform

+

Manufacturer QA

+

Limited Memory

=

Common Problems of Crossplatform Development

- Developer Efficiency
- Certification Failure
- User Experience
- Programming Issues

Targeting Console is Similar to Targeting a Minspec PC

- Valve always tiers our PC experience

High-end (Shader Model 3)

Midrange (Shader Model 2)

Low-end (DirectX 8)

Now We Know Where The Mines Are…

Common Problems of Crossplatform Development

- Developer Efficiency
  - Staff allocation
  - Trouble Iterating
- Certification Failure
- User Experience
- Programming Issues

The Core Team

- **The Console Person**
- Your most experienced programmer.
- Understands the entire codebase.
- Senior enough to affect schedule.
- Gets the game running for the first time.
- Becomes an oracle by project end.

The Core Team

- **<u>The TCR</u>** <u>(**T**echnical **C**ertification **R**equirements)</u> **<u>Expert</u>**
- Producer, Programmer, or QA.
- Learns every item on Microsoft/Sony’s certification checklist.
- Builds test cases.
- TCR is not a job for one programmer.
  - Does need one person in charge.

The Core Team

- **The Devkit Guy**
- Gets people up and running.
- Sets up artists to look at their levels,
- Gets programmers set up with their debugger.
- Isn’t a full time job, but can be a major distraction.
- Doesn’t need to be a lead.

Common problems of cross platform development

- Developer Efficiency
  - Staff allocation
  - Trouble Iterating
- Certification Failure
- User Experience
- Programming Issues

Problem: Iteration is slow.

- Iterating on PC:

- Iterating on Devkit:

Keep your PC version working.

- Debug and load times always faster on PC than console.
- Runtime iteration much easier on PC
  - Edit & continue
  - Reloading assets
- Compiling slower for console target

Simulate console content features on PC

- PC workflow is more comfortable for artists
- PCs are cheaper than devkits
- Encourages experimentation

Cross platform assets

- Consoles have their own formats.
  - Do you byte swap on load?
- Consoles prefer assets compiled into big files.
  - PCs have disk caches.

The Catch-22:

Load asset files individually:

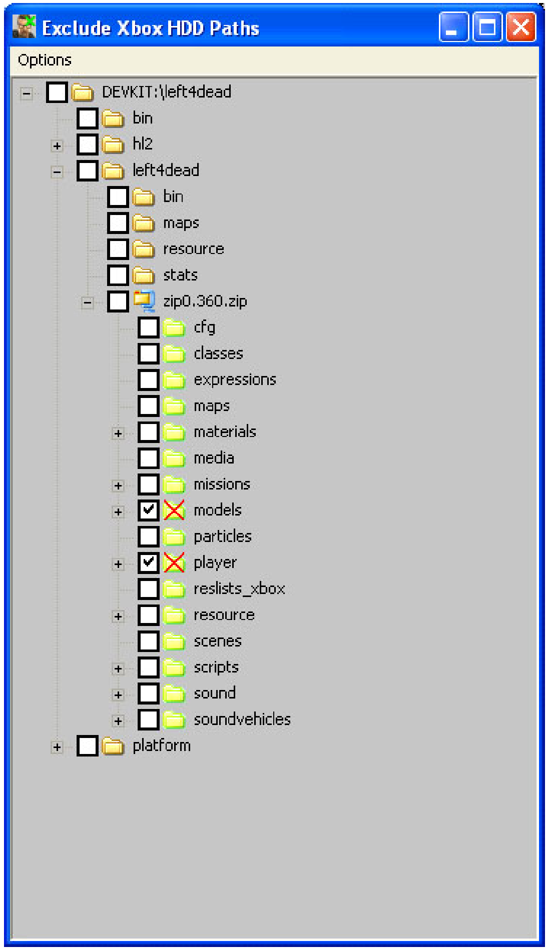
- launch times longer
- Changing data faster

Compile paks:

- code changes faster
- data changes slower

Our hybrid solution:

- Compile asset tree into paks nightly.
- Artists specify individual assets to override locally
- Best of both worlds



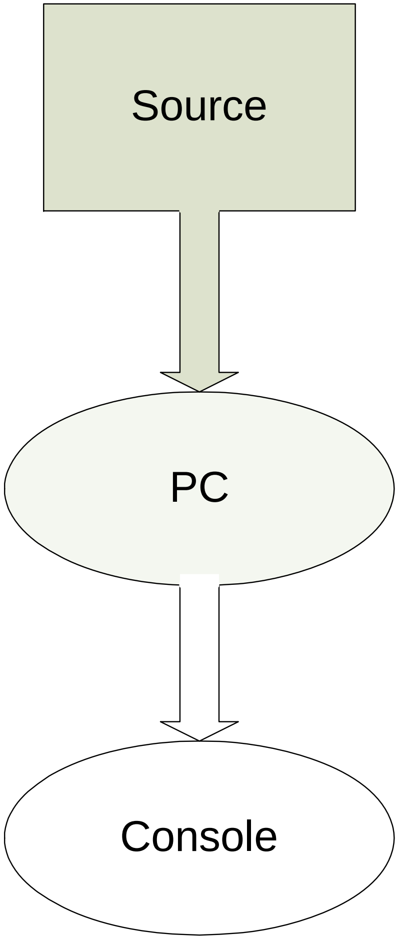
Exclude Xbox HDD Paths

Options

- ⊟ □ DEVKIT:\left4dead
  - □ bin
  - ⊞ □ hl2
  - ⊟ □ left4dead
    - □ bin
    - □ maps
    - □ resource
    - □ stats
    - ⊟ □ zip0.360.zip
      - □ cfg
      - □ classes
      - □ expressions
      - □ maps
      - ⊞ □ materials
      - □ media
      - ⊞ □ missions
      - ⊞ ☑ models
      - □ particles
      - ⊞ ☑ player
      - □ reslists_xbox
      - ⊞ □ resource
      - □ scenes
      - ⊞ □ scripts
      - ⊞ □ sound
      - ⊞ □ soundvehicles
  - ⊞ □ platform

Branch In Pipeline, Not In Source

- You will need to recompile every asset
- Try not to diverge assets
- Make tools deal with platform differences, instead of artists.
- Keep the source art for everything.



Common problems of cross platform development

- Developer Efficiency
- Certification Failure
  - Out Of Memory
  - Starting Too Late
  - Multiplayer

- User Experience
- Programming Issues

Technical Certification Requirements / Technical Requirement Checklist / CERT

- The process by which console manufacturer ensures quality.
- A specific list of requirements that your game must meet.
- Pass, or don't ship.

Most Common Problems:

- Stability
- UI – very specific requirements
- Savegames
  - Need to be completable with no save media
- Online / LIVE

Problem:
Game Runs Out Of Memory.

PC:

Console:

Memory

- Memory is critically strict.
- The #1 reason levels get changed.
  - The later you wait, the more drastic the cuts.
- You will always wish you had worried about memory sooner.
- Account for *everything.*

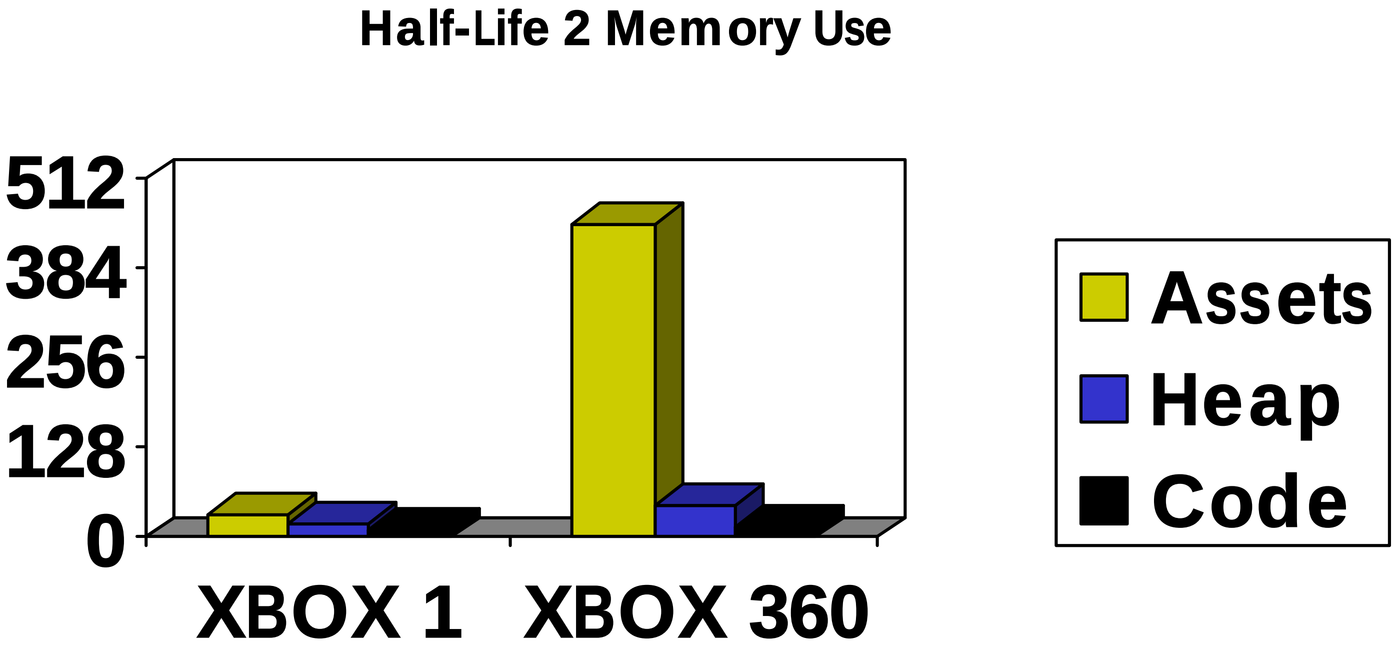
Dynamic Allocation Is Bad.

- If you don’t know how much memory you’re going to need, you don’t know if you’re going to run out.
- PC games tend to allocate memory ad-hoc.
- Keep track of where it goes.

Where Does Memory Go?

- Executable code
  - Does not change at runtime.
- Assets
  - Textures, level geometry, models, animations, sound, sprites, …
  - Loaded into memory from disk.
- Heap
  - Data generated at runtime by code.
  - Anything that is not assets.

Assets Have Grown Faster Than Heap.



Squeezing assets, Step 1: Account.

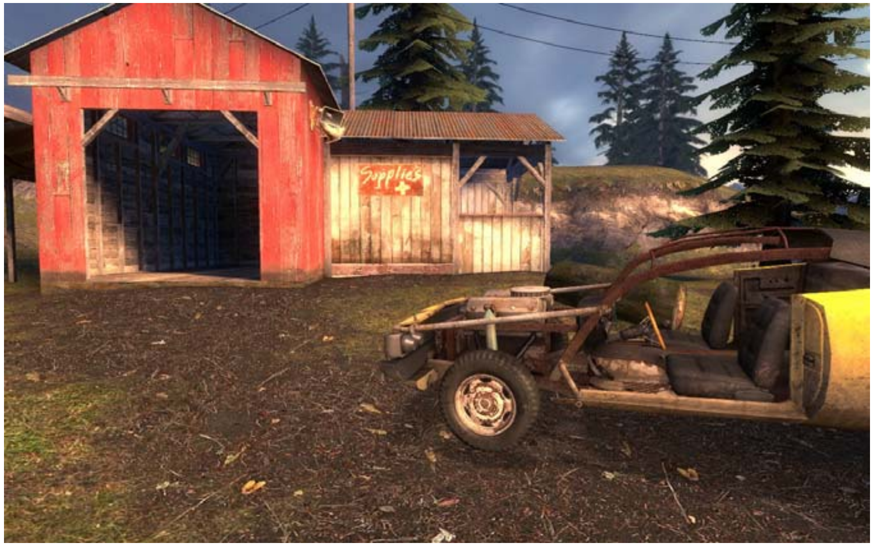
- Track every asset allocated.
- Emit spreadsheets for each level.
- Automate this process.
- Do it every night.
- Will highlight all serious problems...
- ... and make new ones obvious.

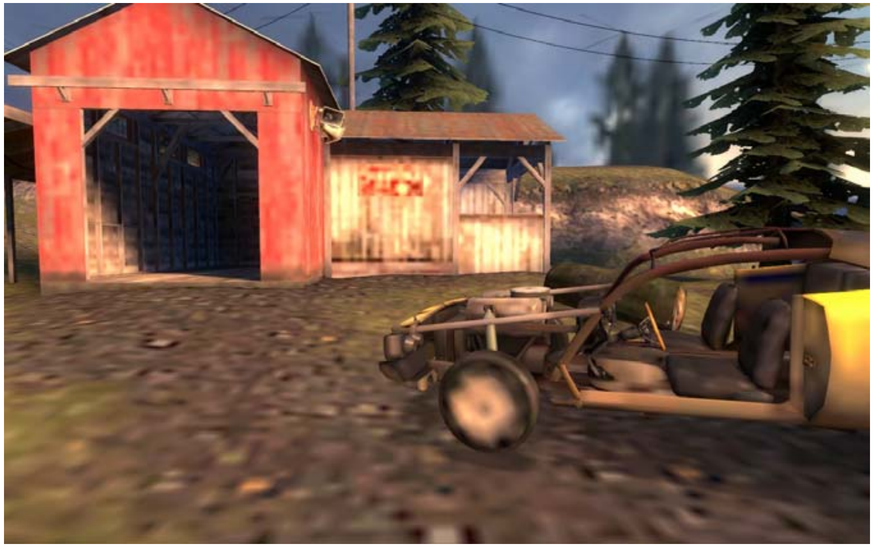
Squeezing assets, step 2: Compress.

- Use platform-specific formats.
  - XMA, AAC have good ratios
- Leverage your shaders' and SPU's power
  - Compress normal maps, grayscale textures, animations…
- May need to split up textures

Squeezing assets, step 3: Reduce.

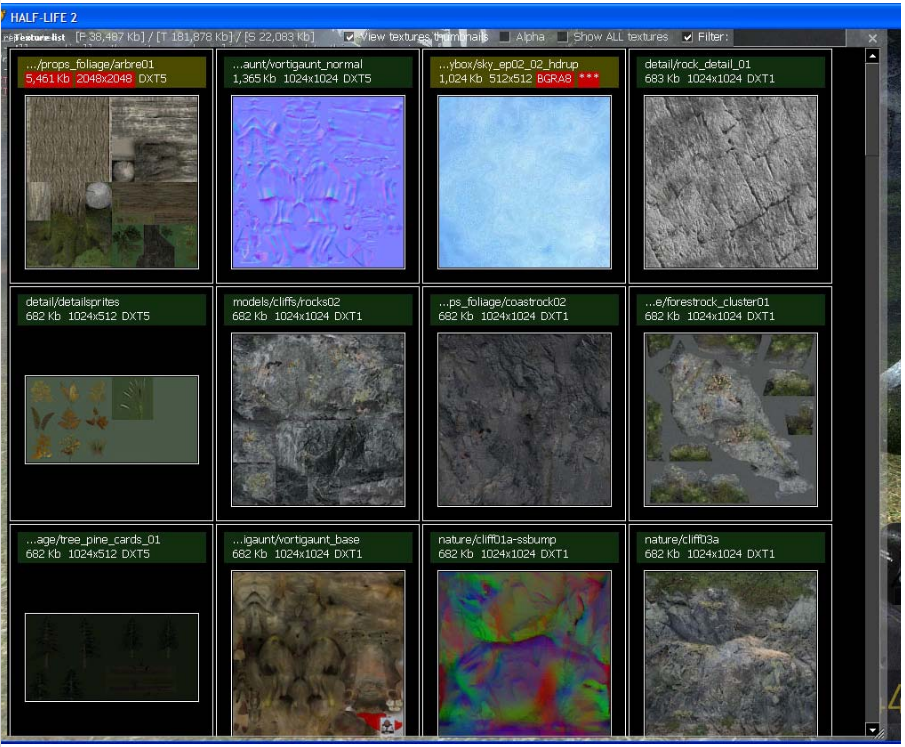
- Budget your textures / models / meshes carefully.
- It’s easy to just downsample all your textures…
- But you can get much better results with careful targeting.





Squeezing textures

- 20% of the textures are 80% of the problem.
- Source has tools to show us *which* 20%:



HALF-LIFE 2

Texture list [F 38,487 Kb] / [T 181,878 Kb] / [S 22,083 Kb] ☑ View textures thumbnails □ Alpha □ Show ALL textures ☑ Filter:

.../props_foliage/arbre01
5,461 Kb 2048x2048 DXT5

...aunt/vortigaunt_normal
1,365 Kb 1024x1024 DXT5

...ybox/sky_ep02_02_hdrup
1,024 Kb 512x512 BGRA8 ***

detail/rock_detail_01
683 Kb 1024x1024 DXT1

detail/detailsprites
682 Kb 1024x512 DXT5

models/cliffs/rocks02
682 Kb 1024x1024 DXT1

...ps_foliage/coastrock02
682 Kb 1024x1024 DXT1

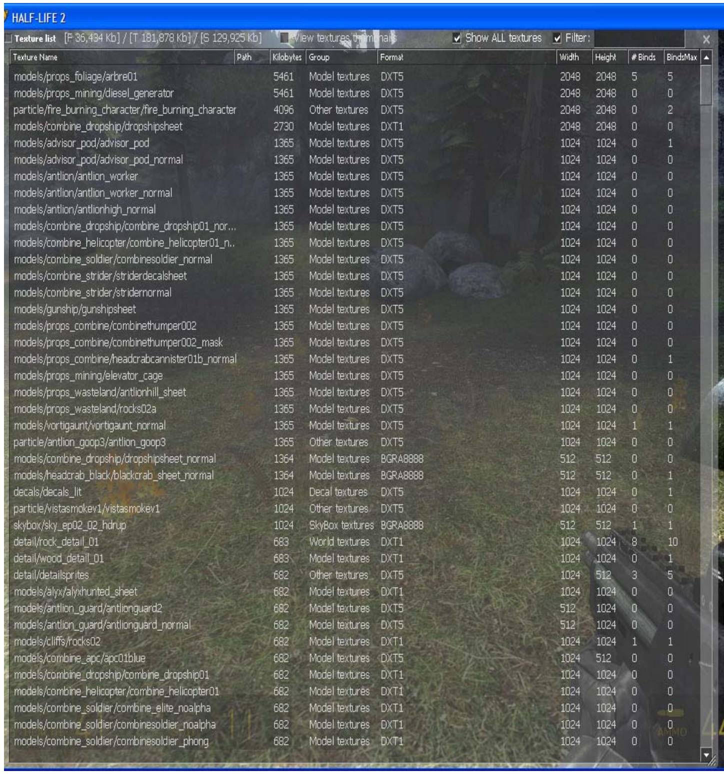
...e/forestrock_cluster01
682 Kb 1024x1024 DXT1

...age/tree_pine_cards_01
682 Kb 1024x512 DXT5

...igaunt/vortigaunt_base
682 Kb 1024x1024 DXT1

nature/cliff01a-ssbump
682 Kb 1024x1024 DXT1

nature/cliff03a
682 Kb 1024x1024 DXT1



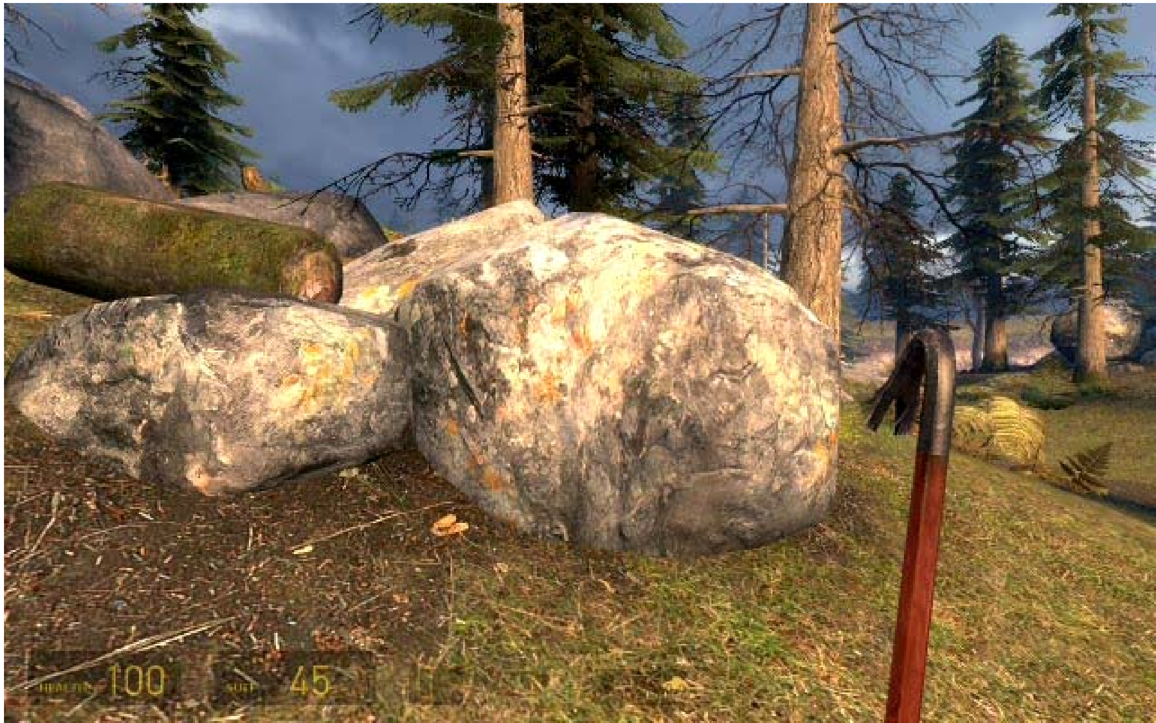
HALF-LIFE 2

□ Texture list [F 36,434 Kb] / [T 181,878 Kb] / [S 129,925 Kb] □ View textures thumbnails ☑ Show ALL textures ☑ Filter:

Texture Name	Path	Kilobytes	Group	Format	Width	Height	# Binds	BindsMax
models/props_foliage/arbre01		5461	Model textures	DXT5	2048	2048	5	5
models/props_mining/diesel_generator		5461	Model textures	DXT5	2048	2048	0	0
particle/fire_burning_character/fire_burning_character		4096	Other textures	DXT5	2048	2048	0	2
models/combine_dropship/dropshipsheet		2730	Model textures	DXT1	2048	2048	0	0
models/advisor_pod/advisor_pod		1365	Model textures	DXT5	1024	1024	0	1
models/advisor_pod/advisor_pod_normal		1365	Model textures	DXT5	1024	1024	0	0
models/antlion/antlion_worker		1365	Model textures	DXT5	1024	1024	0	0
models/antlion/antlion_worker_normal		1365	Model textures	DXT5	1024	1024	0	0
models/antlion/antlionhigh_normal		1365	Model textures	DXT5	1024	1024	0	0
models/combine_dropship/combine_dropship01_nor...		1365	Model textures	DXT5	1024	1024	0	0
models/combine_helicopter/combine_helicopter01_n..		1365	Model textures	DXT5	1024	1024	0	0
models/combine_soldier/combinesoldier_normal		1365	Model textures	DXT5	1024	1024	0	0
models/combine_strider/striderdecalsheet		1365	Model textures	DXT5	1024	1024	0	0
models/combine_strider/stridernormal		1365	Model textures	DXT5	1024	1024	0	0
models/gunship/gunshipsheet		1365	Model textures	DXT5	1024	1024	0	0
models/props_combine/combinethumper002		1365	Model textures	DXT5	1024	1024	0	0
models/props_combine/combinethumper002_mask		1365	Model textures	DXT5	1024	1024	0	0
models/props_combine/headcrabcannister01b_normal		1365	Model textures	DXT5	1024	1024	0	1
models/props_mining/elevator_cage		1365	Model textures	DXT5	1024	1024	0	0
models/props_wasteland/antlionhill_sheet		1365	Model textures	DXT5	1024	1024	0	0
models/props_wasteland/rocks02a		1365	Model textures	DXT5	1024	1024	0	0
models/vortigaunt/vortigaunt_normal		1365	Model textures	DXT5	1024	1024	1	1
particle/antlion_goop3/antlion_goop3		1365	Other textures	DXT5	1024	1024	0	0
models/combine_dropship/dropshipsheet_normal		1364	Model textures	BGRA8888	512	512	0	0
models/headcrab_black/blackcrab_sheet_normal		1364	Model textures	BGRA8888	512	512	0	1
decals/decals_lit		1024	Decal textures	DXT5	1024	1024	0	1
particle/vistasmokev1/vistasmokev1		1024	Other textures	DXT5	1024	1024	0	0
skybox/sky_ep02_02_hdrup		1024	SkyBox textures	BGRA8888	512	512	1	1
detail/rock_detail_01		683	World textures	DXT1	1024	1024	8	10
detail/wood_detail_01		683	Model textures	DXT1	1024	1024	0	1
detail/detailsprites		682	Other textures	DXT5	1024	512	3	5
models/alyx/alyxhunted_sheet		682	Model textures	DXT1	1024	1024	0	0
models/antlion_guard/antlionguard2		682	Model textures	DXT5	512	1024	0	0
models/antlion_guard/antlionguard_normal		682	Model textures	DXT5	512	1024	0	0
models/cliffs/rocks02		682	Model textures	DXT1	1024	1024	1	1
models/combine_apc/apc01blue		682	Model textures	DXT5	1024	512	0	0
models/combine_dropship/combine_dropship01		682	Model textures	DXT1	1024	1024	0	0
models/combine_helicopter/combine_helicopter01		682	Model textures	DXT1	1024	1024	0	0
models/combine_soldier/combine_elite_noalpha		682	Model textures	DXT1	1024	1024	0	0
models/combine_soldier/combinesoldier_noalpha		682	Model textures	DXT1	1024	1024	0	0
models/combine_soldier/combinesoldier_phong		682	Model textures	DXT1	1024	1024	0	0

Squeezing textures

- Halving one 1024x1024 texture saves as much memory as eliminating 32 128x128's.
- Focus on what's actually visible, so you can reduce where no one will notice.



Squeezing assets, step 4: Maintain.

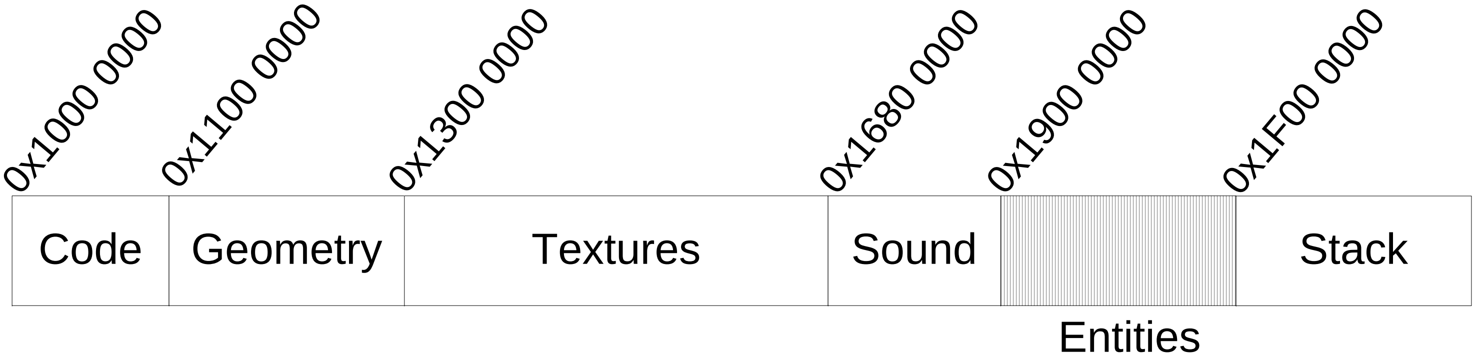
- Staying in memory is everyone’s job.
- Know exactly when and where regressions occur.
- Find exactly which change to blame.

Squeezing assets, step 5: Panic.

- If all else fails… split levels.
- Remove characters.
- Decimate textures.
- Downsample animation.
- Dealing with memory *sooner* will spare you all these painful measures.

In An Ideal World

- Memory would be allocated at load time…



0x1000 0000
Code

0x1100 0000
Geometry

0x1300 0000
Textures

0x1680 0000
Sound

0x1900 0000
Entities

0x1F00 0000
Stack

Managing Heap Growth

- Many games load assets ad hoc
  - Textures, models, animations, sound
- Code generates data too
  - Spawning entities, particle systems, AI state…
- Crashes most likely in level loads

malloc() Considered Harmful

(**new**/**delete** too)

- Gameplay systems most likely source of leaks.
- Good container classes provide easier management, less leakage.
- Only if you write your own allocator!

WHYTO: Make A Custom Memory Allocator

- Replace malloc(), calloc(), **new**, etc. with your own code.
- Better than STUDIONEW, STUDIODELETE macros:
- No big search and replace.
- You can’t fix all the new/deletes in 3d party libraries…
- … so link them to your own allocator.

HOWTO: Make A Custom Memory Allocator

- Override *every* function in the CRT .obj that contains malloc:
  - malloc, free, calloc, realloc…
- Put your implementation in its own .cpp
- Link this .cpp to every project in your game.
- Only works if you override the *whole* module...
- … so you need to re-do this if you change compilers or CRTs.

pwn your memory

- If you own every allocation, you can track every allocation.
  - Even those coming from the STL.
- Write global fixed-size pool allocators.
- Limit fragmentation.
- Look up the **Translation Lookaside Buffer**.

Track Memory Based On Exactly Who Allocates It

- Budget asset allocation by type
  - Texture, geometry, sound…
- Budget code allocation by purpose
  - AI::Navmesh, Particles, Rendertarget…
  - *Not* std::vector<int>

Track Memory Based On Exactly Who Allocates It

```
Thingy *WasteMemory( Thingy* input,
  std::vector<Thingy> &list )
{
  MEM_ALLOC_CREDIT(IMPORTANT_SYSTEM);
  globalSystemList.AddToTail(input);
  list.append(*input);
  Thingy *output = new Thingy;
  output = DeepCopy(input);
  return output;
}
```

Be Careful With Containers

- Container classes mean more:
  - Dynamic allocation
  - Range checking
  - Copying things around
- Use std::vector::reserve

We Do This Work For PC Too

- Disk swapping bad!
- Budget tracking means reliable information everywhere.
- Retrofitting later means touching a thousand different places.

Common problems of cross platform development

- Developer Efficiency
- Certification Failure
  - Out Of Memory
  - Starting Too Late
  - Multiplayer
- User Experience
- Programming Issues

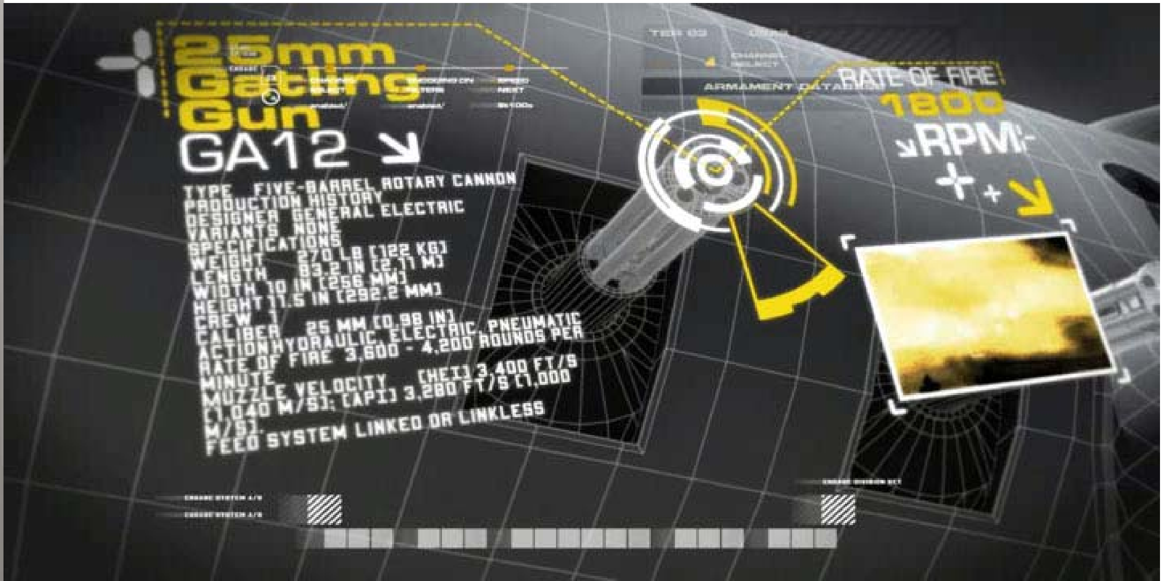
Other Interesting TCRs

- Load times no more than *x* seconds.
- Letting people play their MP3 collection in your game.
- Minimum refresh interval… even while loading.
- Compiled with recent SDK.

Solve It In Design

- Make cert requirements part of your architecture.
- Think about Achievements / Skill Points in your design.
  - (you can get them on PC with SteamWorks)

engaging player during load in *Call of Duty 4*


25mm
Gatling
Gun
GA12
TYPE FIVE-BARREL ROTARY CANNON
PRODUCTION HISTORY
DESIGNER GENERAL ELECTRIC
VARIANTS NONE
SPECIFICATIONS
WEIGHT 270 LB (122 KG)
LENGTH 83.2 IN (2.11 M)
WIDTH 10 IN (256 MM)
HEIGHT 11.5 IN (292.2 MM)
CREW 1
CALIBER 25 MM (0.98 IN)
ACTION HYDRAULIC, ELECTRIC, PNEUMATIC
RATE OF FIRE 3,600 - 4,200 ROUNDS PER MINUTE
MUZZLE VELOCITY (HEI) 3,400 FT/S (1,040 M/S); (API) 3,280 FT/S (1,000 M/S)
FEED SYSTEM LINKED OR LINKLESS
ARMAMENT DATA
RATE OF FIRE
1800
RPM

Savegames

- Use small individual files, not one large package
  - Fits on memory cards.
- Deal with losing memory card during save.
- Do you really need save-anywhere?
  - If you rely on quicksave,
  - preallocate a RAM disk big enough.

UI

- Consider title-safe and widescreen
  - Be readable in 4:3 SD and 16:9 720p.
  - Be readable in 4:3 SD... *in German.*
- TCR has specific requirements for UI layout & flow:
  - Need a way to pop dialogs on top
  - Manufacturer-approved graphics, names
- This usability work makes your PC game better.

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Multiplayer / LIVE

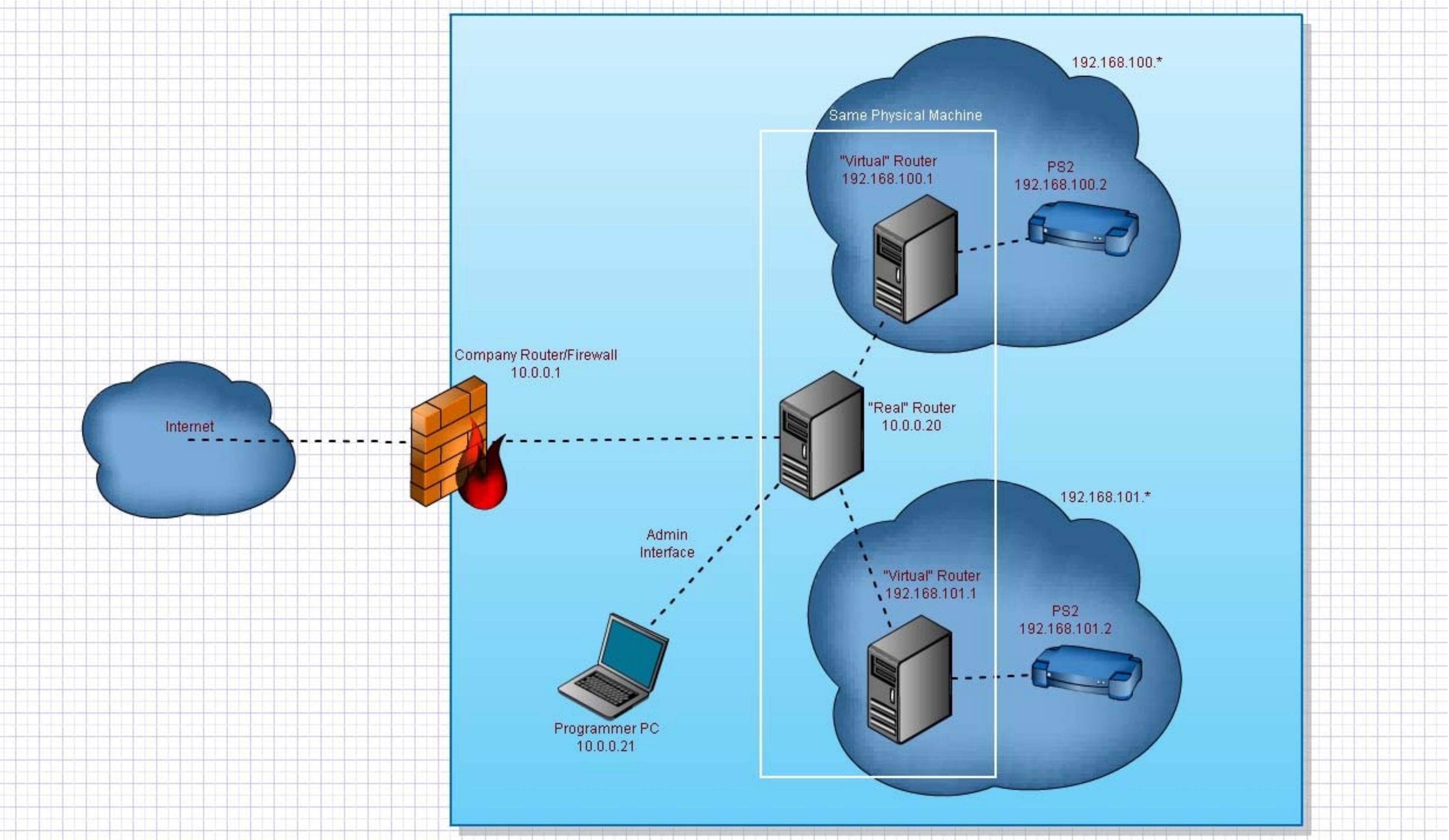
- Was the majority of our cert issues.
- Start working on this from day #1.
  - Do your preliminary work in sample apps.
  - Do not let it be blocked by engine development.
- Rich presence may require architecture changes.
- Enlist Microsoft/Sony’s help.
  - They have lots of good tools for you.

Cort is playing TF: Badlands!
Ahead 3-2 in CTF

Multiplayer Testing

- Your office LAN is not the Internet.
- Debugging without encryption, voice hides problems.
- Some problems arise only with high load.
  - Do a beta if you can.
- Latency, bandwidth, ping, problems as always…

Multiplayer Testing: Simulate Your Own Network Backbone.



Courtesy Ben Stragnell

Common problems of crossplatform development

- Developer Efficiency
- Certification Failure
- User Experience
  - Load Times
  - Use of multicore
  - Controls
- Programming Issues

Problem: Game Takes Too Long To Load.

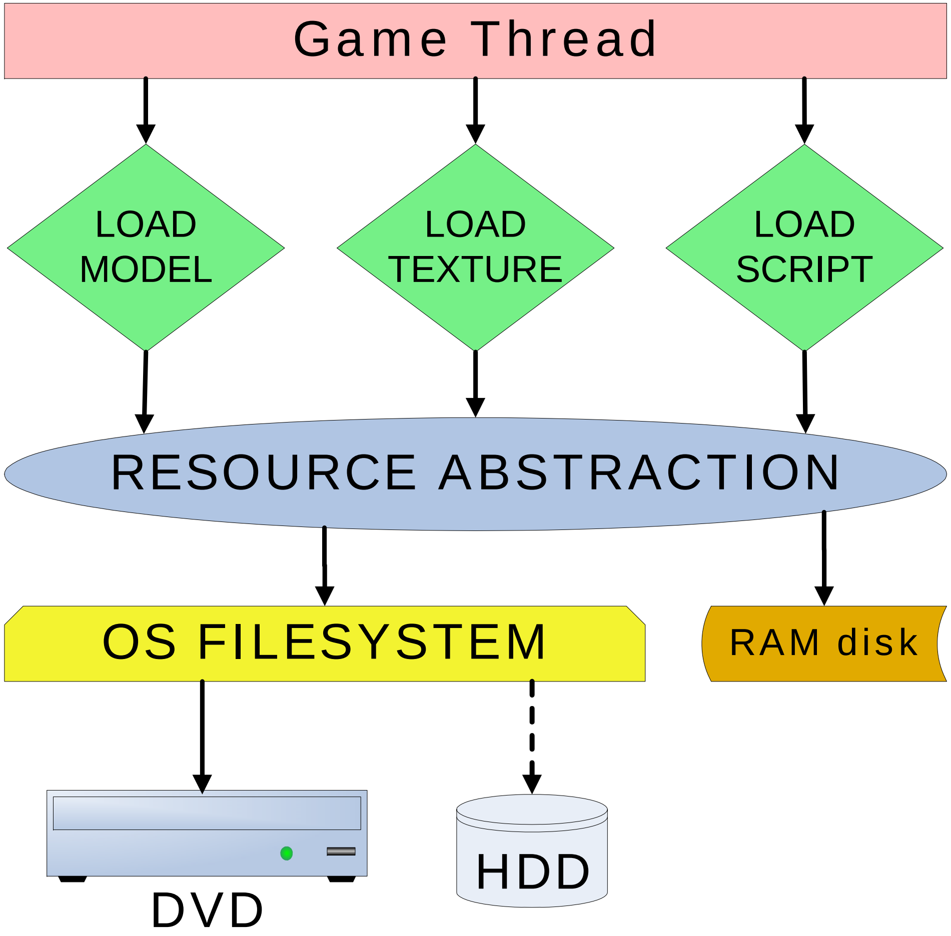
Optical Load Times

PROBLEM	SOLUTION
Seeks	Contiguous files, careful layout
Misaligned reads	Sector alignment
Buffered access	Unbuffered DMA I/O
Synchronous stalls	Asynchronous loading
Small files loaded on demand	Large, single files

Things That Make A DVD Load Faster

- .ZIP files
- Compression
  - (trade CPU for I/O bandwidth)
- Asynchronous loads in a separate thread

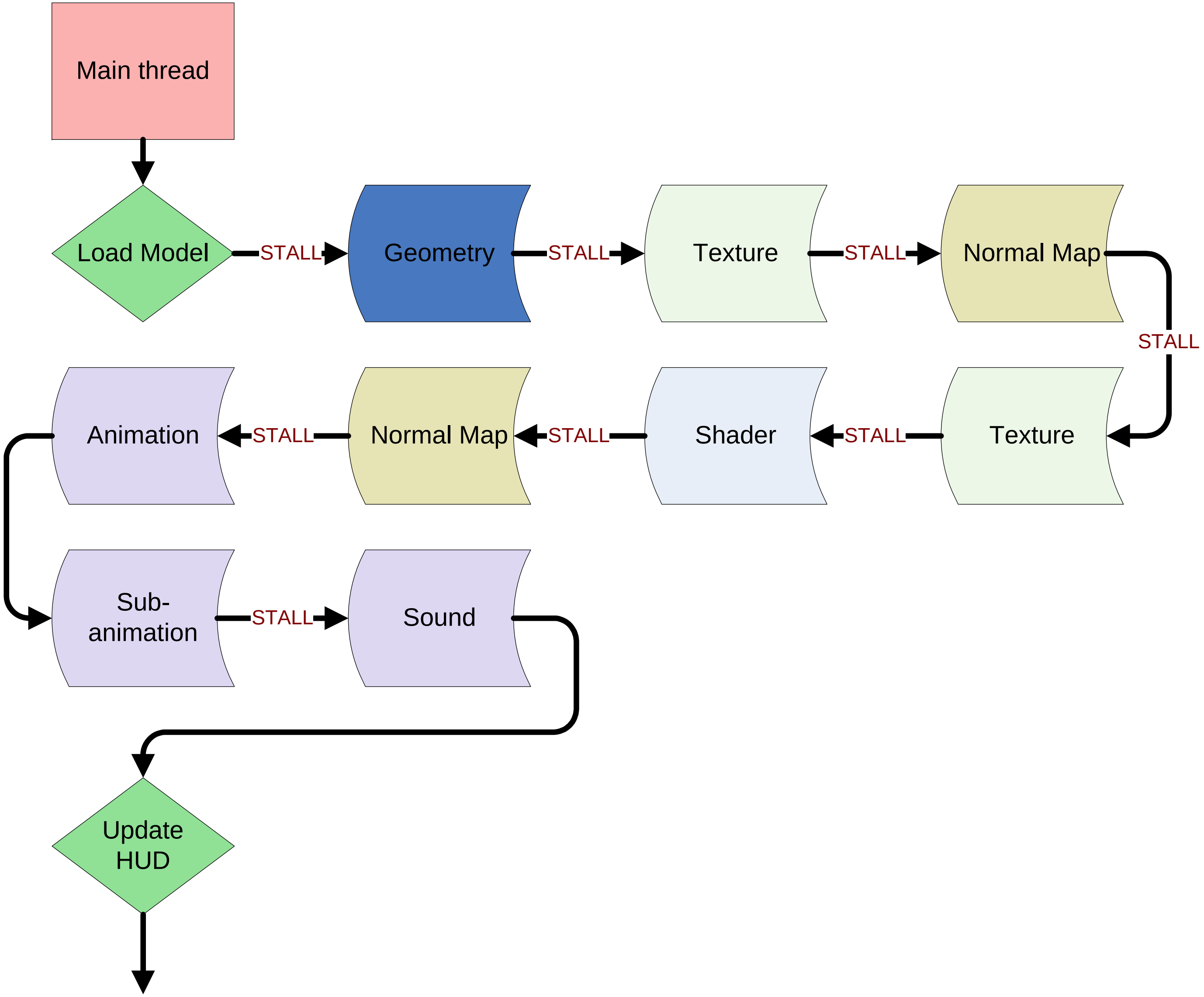
How We Refit Our Game Without Rewriting Everything



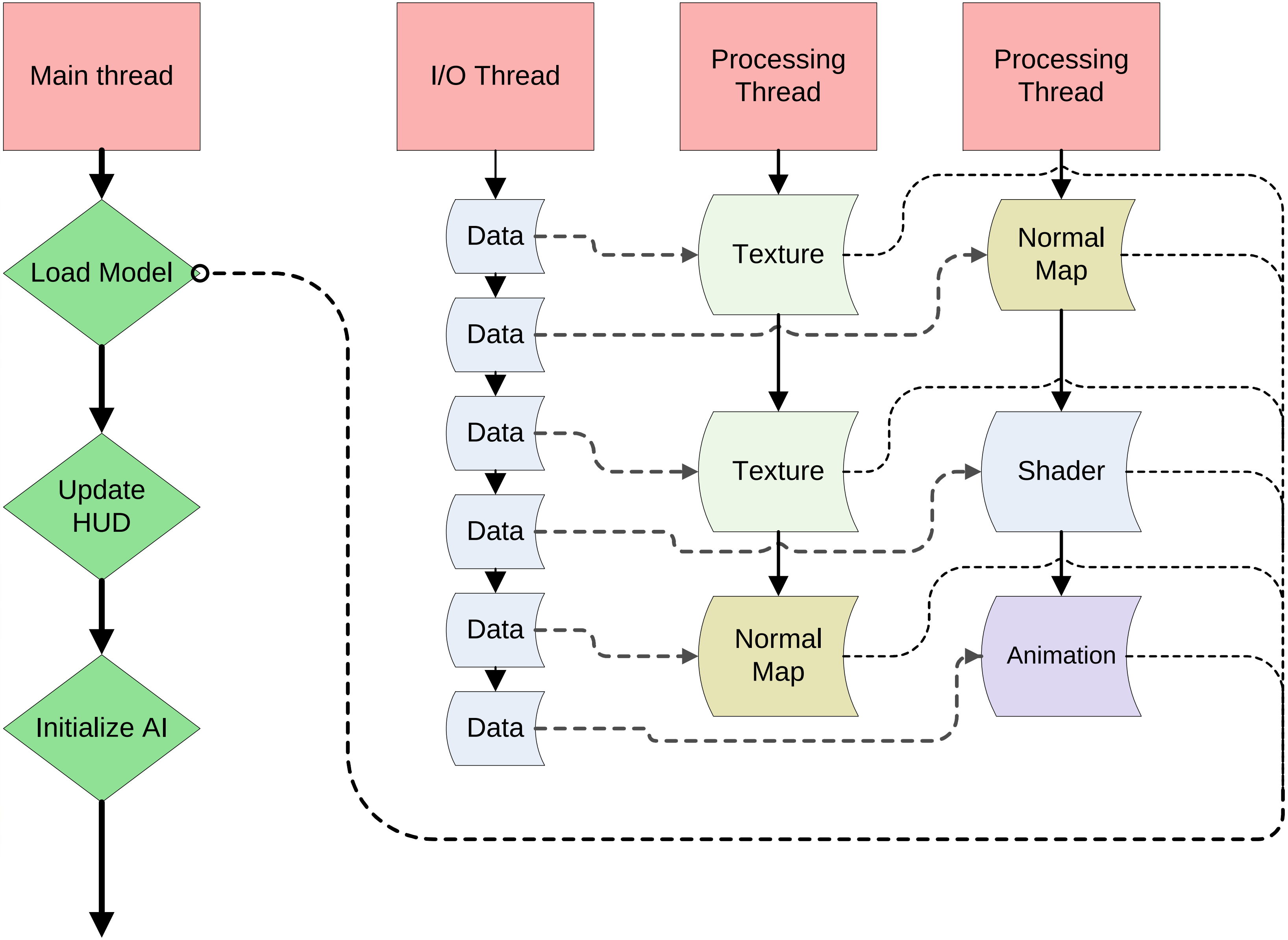
Three Categories Of Data

- Big
  - Textures, models, BSP, sprites, SFX
- Small
  - Config files, scripts, <4k odds and ends
- Really Big
  - Dialog, long animations
  - Stuff you don’t need right away

Synchronous (naïve) loading



Asynchronous loading



Key features

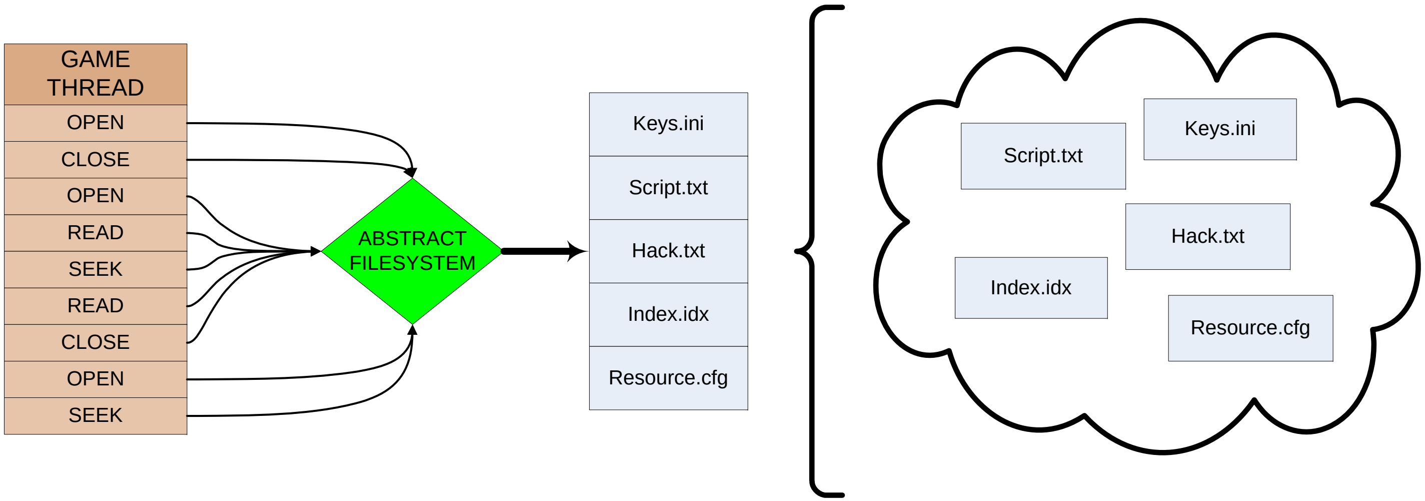
- I/O thread does unbuffered DMA transfers.
    - Keeps the disk *spinning continuously.*
- Lockless implementation
- Trade CPU/SPU for I/O bandwidth
- Return dummy values to sync loads.

Really big files: streaming

- Store the first ½ sec of each animation and audio always
- Asynchronously load the rest in the background
- Need a resource abstraction layer that can say:
  - We have the data
  - We're getting the data
  - We will never get the data

Small files

- Precompile all small ad-hoc files into one large blob
- Read it in one operation with level
- Create a fake file system
- Don't have to change game code!



Know In Advance Each Level's Resource Needs

- If you're going to build a pak, you need to know what goes in it.
- Every single asset.
- Analyze loading dependencies.
- Crash when loading out-of-pak.

Common problems of cross platform development

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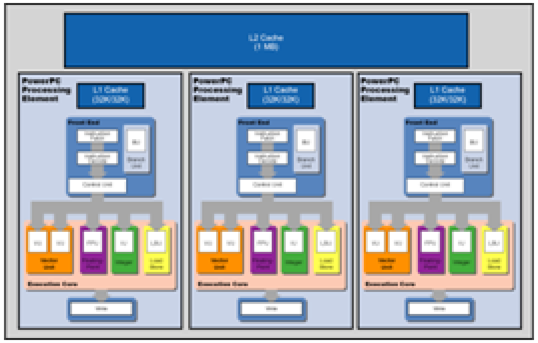
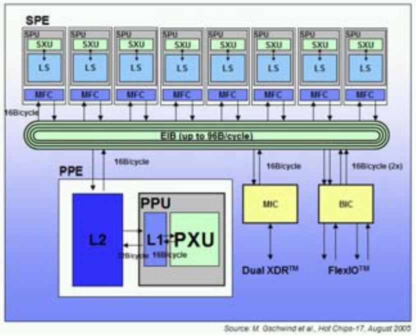
- Certification Failure
- User Experience
  - Load Times
  - Use of multicore
  - Controls
- Programming Issues

Going Multithreaded:
It’s not *next*-gen any more.

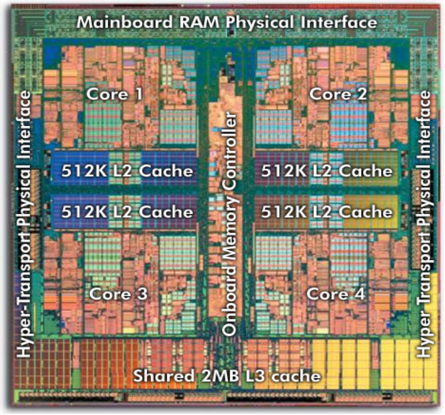


Xenon

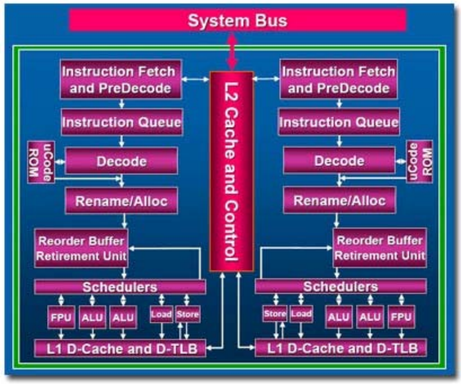


Source: M. Gschwind et al., Hot Chips-17, August 2005

Cell


Mainboard RAM Physical Interface
Core 1
Core 2
512K L2 Cache
512K L2 Cache
512K L2 Cache
512K L2 Cache
Onboard Memory Controller
Hyper-Transport Physical Interface
Hyper-Transport Physical Interface
Core 3
Core 4
Shared 2MB L3 cache

AMD Barcelona



Intel Core 2

All Major Platforms Are Multicore.

- **360**: 3 symmetric PowerPC cores, 6 threads
- **PS3**: 1 PowerPC, 2 threads; 7 vector processors
- **Intel/AMD**: Quadcore now, 8-core tomorrow
- This is not “next gen”, it is “today.”

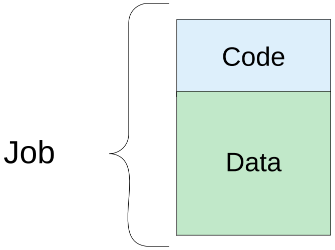
Our technique: Discussed here before

"*Dragged Kicking and Screaming: Source Multicore*"

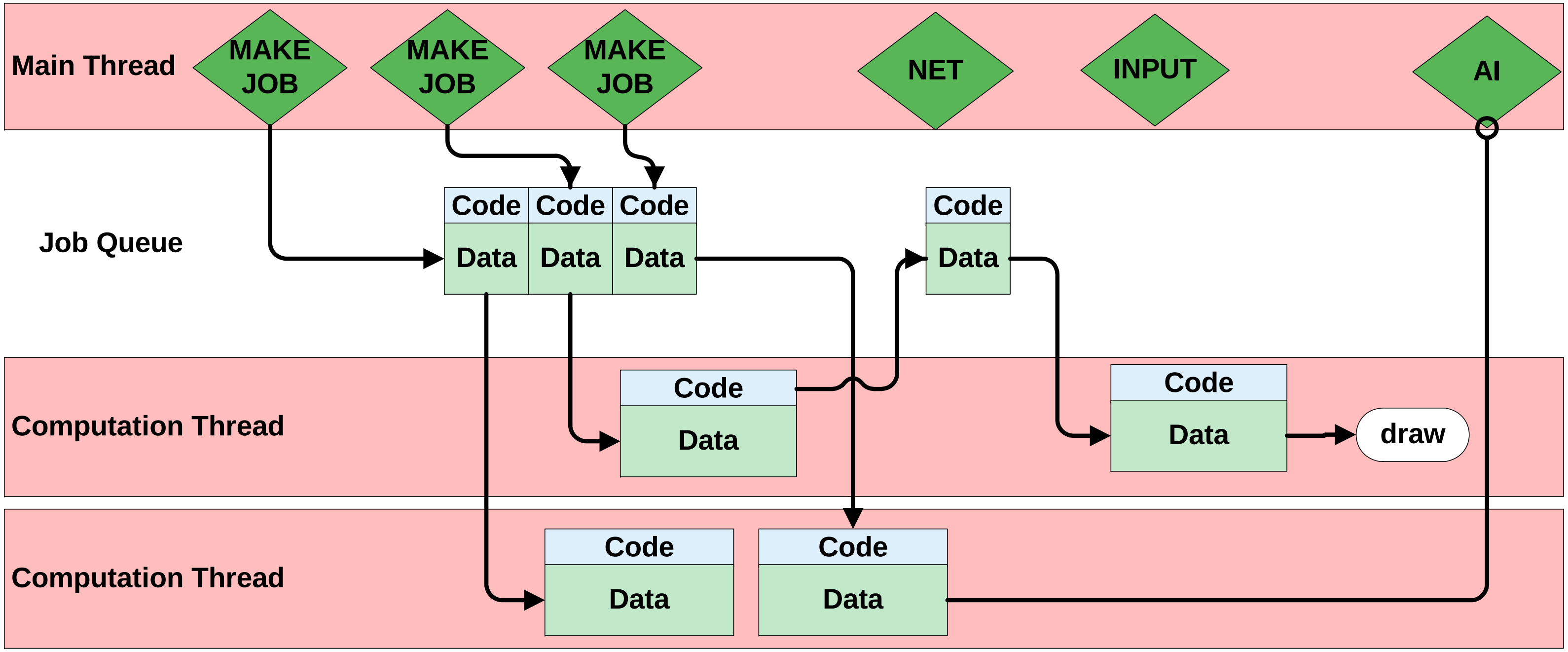
Tom Leonard (Valve), GDC 2007

http://www.valvesoftware.com/publications.html

Job queues: a summary



- A job is code and local data
- Put into a queue; other threads consume from queue



Worked Better Than We Expected!

- On the 360:
  - 50% performance improvement just from queuing graphics functions.
  - 4x increase in framerate with full implementation.
- On the PS3:
  - Game wouldn't run otherwise!
- Our game already had a client/server split.

De-Globalize Your Data

- Pack jobs' data up so they work locally.
  - Put global data into a closure.
- Avoid chasing pointers all over memory.
- Especially critical on PS3.
  - SPUs have only 256kb of memory.
  - Random memory access is huge stall.

PS3 Requires More Aggressive Threading

- All the power of the PS3 is in its Cells.
- The PPU will be always saturated.
- General C++ code does not run well on SPUs.
- Code memory is tight.

Some Things To Worry About

- Callbacks
- Synchronizing simulation clocks
- Mutexes (can make you slower than singlethreaded)
- Hardware threads useful only in certain cases – measure it.

Common problems of cross platform development

- Developer Efficiency
- Certification Failure
- User Experience
  - Load Times
  - Use of multicore
  - Controls
- Programming Issues

Problem: controls don’t feel right.

- Have PC devs test with 360/PS3 controllers.
  - Yes, you can connect them to a PC.
- Makes everyone a usability tester all the time.
- PS3, 360 have different thumbstick calibrations.

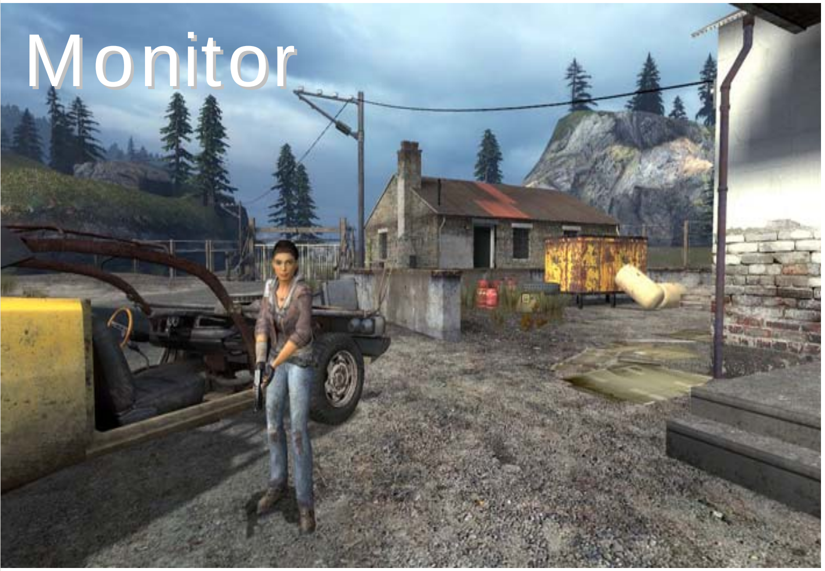
Common problems of cross platform development

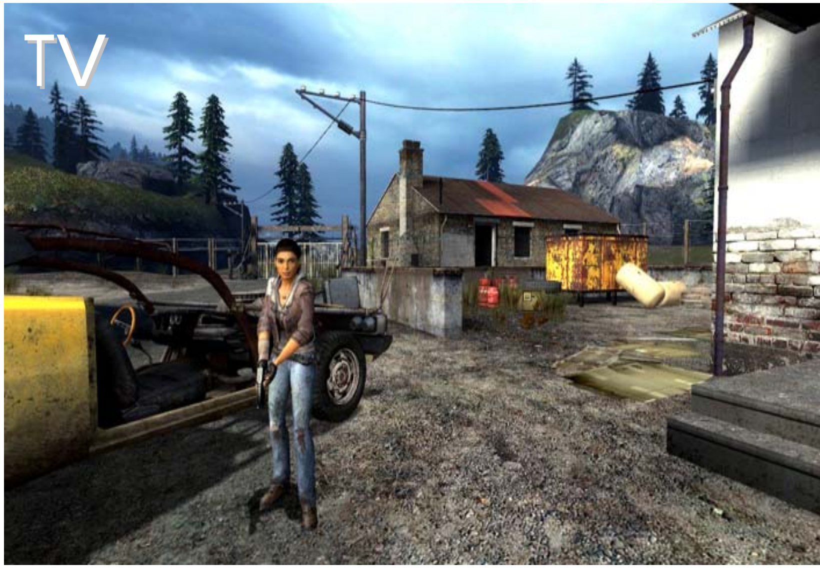
- Developer Efficiency
- Certification Failure
- User Experience
- Programming Issues
  - Graphics
  - Framerate / CPU

Time For *Good* Graphics!

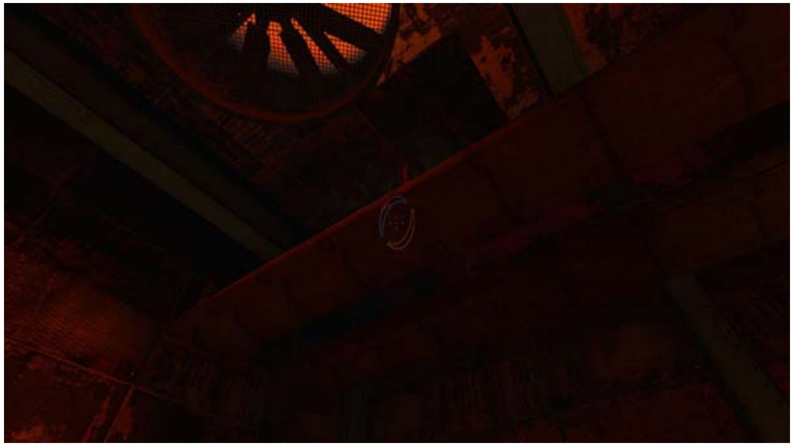
Homestar Runner

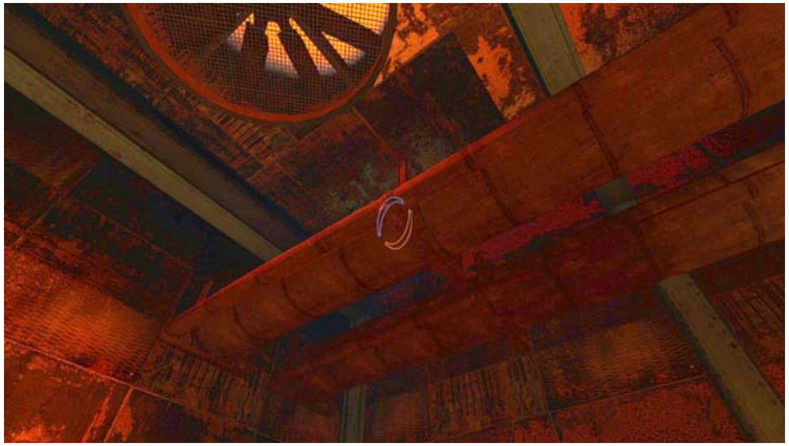
TV pixel and color spaces differ from monitors

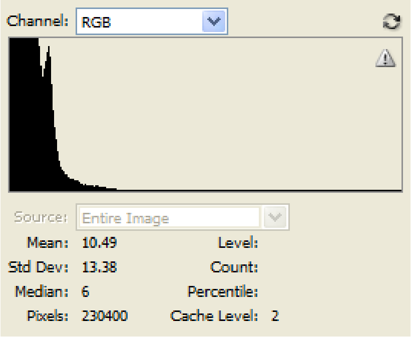




TVs rebalance histograms







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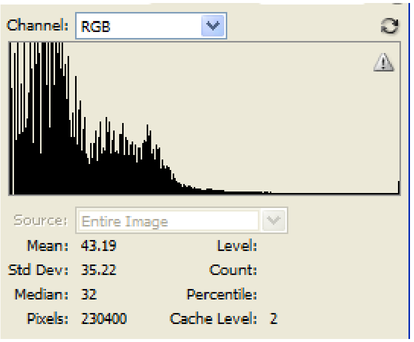
Std Dev: 13.38          Count:
 Median: 6         Percentile:
 Pixels: 230400   Cache Level: 2
```



```
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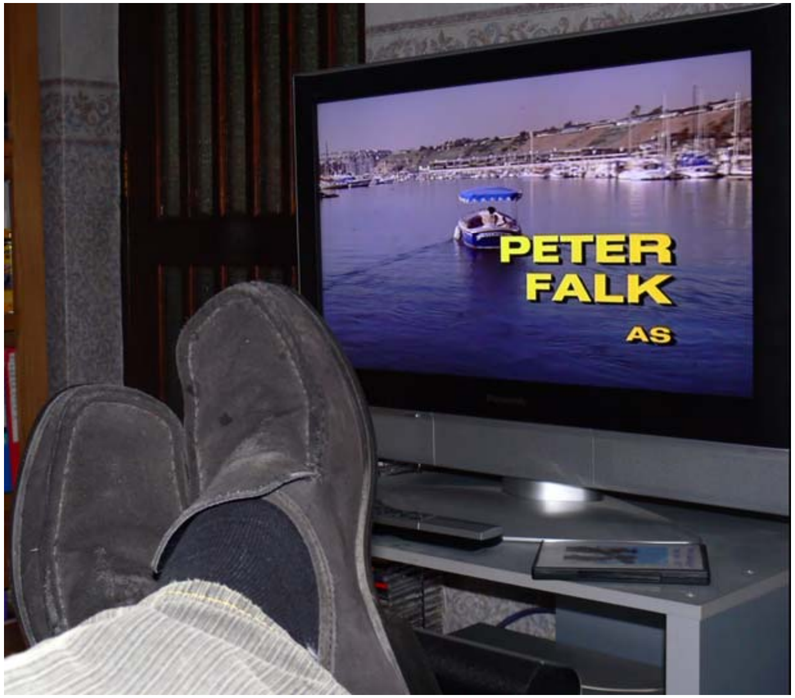
Std Dev: 35.22          Count:
 Median: 32        Percentile:
 Pixels: 230400   Cache Level: 2
```

TVs vary in quality

- A common office fight:
  - Look good on a default-settings TV?
  - Or one that’s been calibrated?
- TV default settings vary very widely.
- The solution:

Watch TV At The Office.

- Watch television on the displays you're developing with.
- Calibrate your TV so TV looks good.
- **Don't buy the same TV for everyone!**

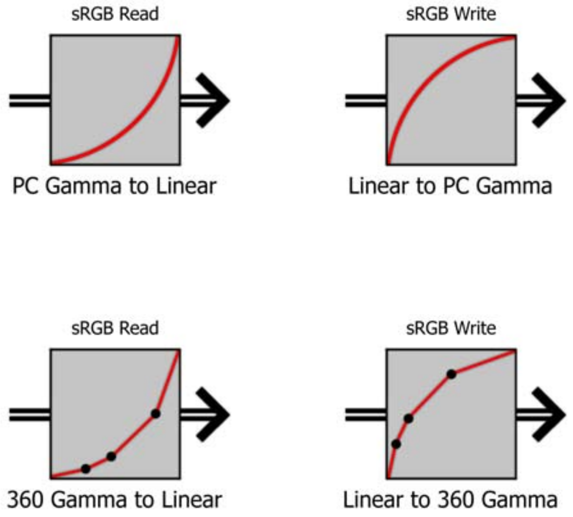


Shaders

- PC uses HLSL. Consoles use HLSL. Done.
- Shader compilers may be a bit different.
  - The few problems will be with the most complicated shader.
- GPU/CPU power balance a little different.
  - Shader conditionals perform well!
- We distribute our shader compiles.
  - Compile each shader for both platforms before checkin.
  - Compile everything offline nightly for regression testing.

sRGB

- sRGB read/write curve different on 360.
- Keep your source art
  - Compiling from another space loses precision.
- See Alex Vlachos’ talk: “Post Processing In *The Orange Box*”, Feb 18, 2008. http://www.valvesoftware.com/publications.html



Other notes:

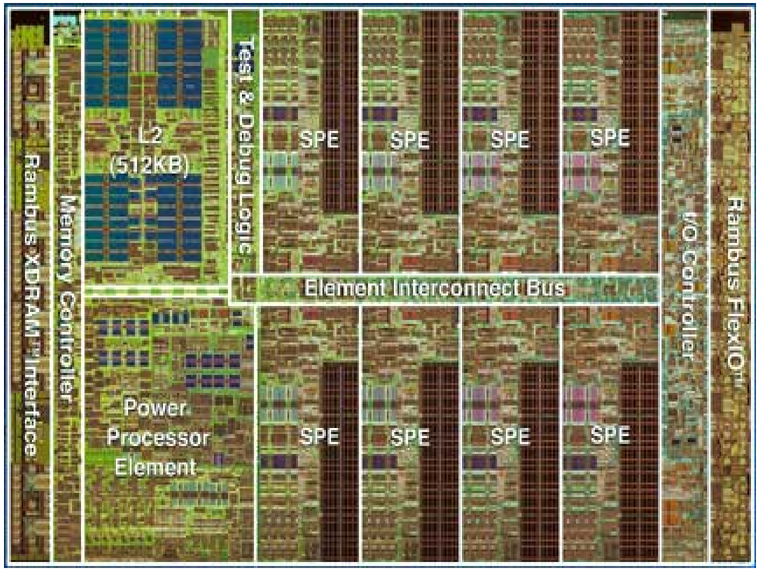
- PIX / GCM Hud excellent for very specific, actionable info.
- Look into tiled rendering on 360
  - Makes antialiasing easier, but isn’t critical.
- If you’re hung up on getting PC and console to match perfectly… let go.
  - No one is playing your game twice simultaneously side-by-side.
  - It just has to look good.

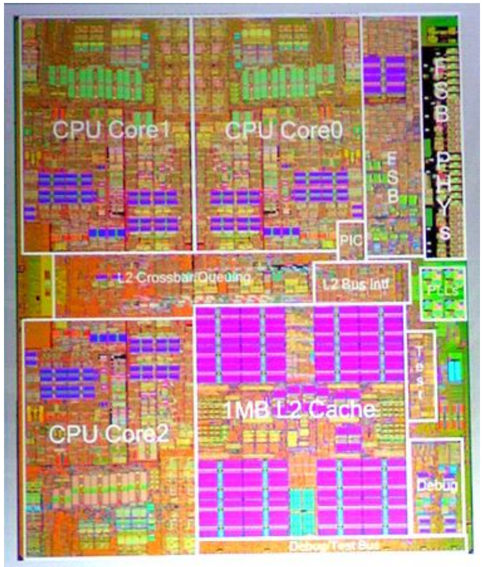
Common problems of crossplatform development

- Developer Efficiency
- Certification Failure
- User Experience
- Programming Issues
  - Graphics
  - Framerate / CPU

360, PS3 have in-order PowerPC CPUs.

- They do not rearrange instructions to eliminate dependencies.
- Sloppy code runs more slowly.
- Why? Reorder circuitry is costly, takes up space…
- …space now used for *additional entire cores!*





In-order PPCs run sloppy code more slowly than x86

- 25%-50% speed for straight cross-compiled code.
- Careful optimization gets close to parity.
- SIMD a bigger win on PPC than x86.
- Remember: on 360 you have *three of them*.

LEARN THE ASSEMBLY

- Sometimes you still have to do this.
- Use intrinsics, understand what they are doing.
- Helps debug release-build crashes.
  - Learn the calling convention, how to augur crash dumps.
- Double-check what compiler emits.

LEARN THE PIPELINE

- PPCs are high-latency, high-throughput
- Learn about all the hazards
  - Register dependency, load-hit-store, cache miss, microcode, ERAT, TLB…
  - Understand what the profiler is telling you.
  - 80% of perf from touching 20% of code.

Actually Use SIMD

- Abstract interface for all platforms.
- Push native vector class everywhere.
- Replace doubles with floats.

```
FORCEINLINE Vector Add ( const Vector & a,
                     const Vector & b )
{
#ifdef _X360
   return __vaddfp( a, b );
#elif defined(_SSE)
   return _mm_add_ps( a, b );
#else
   return Vector( a.x + b.x, a.y + b.y,
                  a.z + b.z, a.w + b.w );
#endif
}
```

#ifdef Is Not The Way To Go

- Compilers will elide code in an if() block that is always false.

```
#define IsX360() true
#define IsPC()   false

void DoStuff()
{
  if ( IsX360() )
  {
         PlatformSpecificFunction();
  }
  else if ( IsPC() )
  {
         WindowsSpecificFunction();
  }
  else
  {      // you might be on the Wii one day!
         GeneralCaseFunction(); // or throw an assert
  }
}
```

Use if() Instead of #ifdef.

- Stops “the PC guys broke the PS3 build again!”
- You may need stub functions
- Don’t assume “if” PC “else” 360. You might be on PS3 or Wii one day.

Not All Optimization Is Premature

- Don’t “do a big perf pass at the end”.
- Getting from 5fps to 15fps isn’t optimization, it’s a key feature.
- Have budgets from the start,
  - Have tools to stay inside them.

Things you need to buy: Devkits

- Development kits
  - Live debugging
  - Engine, system programmers – anyone whose bugs block someone else
- Test kits
  - Printf debugging.
  - Artists, QA, maybe gameplay programmers.
- Prepare for failure rate.

Cost:

Cost:

Other Suggestions

- For your first title: keep it simple!
- Keep people on kits.
- Work to the most constrained platform.

Measure Everything

- Measure everything yourself, as often as you can.
- Take nothing for granted.
- Verify your compiler output.

Recap

- Make cert part of your design.
- Memory will always be a struggle.
- Automate offline testing.
  - Regression is a bigger problem in cross-platform development.
- Keep the PC version working!
- Most importantly…

DO IT NOW

- The sooner you start, the better off you will be.
- Manufacturing lead times are longer on console, and you have TRC.

The Terrible Secret Of Cross-Platform Development:

All This Will Make Your PC Title Better!

- TRC is just a group of good usability rules.
- Memory efficiency helped us on every platform.
- PC games deserve shorter load times.
- Making money on the PC means hitting the low end.
- If it runs well on console, it’s easy to make it run well on PC.
  - Steamworks even lets you have achievements and updates!

Special Thanks

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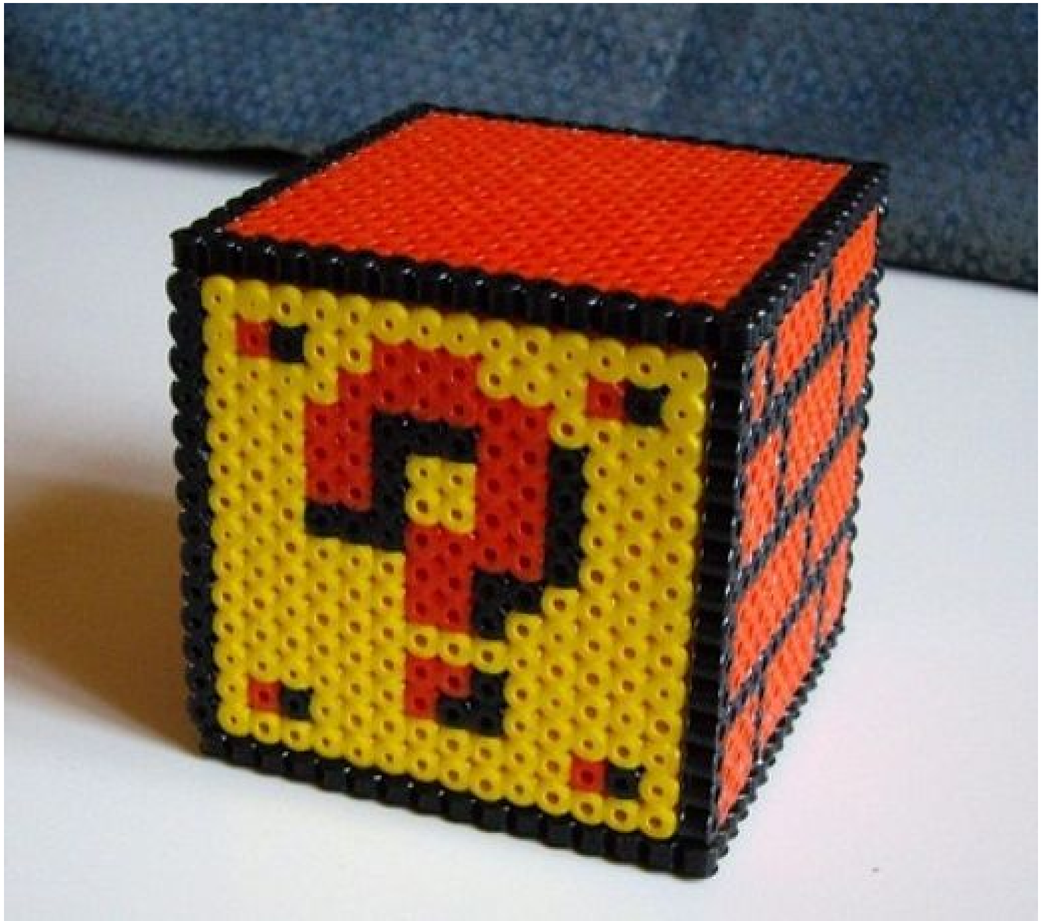
- Jon Parise
- Robert Pitt
- Kain Shin
- Ben Stragnell
- Cort Stratton

Questions?



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