

game developer



THE LEADING GAME MAGAZINE VOL 17 NO 10 NOVEMBER 2010 INSIDE: GAME DEVELOPER 50
SPIDER-MAN
SHATTERED DIMENSIONS



THE LEADING GAME INDUSTRY MAGAZINE VOL 17 NO 10 NOVEMBER 2010 INSIDE: GAME DEVELOPER 50



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Beenox had traditionally staffed its production teams with recent graduates. This approach worked well for the studio when it was working principally on ports, but designing the large scale SPIDER-MAN: SHATTERED DIMENSIONS was often in conflict with the demands of managing a young team. Fortunately, the studio was working with its own internally-developed technology which helped spread the workload across small groups.
By Martin Rheume

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By Eric-Jon Rössel Tairne

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The 25th Annual Game Boss Conference



THE MYTH OF THE BASEMENT DWELLER

GETTING BEYOND SOCIAL STIGMA IN ORDER TO ADVANCE THE MEDIUM OF GAMES AS A WHOLE

RECENTLY I WAS TALKING TO MY mother about the game I'm working on. I had told her about the new types of characterization I was going for, and the messages I was trying to imbue into this universe, and she was intrigued. She said she was proud of what I do, but always makes sure to tell her friends that I "don't work on those rape games."

What did she mean by this? "You know, the games where you go around raping Native American women," she explained.

At some point in time, some sensationalist news story informed my mother about the controversial 1982 Atari 2600 title *CUSTER'S REVENGE*, which most current game players have never even heard of. This, unfortunately, is the kind of image that sticks in peoples' minds, and instills in them a negative stigma, even if they don't know very much about games in general. The Hot Coffee scandal was similar in that way—completely blown out of proportion, while leaving an indelible scar on the minds of those who don't play or really understand games.

It's not really her fault. She understands games better than do her friends, and that's part of the reason why she feels the need to make this clarification. But there's definitely a social issue at work here that makes her feel that way, and I realized that it's up to people like me, and other game developers, to change this thought pattern—one person at a time, if need be. We should start with ourselves, while we're at it.

YOU SERIOUSLY PLAY VIDEO GAMES?

» I'm making a generalization here, but I'm going to go out on a limb and guess that a lot of people you meet for the first time aren't super impressed when they hear that you work on video games.

How often, when asked what you do by a member of whichever gender you're attracted to, have you taken a little pause before

figuring out how to position "game developer" in the most appealing light? Maybe you've done this with a family friend or relative, as well. This may be part of the problem. So long as we continue to allow the playing of games to be considered fringe or marginalized, the longer the stereotypes will perpetuate.

We, the decent human beings of the game development community, needn't feel ashamed to get excited about a *SONIC THE HEDGEHOG* revamp—most people get excited about movies, novels, or bands they like coming through town. Why should games exist in



a second tier of entertainment? If someone else can get excited about *Twilight*, of all things, I can anticipate *THE LAST GUARDIAN*. But I, and many other people I know, still do feel some trepidation or embarrassment when talking about this particular hobby, and like they always say, change begins with you.

SUBTERRANEA

» As MMO, social, and multiplayer games become more popular, and games become less of a solitary experience, the old joke about gamers living in their parents' basement becomes less plausible. We're almost always connected to people when playing games on a console or PC now, even if we've simply signed into Xbox Live.

Unfortunately, I feel that we players and creators of games perpetuate these self-deprecating ideas about games

being an inferior or childish hobby, even as we argue for its advancement as an artform. In conversations with those outside the industry, we may say "I know this is how game players are, but I'm not like that." This allows us to go on the defensive, putting ourselves down before the other party can get the chance. We distance ourselves from a negative stereotype, but simultaneously enforce it.

People that fit the basement-dweller stereotype do exist, but they're not the majority. The trouble is they're often the most vocal. What I'm suggesting is an (admittedly somewhat silly) call to action for people to make their significant others, family members, and estranged school chums understand why games matter, why what you do is important, so that perhaps they'll learn for themselves that game players and developers can be normal people. Maybe even mildly awesome people.

THE SHRINKING WORLD

» Maybe all these folks need is a subtle nudge in the right direction. The number of people playing Facebook, casual, and mobile games is increasing rapidly. Many of them don't consider themselves game players, inherently, but with the right coaxing can probably be made to realize they're essentially doing the same thing we do. While they may not want to sink 70 hours into *FALLOUT 3*, they might spend some 20 hours playing *PEGGLE* during their commute. And how different is that, really?

Games are becoming more and more a part of global culture, but stereotypes still persist. The more we weed them out of the social subconscious, the fewer sensationalist stories we'll see about mainstream "raping games," and the less often our moms will say "you do what for a living, again?"

—Brandon Sheffield

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GAME INDUSTRY LAWYER TALKS SUPREME COURT VIOLENT GAMES CASE



GRAND THEFT AUTO IV.

The lead counsel for the video game industry in the fight against California's proposed violent video game restrictions gave a preview of the types of arguments he will make when the case is argued before the Supreme Court next month.

Speaking at a *Game Developer*-attended intellectual property forum at Chicago-Kent University last week, Jenner and Block LLP partner Paul M. Smith said that treating violent content like sexual content, as the state wants to, runs up against the current state of American culture.

"Violence is considered a perfectly appropriate and normal part of what we give our kids to see starting from a very young age," Smith argued. "*Star Wars*, *Lord of the Rings*, *Harry Potter*, there's lots and lots of violence in all of those things."

Trying to write a definition of violence that accepts things like *Lord of the Rings* but restricts more extreme violence for minors causes constitutionally unacceptable vagueness problems, Smith said. "That's different in a very fundamental way, I think, from sex, where there's not a lot of sexually explicit things that are targeted at the kid-friendly side of the world that you have to carve out," he said.

There are additional vagueness problems introduced

by a clause in California's law that limits restrictions to games that "as a whole ... lack serious literary, artistic, political, or scientific value for minors." Smith said such a standard is impossible to enforce uniformly.

Who's to say, Smith asked, "that a video game about D-Day where everybody is being shot at constantly ... would have value, but a game about car theft in L.A. doesn't have value? ... Is it because you can be an American soldier killing Nazis in the D-Day game but you're a 'bad guy' in the GRAND THEFT AUTO game? ... How do



you decide which of those games has redeeming value?"

Furthermore, Smith said specifically restricting content that includes "maiming or killing an image of a human being," as California's law does, just doesn't make sense in a video game context.

"Think about in a video game, trying to figure out what an image of a human being is when there are characters that are the living dead or aliens that look like they're green or they turn into a car then back into a lion," Smith suggested. "How do you apply that definition?"

Smith warned that any new exception to the First Amendment for exposing minors to violent content would be impossible to contain to just the gaming medium. "It's going to be extended to movies, to the internet, to television, all of which are out there with no limit at all on what they can contain. So that is something that would be an extremely bold, revolutionary move by the court."

As for the scientific evidence that playing violent games is actively harmful to minors' development, Smith argued the studies presented by the state are too weak to stand up against the 87 researchers who signed on with the industry's claim that "this is all hogwash."

"There is a group of psychologists out there who have made their careers trying to prove that there's something wrong with video games, but their studies ... find these tiny little effects of maybe three percent more [likelihood] that you would be an aggressive school kid with violent video games," he said.

"But they don't consider the possibility that the violent, more aggressive kids might [simply] like the more violent games, so they have all these methodological problems," he continued.

Smith also noted that the reality of the game industry's ratings system enforcement provides a good answer to concerned parents who might support the state's efforts. "There are FTC surveys that suggest the video game rating system is much more strenuously-enforced than movie ratings or the sale of DVDs, where 60 percent of the time kids can buy R-rated DVDs," he said.

The Supreme Court will hear arguments in *Schwarzenegger vs. Entertainment Merchants Association* on November 2nd. The law being argued has been subject to an injunction preventing its enforcement since it was signed by Governor Schwarzenegger in 2004. Similar laws passed by eight other states and two cities have all been struck down by state or federal courts.

The game industry has garnered formal support from ten U.S. Attorneys General and many other media groups in its arguments, while California has attracted friend of the court briefs from eleven states and many media advocacy groups.

—Kyle Orland

BABYCASTLES GETS FUNDRAISER SUPPORT

New York City indie video game arcade Babycastles is receiving financial support from consumer gaming network IGN, which promised to match Kickstarter donations to the non-profit establishment, dollar for dollar.

The funds, just over \$18,000 after the match, were raised for the arcade's upcoming games exhibition, scheduled for October 8 through December 29 this year in a new Manhattan space. Both parties say that IGN's charitable donations come "no strings attached," and are part of the media organization's new aim to publicly support the indie scene.

The indie-centric arcade said it will put the money toward "rent, computer equipment, video projection, sound equipment, cabinet materials, workshop rental, artist reimbursement, promotional materials and production, staff, a bigger neon sign, and everything

unforeseen that it takes to run a smoothly functioning arcade and game culture event space at a highly trafficked public location in Manhattan."

Babycastles is a collaboration between the arcade operators and Showpaper, a New York-based bi-weekly print publication that promotes all-ages and DIY music shows in the area. Showpaper will assist in music production, and also curate rotating exhibitions of artwork alongside each arcade lineup, according to Babycastles.

The Manhattan Babycastles will have free admission during the day, acting as an art gallery for indie games, and at night will host events such as lectures, performances, workshops, and game release parties. Indie games from Eric Zimmerman, Mark Essen, Experimental Gameplay Project, Attract Mode, Playpower, and others will be featured in arcade exhibitions.

—Kris Graft



At play in Babycastles.

PHOTO BY BEN JOHNSON

JUDGE MANDATES "EDGE" TRADEMARK CANCELLATION

A U.S. District Court Judge has ordered controversial "Edge" trademark holder Tim Langdell to notify all licensees that Edge Games-related U.S. trademarks are no longer valid.

Following a rejection of a preliminary injunction in favor of Langdell, the judge said that Edge Games must submit a sworn declaration to the court



that states all licensees have been notified of the trademark cancellations. EA and Edge Games are to cover their respective legal fees.

Edge Games had been the holder of the U.S. trademarks "Edge," "Cutting Edge," "Gamers Edge," and "The Edge." Langdell became known for challenging individuals and companies that used any of the words or phrases in their products.

Langdell had filed suit earlier this year against major game publisher Electronic Arts for using the word "Edge" in the EA

DICE-developed 2008 first-person shooter MIRROR'S EDGE. The suit followed EA's September 2009 petition with the U.S. Patent and Trademark Office to cancel Langdell's trademarks.

In a separate recent court filing in which lawyers proposed a final judgment stripping Edge Games of the marks, Judge Alsup stated, "The record contains numerous items of evidence that plaintiff willfully committed fraud against the USPTO in obtaining and/or maintaining registrations for many of the asserted 'EDGE' marks, possibly warranting criminal penalties if the misrepresentations prove true."

In the midst of the legal disputes, members of the International Game Developers Association voted to remove Langdell from the organization, on the grounds that he exhibited "a lack of integrity," and "unethical behavior."

EA said in a statement that the company is "... pleased that we've reached a settlement and can put this behind us. This settlement goes a long way in protecting the rights of independent developers."

—Kris Graft

GAMIFICATION SUMMIT 2011 ANNOUNCED

The first ever Gamification Summit, dedicated to the use of game-like systems to drive participation in non-gaming activities, will take place January 20–21, 2011 at San Francisco's Mission Bay Conference Center. It will include keynote addresses by designer Jane McGonigal and Gabe Zichermann, author of *Game-Based Marketing*.

Other speakers include game designer Amy Jo Kim, Sustainable Life Media president Koann Skrzyniarz, Playmatics CEO Margaret Wallace, and Microsoft Bing Rewards director Keith Smith.

The concept of gamification has risen to prominence in the past year, with products like FourSquare, Groupon, Epic Win, and even Facebook increasingly integrating features like achievements, levels, and challenges into formerly non-gaming activities.

—Kyle Orland

UNREAL TECHNOLOGY NEWS

BY Mark Rein
Epic Games, Inc.

UNREAL ENGINE 3 HELPS INXILE RESCUE THE DUNGEON CRAWLER

The lead creatives behind some of the most popular classic dungeon crawl role-playing games of all time, including *Baldur's Gate*, *Fallout* and *Icewind Dale*, are updating the genre for today's more action-oriented gamers. inXile entertainment licensed Unreal Engine 3 technology to bring their new PC, Xbox 360 and PlayStation 3 creation, *Hunted: The Demon's Forge*, to life. Published by Bethesda Softworks, the RPG places focus on cooperative exploration both aboveground and in the depths of dungeons.

Brian Fargo, CEO of inXile, loved the heyday of dungeon crawl games in the '80s and '90s. He said the goal going into *Hunted* was to answer the question, "What would that kind of gameplay look like with today's technology, using the Unreal Engine, PlayStation 3, Xbox 360, and a really high-end PC?"

"We've been using UE3 for about five years," said Maxx Kaufman, game director at inXile. "We love the tools, and the engine has improved tremendously, especially as it relates to PS3. Epic opening up its PS3 tools was hugely helpful for making this game across all three platforms."

The team has relied heavily on the Unreal Developer Network (UDN), the support hub for Unreal Engine licensees. Having used the service for years, Kaufman said that posting an issue online always receives great feedback.

"It's a huge help when developing a game," he said, comparing it to having an entire network of experts at one's fingertips.

"We used the majority of Unreal Engine 3's features to create this game," said Kaufman. "All of our cut scenes utilized Matinee, and some of the scripted events within the world also used it."

He added, "The story is very important in this game. We used Kismet and we also have our own scripting language that we created to work with Unreal."

In addition to using Epic's UE3 technology, inXile also drew inspiration from what the studio has done with its *Gears of War* games in the co-op department. In addition to offering two-player online gameplay, the single-player experience keeps both protagonists in the heat of the action.

One of the new innovations is the ability for the two players to switch between the two characters, each of which has unique weapons and skills, between levels.

Players can also jump from single-player to online co-op at any point in the game between levels. Gamers can use their own characters from the single-player experience in these online games, accrue gold and crystals, and then return later to the offline experience with all that loot.

inXile Entertainment President Matthew Findley said *Gears* was also an inspiration for *Hunted's* cover combat system. The team designed the action to mirror the leapfrogging and flanking gameplay that established the *Gears* franchise as an innovator in the shooter genre. Findley said the controls for *Hunted* match nicely with *Gears*, as well, which will make it easy for console gamers to jump right into the game.

"There were a number of games that we looked at, but *Gears* was a huge influence for us," said Kaufman. "We all love *Gears* at the office. It's always been

something that we looked at. We looked at a lot of old first-person shooters and a lot of action games. But being that *Hunted* was created using Unreal Engine 3, it was natural to look at the *Gears* games and utilize a lot of the really great stuff that they did, as well."

At the end of the day, inXile CEO Fargo hopes that *Hunted* introduces a new generation of gamers to the genre that he fell in love with in his youth.

"When I used to play all those old games, I would lose myself in them," said Fargo. "I like the action games but I also like the break in the action when you're hearing creepy sounds in the distance and you want to move forward and find out what lies further down that corridor."

Unreal Engine 3 is the perfect choice to help inXile bring back the feel of the dungeon crawler to old school gamers, while pushing it in new directions with *Hunted: The Demon's Forge*.

Thanks to inXile Entertainment for speaking with freelance reporter John Gaudiosi for this story.



Canadian-born Mark Rein is vice president and co-founder of Epic Games based in Cary, North Carolina. Epic's Unreal Engine 3 has won Game Developer magazine's Best Engine Front Line Award four times along with entry into the Hall of Fame. UE3 has won three consecutive Develop Industry Excellence Awards. Epic is the creator of the mega-hit "Unreal" series of games and the blockbuster "Gears of War" franchise. Follow @MarkRein on Twitter.

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the game developer

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B R A N D O N S H E F F I E L D A N D J E F F R E Y F L E M I N G

People are what power our industry. Development teams pull together to create awe-inspiring pieces of interactive technology, and rarely outside of the indie world is any one piece of a game a single-person effort. But at times it's nice to single out those who have made great strides for our industry, on an individual level, even as a team leader.

And so, we present here our second-annual editor-chosen list of 50 important accomplishments of the last year-or-so, in the fields of art, programming, design, business, and evangelism, attempting to focus on the specific achievements of specific persons.

It should be noted that these names are not ranked—they are listed alphabetically by last name. As independent game making becomes increasingly popular and profitable, we expect to be honoring individual achievements more and more in the near future.

■ ART

JEREMY BENNETT VALVE

Valve's *LEFT 4 DEAD 2* has received much-deserved accolades for its carefully tuned and intense game play. But we should also take a moment to recognize what an amazing visual accomplishment the game represents. Under the art direction of Jeremy Bennett, the team at Valve created a game that rises to phantasmagorical heights while remaining firmly grounded in a lovingly-detailed reality. Anyone who has spent time in the American South will instantly recognize the game's well-worn environments and the sluggish afternoon light as it filters through humid air. The game's character designs also stand out for their verisimilitude. They are not comic book fantasies, but are instead reminiscent of the people that you see every day in line at the supermarket. The game's visuals trigger a remarkable level of emotional investment from the player and are a reminder of the power of great art direction.



JASEN WHITESIDE VOLITION

Creating convincingly destructible game environments is a big hurdle for both engineering and art. It's a challenge that Volition has fully embraced, and the studio's ongoing *RED FACTION* series is a love letter to armchair demolitionists everywhere. Under Jasen Whiteside's art direction for *RED FACTION GUERRILLA*, the studio crafted a somber, terraformed Martian landscape dotted with industrial settlements that beg to be aggressively disassembled. Here lies the art team's greatest accomplishment: not only have they built an engaging game environment, but they've also designed for its piece-by-piece destruction. It's a testament to

Volition's skill that broken things in their games look so good.

AMY HENNIG NAUGHTY DOG

Naughty Dog's creative director Amy Hennig is at the forefront of digital acting. As a writer and director on *UNCHARTED 2: AMONG THIEVES*, Hennig helped to create complex, believable, and most importantly, relatable characters. The days of computer marionettes in games are over, and for a title to reach the widest audience it has to have human characters that players can identify with. While good writing and solid voice acting are essential, Naughty Dog's innovation has been to integrate voice acting and motion capture in an effort to imbue its characters with uniquely human performances. By casting actors to handle both tasks and by treating mocap sessions as a film set with careful attention to rehearsal and performance, the studio is able to create games with the pulse of real life flowing through them.



CHRISTOPHER M. HUNT (FORMERLY PANDEMIC)

Though *THE SABOTEUR* was underpromoted and rather underappreciated in its time, the "will to fight" concept was undeniably well-executed, especially in a visual sense. In this France-based WWII-era game, areas controlled by the Nazis were represented in black and white, with only the Nazi iconography showing up as red. As the player liberates France, color returns to the world in real time, giving the player direct feedback regarding their in-game successes. This visually-striking feature was led by art director Christopher M. Hunt to excellent

effect, and was one of the most successful elements of the game.

ISAMU KAMIKOKURYO SQUARE ENIX

FINAL FANTASY XIII's luxurious visuals are a sparkling, candy-coated spectacle of teenage love fantasies and utopian fever dreams. The game's status as a flagship for Square-Enix's much-vaunted Crystal Tools framework, combined with a protracted development time, gave Isamu Kamikokuryo's art team the opportunity to push the limits of real-time digital imagery. The result is a visual feast of baroquely detailed models that are shaded and rendered with an obsessive eye for the physical qualities of light. Square-Enix has always been known as a graphics powerhouse with a particular emphasis on beautiful pre-rendered visuals. With *FINAL FANTASY XIII* we can see that real-time graphics are quickly approaching traditional computer animation techniques.

HYUNG-TAE KIM NCSOFT

Kim is best known as an illustrator, adding lithe female forms and brutish male bruisers to games such as *MAGNA CARTA* and *WAR OF GENESIS*. Now, as art director for NCSOFT's upcoming *MMO BLADE & SOUL*, Hyung-Tae Kim is taking control of the whole of the game's visuals, making his distinctive illustrations (which often "modify" anatomy for greater impact) finally come to life in a polygonal world. Though the game will not be out for some time, the results of his efforts are already visible, in the larger-than-life interactive characters, distinctive architecture, and weaponry that make video games unique.

IKUMI NAKAMURA PLATINUM GAMES

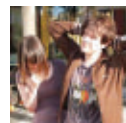
Video games have an innate capacity to be extremely, unaccountably weird. Unfortunately, the current of gleeful weirdness that once ran through games is rarely tapped into with any intention. Realism is the rule of the day, particularly when applied to high concept console

games. What a relief then to start up Platinum Games' *BAYONETTA* and find a game that is a head spinning mash up of art nouveau, shōjo manga, and gothic revival, along with a hit of pure nitrous oxide. As conceptual designer for *BAYONETTA*, Ikumi Nakamura helped create a game with visuals delirious enough to match its frenetic play.

JEAN-PHILIPPE RAJOTTE UBISOFT

SPLINTER CELL CONVICTION represented not only a design reboot for the series, but a visual one as well, incorporating an innovative use of light for objectives and projecting characters' inner thoughts on nearby surfaces. The concept originally came from creative director Maxime Beland after he saw Tony Scott's *Man on Fire*—but it was expertly implemented by art director Jean-Philippe Rajotte. Though inspired by a movie, Rajotte and his team's implementation represented something only games can really do. In this way, *CONVICTION* made a step forward in visual interactive storytelling.

PAUL ROBERTSON INDEPENDENT (UBISOFT)



Paul Robertson is an Australian pixel animator whose short film projects have alternately delighted and horrified the game-playing public for many years. In the past, his work had often been relegated to backgrounds and contract animation—but for *SCOTT PILGRIM VS. THE WORLD*, Robertson was given more free reign than ever before, assisted by longtime associates Jonathan Kim and Mariel Cartwright, and the result is a game that bears his unmistakable style and flourish, demonstrating his substantial abilities to a larger group of people.

NOBUYOSHI SANO DETUNE

As the creator of classic soundtracks for *RIDGE RACER* and *TEKKEN*, composer Nobuyoshi Sano

has a deep passion for synthesizers and their place in games. Teaming up with Korg and Cavia (now AQI), he helped design the KORG DS-10 and DS-10 PLUS for the Nintendo DS. Radical in concept, the KORG DS-10 delivers the experience of playing the classic Korg MS-10 analog synthesizer in a creative recording environment that is completely free from any game play concessions. With the upcoming KORG MQ1, Sano has now turned his attention to recreating one of the foundational instruments of modern club music, the Korg M1 workstation, in Nintendo DS form. Never before have pro level electronic instruments been so accessible.

■ DESIGN

MATTHEW ARMSTRONG
GEARBOX SOFTWARE

In this the age of first person shooters, if you are going to step into the free fire zone between HALO and CALL OF DUTY, you need to have some major tricks up your sleeve. Fortunately Gearbox's BORDERLANDS had more than a few interesting twists for players. With game design direction from Matthew Armstrong, BORDERLANDS successfully married



MMORPG-style level grinding and item collecting to fast-paced shooter play. Other creative innovations included the game's procedural content system that generated unique item drops in order to keep gameplay fresh.

TOM "ZILEAS" CADWELL
RIOT GAMES

Riot Games went from unknown quantity to industry standard in just over a year of LEAGUE OF LEGENDS' operation. This was the first major attempt to commercialize the style of gameplay of the hugely popular WARCRAFT III mod DEFENSE OF THE ANCIENTS, and the design, under Tom "Zileas" Cadwell, resonated with enough people to rocket Riot

Games to the top of the online space. Not only that, the game recently swept the GDC Online awards, including Best Online Technology, Visual Arts, Game Design, and New Online Game.



CHRISTIAN CANTAMESSA
ROCKSTAR SAN DIEGO

One of the old axioms of the game industry states that "Westerns don't sell." RED DEAD REDEMPTION disproves that theory several times over, with massive sales in North America and Europe. The game takes the sandbox genre and depopulates it, effectively strengthening players' bonds with the main character, his horse, and the story in general. Riding over vast landscapes has never felt more immersive, and the illusion of player agency is incredibly strong, even though the gameplay is clearly objective and node-based. The game's design leads the player to feel as though they've discovered something new, while they've actually been cleverly lead to a conclusion. Modern game design at work.

STEVE GAYNOR
2K MARIN

THE MINERVA'S DEN downloadable campaign for BIOSHOCK 2 was an interesting creative approach to DLC that brought completely new characters and environments to the familiar BIOSHOCK universe. Not often is a DLC "expansion" a complete unique narrative experience. It also subtly tweaked the balance on upgrades and enemies to encourage a slower and more considered pace through the game without radically altering established mechanics. Led by Steve Gaynor, the MINERVA'S DEN team was a 10-person, self-contained group within the larger

company, proof that working small and fast can lead to real creative breakthroughs.

SUEHIRO "SWERY" HIDETAKA
ACCESS GAMES

DEADLY PREMONITION was, for some, the surprise success of last year. The combat was troublesome, and the controls subpar, but the story, the script, and the character interaction was deeper and more subversive than any other linear game that year. Hidetaka "Swery" Suehiro is the mastermind behind the game's text and direction, and he filled his fictional town of Greenvale with life—characters go about their daily lives whether the player is watching or not. They have breakfast, drive to and from work, and voice their own hopes, dreams, and troubles. Most impressive is the main character, with his carefully considered persona and deep monologues. Anyone writing modern video game characters could learn something from DEADLY PREMONITION.

JUNICHI MASUDA
GAME FREAK

POKEMON is a seemingly unstoppable cultural force, with games spanning multiple consoles, movies, television, a card game, and so forth. The newest game combo, POKEMON BLACK/WHITE, moved over 2.6 million units in the first two days of its Japanese release. This is largely due to the absolute perfection of obsessive-compulsive addictive gameplay that has been infused into the series, lately under the stewardship of game director Junichi Masuda. BLACK/WHITE has added some complexity to the story, but overall has stuck to its tried-and-true formula. If you can sustain interest in one game series for so long without any lull, we would say that warrants notice.

SID MEIER
FIRAXIS

Sid Meier's oft-quoted "fun over realism" design maxim was in full effect in CIVILIZATION REVOLUTION,

but it was Meier's Zen-like ability to simplify the well-established CIVILIZATION gameplay without losing any of its strategic complexity that was the real accomplishment. From streamlining the visuals and user interface, to trimming down the variety of units, the game was made to be CIVILIZATION's most accessible incarnation yet. Still, the game's fundamental pleasures of exploration and city building and its deep mechanics of diplomacy and warfare remain unchanged. Now that an iOS version of CIVILIZATION REVOLUTION has been released, we may have the game in its most elegant form yet.



HIDETAKA MIYAZAKI
FROM SOFTWARE

Is Japanese game development in a bit of a slump lately? Perhaps not if you look at games such as From Software's DEMON'S SOULS. Directed by Hidetaka Miyazaki, DEMON'S SOULS is big, ambitious, thoughtfully designed, and crafted to perfection. Much has been written regarding the game's creative online implementation and notorious difficulty, but designers should take note of the way that DEMON'S SOULS allows serious players to create uniquely personal experiences within the game. As one travels deeper into DEMON'S SOULS, it becomes apparent that players are actually being tested against themselves, eliciting a level of mental concentration that may be closer to mountain climbing than game playing.

DANIEL NEUBERGER
CRYSTAL DYNAMICS

The TOMB RAIDER franchise has been around for almost 15 years, and

just when it seemed like there was nothing new to add to the series, Crystal Dynamics reinvigorated an interest in all things Lara Croft with *TOMB RAIDER AND THE GUARDIAN OF LIGHT*. Now radically molded into a fixed-camera, isometric game by lead designer Daniel Neuberger, the new title puts a fresh face on the series while still retaining all of *TOMB RAIDER*'s signature moves. It's a smart design choice that gets to the heart of the series' exploration and traversal play while eliminating many of the annoying camera and control issues that accompanied the previous free-roaming 3D *TOMB RAIDER* games.

MARKUS "NOTCH" PERSSON
MOJANG SPECIFICATIONS

MINECRAFT was a labor of love for Markus Persson, also known as Notch. He created the game from



an old project he had been working on some time ago, infusing a mining and building mechanic with a blocky, pixel-like 3D world. The resulting game has taken off dramatically. The game's user-created content and addictive gameplay have struck a chord with fans around the world, to a degree which even Persson didn't predict. The well-designed, one-person indie game has gone on to net almost \$4 million as of this writing, and Persson is now setting up a studio to better support his breakaway hit.

■ **PROGRAMMING**

SEBASTIAN AALTONEN
REDLYNX

As the lead programmer on RedLynx's *TRIALS HD*, Sebastian Aaltonen helped create a unified physics engine for the studio's popular motorcycle stunt game. A traditional approach would have called for separate physics

systems to handle rider ragdoll, bike motion, and track obstacles, but the resulting layer of programming work in order to support the varying game states and animations was too extensive for the small studio. Aaltonen's elegant solution was to apply the same realistic physics model to every object in the game, a technique that enabled RedLynx to streamline development and completely eliminate the need for key-frame driven animation.

JOACHIM ANTE
UNITY TECHNOLOGIES



Joachim Ante began writing the core of Unity as a teenager, and nine years later the engine is now in the hands of more than 200,000 users. As Unity's chief technology officer and co-founder, Ante has brought pro-level game tools to the masses, and is playing a major role in the renaissance of independent games. While the latest version of the engine sports a number of graphics enhancement such as deferred rendering, licensed light mapping, and occlusion culling solutions from Illuminate Labs and Umbra, it is Unity's cross-platform editor that has made it a major tool of choice for developers both indie and pro.

RONAN BEL
UBISOFT

FROM DUST is not yet released, but the tech has already demonstrated itself as exceptional. Ubisoft technical director Ronan Bel has partnered with lauded designer Eric Chahi to create a world of dynamically-changing water, greenery, earth, and lava, which evolves before players' eyes, even if left alone. More impressively, the player can mould the world like clay, redistributing resources in real time, or forming massive structures of water or molten rock that could never exist in reality. Bel and his team have made this living world run seamlessly, with an intuitive user interface, demonstrating some of the most impressive tech yet seen in a downloadable title.

JON CABLE
BUNGIE

Giving players the tools to create their own maps has long been a Bungie tradition, and the Forge tool saw its first incarnation in *MARATHON INFINITY*. Now within *HALO: REACH*, the latest version of the map-building Forge tool has been integrated into the massive Forge World, giving players an almost limitless sandbox with which to build their own

elaborate erector set constructions. Using a simple set of conditions for each placed object in the Forge World, Forge allows objects to be aligned and blended with ease. It's a testament to Forge's capabilities that Bungie itself used Forge to create a number of the maps in *REACH*.

ERIN CATTO
BOX2D

Box2D is an open source 2D rigid body physics engine, which was created single-handedly by Erin Catto, and then further refined by the community. The tool has proved to be popular among indies and iOS developers, powering the physics behind games like *CRAYON PHYSICS*, *FANTASTIC CONTRAPTION*, *ROLANDO* (iPhone) and a host of others. As of now, the tool works in Flash, Java, C#, Python, and of course its native C++. While the original version was released two years back, in the last year the game has had a significant uptick in users due to the increasing number of game creators using the engine on iPhone.

JAMES HALL AND DEE JAY RANDALL
BLUE CASTLE GAMES

On top of its solid gameplay, Blue Castle Games' *DEAD RISING 2* is a



DEAD RISING 2



Streeting.

remarkable technical achievement. Rarely have we seen such a vast number of characters on the screen at once; all moving independently and with realistic and unique (for zombies at least) animations. It is a credit to the studio's tech that publisher Capcom was so pleased with DEAD RISING 2 that it bought the company outright. Under the technical direction of James Hall and Dee Jay Randall, the studio also employed advanced telemetry to get feedback and even bugs from players across the globe.

AMITT MAHAJAN
ZYNGA

Making a full-featured game in five weeks is no simple task at any scale, but that's what Amitt Mahajan and his small team of web developers at Zynga managed to do with FARMVILLE for Facebook. Mahajan cleverly scaled the project so that it would be able to adapt to Facebook's quickly-changing development environment, and also require minimal programmer support when designers wanted to implement new features, all the while keeping track of important player metrics. Mahajan and his cohorts have helped to create a set of best practices for Facebook game development, even as the platform continues to evolve.

MARK OVERMARS
YOYO GAMES

Mark Overmars' Game Maker engine is a key learning tool for budding game developers. By abstracting game creation with simple drag-and-drop functionality, Game Maker allows beginning users to easily build working games without programming. Those wanting to go deeper can utilize the Game Maker Language to script complex

game logic, as well. This, combined with the tool's nominal cost, has lowered the barrier to game development to almost nil. But don't assume that amateur hour is the rule of the day. Standout indie titles like SPELUNKY and SEIKLUS are creative examples of what is possible with the tool.

STEVE STREETING
TORUS KNOT SOFTWARE

For most of the past decade Steve Streeting has been overseeing the open source OGRE 3D rendering engine. The engine is tightly focused on providing an object-oriented, cross-platform graphics rendering solution for Direct3D and OpenGL APIs. Commercial projects, including the high-profile TORCHLIGHT from Runic Games, are increasingly turning to OGRE 3D for its mature design and flexible class hierarchy. While Streeting may have stepped back from the day-to-day stewarding of OGRE 3D this year, his team continues to polish what is already a class leader in 3D rendering.

MATTHEW VERSLUYS
AND ROB PARDO
BLIZZARD

Battle.net was Blizzard's longtime online gaming service, but only for its older titles—crucially, WORLD OF WARCRAFT wasn't supported. But in 2009, a massive revamp effort was undertaken, dubbed "Battle.net 2.0." The initiative was spearheaded by Rob Pardo's design, and implemented by technical director Matthew Versluys' team. Versluys has been working on Battle.net since 2000, and is principally responsible for maintaining the current service's reliability. Migrating millions of WORLD OF WARCRAFT users to a new system, while also providing useful integration with STARCRRAFT II and future titles, is no simple task. The studio's work proves that valiant efforts in programming don't only happen in-game—they happen on the service side, as well.



Pardo.

BUSINESS

ROBERT A. ALTMAN
ZENIMAX MEDIA

Under CEO Robert Altman, Zenimax has been quietly buying up developers of immersive and emotionally-arresting open-world first person content over the last year, with id Software and Arkane Studios now under its wing, alongside existing development/publishing house Bethesda Softworks. With these three powerhouses, Zenimax has the potential to really push the first person genre forward. Also interesting is the company's publishing effort in Japan, helping bring western games from many different publishers to the region. While that initiative hasn't necessarily been a massive financial success, the company has helped to increase awareness of western games on Japanese shores.

MIKE CAPPS
EPIC GAMES



Even though it's financially secure in its position as one of the supporting pillars of the current game industry, Epic has never been comfortable resting on its own success. The studio has taken the dramatic step of offering its Unreal Development Kit free to anyone who cares to download it. Of course, if you have commercial aspirations for a game made with the UDK, the licensing terms are a bit less altruistic, but that's really beside the point. Getting the Unreal engine technology into the hands of as many users as possible is training a new generation of developers to use Epic's tools.

GORDON HALL
ROCKSTAR LEEDS

Most often, if a game doesn't financially succeed immediately, the company moves on. But in the case of GRAND THEFT AUTO: CHINATOWN WARS, when the title didn't meet sales expectations on the DS, it was ported to the PSP. From there, it was ported to the iOS devices, where the

game wound up the highest grossing paid app for several weeks. Rockstar Leeds and president Gordon Hall knew the game itself was solid, and was reviewing well, so kept the title alive until it could find the right home. The game wound up split across three similar-spec consoles, turning a "moderate success" into something much larger.



STEVE JOBS
APPLE

Steve Jobs has said several times in the past that video games were important to Apple, but in truth games were never really a reason to buy the company's computers. Until now, that is. The overwhelming popularity of the iPhone and iPad has opened up a huge market for games on Apple's iOS platform and quality games are no doubt helping drive the device's sales. Thanks to a loosening of the iOS SDK's code restrictions and the addition of new social gaming functionality, ad serving, and better revenue reporting, Apple's handhelds are edging ever closer to being the portable format of choice for developers.

ROBERT KHOO
PENNY ARCADE

Penny Arcade has grown from a simple web comic into a cottage industry, including books, games, and an extremely successful bi-coastal expo (PAX). So how did Jerry Holkins and Mike Krahulic, two staunch creatives, manage to get so far in the world of business? The answer, at least in part, is Robert Khoo, their longtime business partner. From the gamer goodwill spread through their expo to the overwhelmingly positive influence of the group's Child's Play charity, which has donated over \$5 million in cash and toys to children's hospitals across the globe, Khoo has been there keeping everything solvent and successful—while still allowing the creators to do what they do best, unabated.



Newell.

GABE NEWELL
VALVE SOFTWARE

Valve has a well-deserved reputation for creating quality games, but it has always had the slightly monastic air of a studio that is predominately Microsoft facing (no surprise considering that its founders spent many years in OS development at Microsoft before forming Valve). This has changed rather dramatically with the studio's recent release of a Mac version of Steam. With that comes the promise of Valve games for the Mac delivered simultaneous to their PC release. After being neglected for the past several years, the PlayStation 3 is also suddenly looking very attractive to Valve, and the studio is developing a version of its upcoming PORTAL 2 directly for the console rather than farming the port out as it did with THE ORANGE BOX. This realignment of resources is not easy and points to a major change in Valve's outlook, as the company becomes more comfortable with its role as a lead player in the game industry.

HILMAR VEIGAR PÉTURSSON
CCP GAMES

Since the early MMO gold rush, EVE ONLINE has been one of only a handful of titles to significantly grow its subscriber numbers over the long term. After taking over EVE ONLINE publishing duties for itself, CCP (under CEO Hilmar Veigar Pétursson) has been cultivating its fan base with regular updates to the EVE universe as well as keeping a vigilant stance against real-money traders. CCP is also remarkably accessible to its players and keeps them well informed on its design and development process

through detailed blog postings. The upcoming DUST 514 will see the company stepping into the console space to reach an audience that has the potential to be even larger than that of EVE ONLINE.

JOHN RICCIETIELLO
ELECTRONIC ARTS

EA gets its lumps for being very franchise-focused at times, but lately the company has been doing much more to foster original IP with its EA Partners program. More than that, though, EA has been innovating in the digital download space. In an attempt to reclaim some of the money spent on used games, the company has started including one-time use day-one downloadable content vouchers in boxed games, which used game buyers would have to purchase themselves. Though the extent of this program's success has not been publicly proved, it has convinced other publishers, such as Ubisoft and THQ, to adopt similar programs. John Riccitiello is making interesting moves with the company, and we will likely see the ramifications in the next few years.

MAX SCHAEFER
RUNIC GAMES

Born as it was out of the collapse of Flagship Studios, Runic Games has endeavored to run a stable business right from the beginning, with Max Schaefer as its captain. Staying lean, working fast, and sticking close to its core talents as a developer has resulted in TORCHLIGHT, a debut title whose success has been

a resounding affirmation of the studio's efficient approach. With TORCHLIGHT's sequel due early next year and an even more ambitious TORCHLIGHT MMO in the works, Runic Games is in the business to stay.

KELLEE SANTIAGO
JONATHAN BLOW
RON CARMEL
KYLE GABLER
AARON ISAKSEN
NATHAN VELLA
MATTHEW WEGNER
INDIE FUND

The Indie Fund was created by a group of successful indies looking to help future creators make good games without the overhead of a traditional publisher relationship. Santiago (FLOWER), Blow (BRAID), Carmel and Gabler (WORLD OF GOD), Isaksen (ARMADILLO GOLD RUSH), Vella (CRITTER CRUNCH), and Wegner (OFF-ROAD RAPTOR SAFARI) banded together to create a fund with flexible budgets, no milestones, reasonable revenue share, and no long-term obligations. Though the group is still testing out their theories, we feel this is a good step toward enabling "art house" games' increasing viability.

■ **EVANGELISM**

FEDERICO BEYER
SLANG

Latin America has had a long game development history, but much of it has gone under the radar, being too far afield to achieve mainstream success in Asia, North America, or

Europe. Slang has taken it upon itself to not only popularize Latin American game development, but to also target Latin American consumers at home and abroad. The first major game to come out of this arrangement, LUCHA LIBRE AAA HEROES DEL RING, is being created by two different Latin American game studios, Immersion Games, and Sabarasa Entertainment. Spokesperson Federico Beyer, first party liaison and director for Slang, has also made it clear that he feels the Latin American gamer population is underserved, and he aims to bring them into the circle of game development.

TOM BISSELL
INDEPENDENT



Often called a travel journalist or simply a writer of short stories, Tom Bissell writes for proper journalistic publications, like *Harper's Magazine* and *The New Republic*. So when he turned his eye on video games, with his new book *Extra Lives: Why Video Games Matter*, he took a much different approach than others who have tackled the subject. In clever language, he discusses the importance of games as a cultural and social movement, arguing their validity as an artform, but without preaching to—or necessarily appearing to be part of—the crowd.

IAN BOGOST
PERSUASIVE GAMES

As an author, serious games designer, and art game creator, Bogost has consistently challenged the game industry to take itself and the work that it does seriously. To Bogost, games should not be designed as clever time-wasters. Rather, they need to bring tangible meaning to player's lives. His Facebook game COW CLICKER was created as a satirical response to what he saw as the emptiness of some social games. However, the game did its job too well and ultimately reached 50,000 users, leading some to wonder if the industry might be headed toward tulip mania. If it does, we can't say we weren't warned.





Samyn and Harvey.

MIKE GALLAGHER
ENTERTAINMENT SOFTWARE
ASSOCIATION

The Entertainment Software Association got a new leader in 2007—Mike Gallagher, former assistant secretary of commerce for communications, and chief telecommunications and policy advisor to the Bush administration. For a time, it seemed as though Gallagher was not living up to the high bar set by his predecessor, ESA founder Doug Lowenstein. But in the last year or so, the ESA has kicked into high gear, funding research, and donating money to pro-electronic software political initiatives, while making all this information available to the public. Along with the EMA, the organization has also filed a brief in the current case on violent video games in the Supreme Court. On top of this, the ESA has awarded some \$90,000 in scholarships to aspiring game developers. It's clear that the ESA is doing work for all of us, and Gallagher is at the head of that movement.

**AURIEA HARVEY AND
MICHAËL SAMYN**
TALE OF TALES

Positioning themselves as somewhat of a Jean Cocteau of

video games, the development duo Tale of Tales is a staunch believer in the transformative power of games. There is no question that games are art in their perspective, and as such, games should strive to touch players on a deep level, beyond simple neuro-motor stimulation. It's a stance that doesn't always win them friends, but their constant questioning of what games are and what they could be is absolutely essential if we want a future beyond adolescent power fantasies.

JANE MCGONIGAL
INSTITUTE FOR THE FUTURE

As a leading proponent of alternate-reality games and games for change, McGonigal has continually challenged the notion of what a video game is or can be, striving to integrate games into the social world outside the screen. Recently, her games have taken a more ecological and political bent, attempting to get players to confront or assess the realities of their world, through organizations such as the Institute for the Future (SUPERSTRUCT), and the World Bank Institute (EVOKE). McGonigal has consistently pushed the boundaries of games and interactive media—but adding social responsibility to that mix is what puts her on our list.

**STEVE MERETZKY AND
BRIAN REYNOLDS**
PLAYDOM AND ZYNGA



Meretzky.

When it comes to evangelizing social games to the game development public, Meretzky and Reynolds have been two of the most vocal participants. With long careers in both traditional and casual game development, when social gaming emerged, both of these fellows were right there alongside, attempting to show other developers why this platform should be exciting and encouraging, rather than frightening and daunting. Though the two are not associated—Meretzky works for Playdom, and Reynolds for rival Zynga—their messages are similar: Social games are the future.

**ADAM SALTSMAN AND
CHEVY RAY JOHNSTON**
FLASH GAME DOJO

Saltsman and Johnston are two accomplished Flash game makers, each with his own free-to-use development tool (Flixel and FlashPunk respectively). The two have paired up to make Flash Game Dojo, web site dedicated to

tutorials and FAQs about free Flash development. The tools are so easy to use that non-programmers and non-artists can get started with ease. This is the truest and most pure sort of game evangelism—Saltsman and Johnston have effectively lowered the barrier to making games, meaning that if you've got an idea, you can make it happen—within reason.

MEGGAN SCAVIO
GAME DEVELOPERS
CONFERENCE




Though Meggan Scavio works for the same organization that publishes *Game Developer* magazine

(UBM Techweb Game Group), there is no denying that the Game Developers Conference does a lot to bring game developer awareness to the world. GDC is the premier venue for game developers to meet up en masse and discuss the issues that concern them, even as the industry evolves and platforms fragment (and then reconvene). Under Scavio's stewardship, the conference has grown, and its impact on developers has increased, as the sessions and summits focus more and more on valuable takeaways, and less on panels and general discussions—that's left for the hallways!

GUILLERMO DEL TORO
FILMMAKER



Pan's Labyrinth director Guillermo Del Toro is unapologetic in his love for "culturally

suspect" material such as monster movies, comic books, and video games. Fortunately, when he says that he considers LEFT 4 DEAD to be a family game, even people who may not exactly get the joke will still listen, because his films have moved so many. Del Toro is quick to extol the virtues of games as a story telling medium, and with hints of a large-scale game project to be headed by Del Toro in the works, we may soon get to experience his brand of the outré in our game consoles. 

NO DARKNESS WITHOUT LIGHT

TOP FIVE THINGS THAT GO WRONG WITH SHADOWS MAPS

DAVID TUFT

WE'VE ALL BEEN THERE. AFTER SEARCHING THE INTERNET AND PERUSING SOME GRAPHICS ARTICLES, YOU SET UP THE VIEW MATRICES CORRECTLY. YOU RENDER TO A TEXTURE FROM THE LIGHTS' POINT OF VIEW. YOU SET UP THE TEXTURE COORDINATES CORRECTLY TO GIVE A POSITION IN LIGHT SPACE. YOU SAMPLE THE TEXTURE YOU'VE CREATED AND SHADE PIXELS BLACK BASED ON THE DEPTH TEST. AND ... YOUR SHADOWS LOOK TERRIBLE. THE NEXT FEW WEEKS ARE SPENT PLAYING WITH MATRICES, READING MORE ARTICLES, AND DOWNLOADING MORE SAMPLE CODE IN ORDER TO GET YOUR SHADOWS TO AN ACCEPTABLE STATE.

THIS ARTICLE ENUMERATES, IN DETAIL, SOME GOOD APPROACHES TO ATTACKING FIVE OF THE UGLIEST PROBLEMS THAT TEND TO SHOW UP EVERY TIME SHADOWS ARE ADDED INTO A TITLE. SOME APPROACHES, SUCH AS CALCULATING A TIGHTLY BOUNDED NEAR AND FAR PLANE, ARE ONLY ENUMERATED IN ONE SECTION WHEN IN REALITY THEY WILL HELP MULTIPLE SHADOW MAP ISSUES.

1 /// YOUR SHADOWS ARE BIG AND BLOCKY

PERSPECTIVE ALIASING

¶ Perspective aliasing is shown in Figure 1. It occurs when multiple pixels in view space map to a single texel in the shadow map. This is because objects near the eye occupy more pixels than objects further away due to the perspective transform.

For the left image in Figure 1, perspective aliasing is higher, because too many eye space pixels map to the same shadow map texels. In the image on the right, perspective aliasing is low because there is a 1:1 mapping between the eye space pixels and shadow map texels.

PROJECTIVE ALIASING

¶ Projective aliasing is harder to show than perspective aliasing. The distended shadows highlighted in Figure 2 demonstrate projective aliasing errors. This occurs when the mapping between texels in camera space to

texels in light space is not a one-to-one ratio due to the orientation of the geometry with respect to the light camera. Projective aliasing occurs as the tangent plane of the geometry becomes parallel to the light rays.

Techniques used to alleviate perspective aliasing errors also mitigate projective aliasing. Another silver lining to the problem of projective aliasing is that it occurs when the surface normal is orthogonal to the light; these surfaces should be receiving less light based on diffuse lighting equations.

WARPING THE PROJECTION MATRIX TO FIX PERSPECTIVE ALIASING?

¶ Perspective shadow maps (PSMs) and light space perspective shadow maps (LSPSMs) attempt to address perspective aliasing by skewing the light's projection matrix in order to place more texels near the eye where they are needed. Unfortunately, neither technique is able to solve the perspective aliasing problem. The parameterization of the transform required to map eye-space pixels to texels in the shadow map cannot be bound by a linear skew. A logarithmic parameterization is required.



FIGURE 1 High perspective aliasing (left) vs. low perspective aliasing (right).



FIGURE 2 High-projective aliasing (left) vs. low-projective aliasing (right).

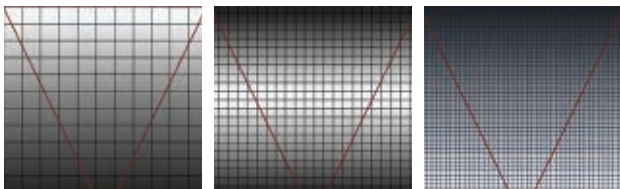


FIGURE 3 Shadow map coverage.

PSMs put too much detail near the eye, causing distant shadows to be of low quality or to even disappear. LSPSMs do a better job of finding a middle ground between increasing resolution near the eye, and leaving enough detail for objects far away. Both techniques degenerate to orthographic shadows in some configurations of the light camera with respect to the view camera. This degeneration can be counteracted by rendering a separate shadow map for each face of the view frustum, although this is expensive.

Logarithmic perspective shadow maps (LogPSMs) also render a separate map per face of the view frustum. This technique uses nonlinear rasterization to place more texels near the eye. D3D10 and D3D11-class hardware do not support nonlinear rasterization. For more information about these techniques and algorithms, see References.

CASCADED SHADOW MAPS

¶ Cascaded shadow maps (CSMs) are the most popular technique for dealing with perspective aliasing. Although CSMs can be combined with PSMs and LSPSMs, it's not common. This is because of the places where the warping algorithms degenerate and other complications that make it hard for them to work together in all cases.

The basic concept of CSMs is easy to understand. Different areas of the camera frustum require shadow maps with different resolutions. Objects nearest the eye require a higher resolution than do more distant objects. In fact, when the eye moves very close to the geometry, the pixels nearest the eye can require so much resolution that even a 4096 x 4096 shadow map is insufficient.

The basic idea of a CSM is to partition the frustum into multiple frusta. A shadow map is rendered for each subfrustum; the pixel shader then samples from the map that most closely matches the required resolution.

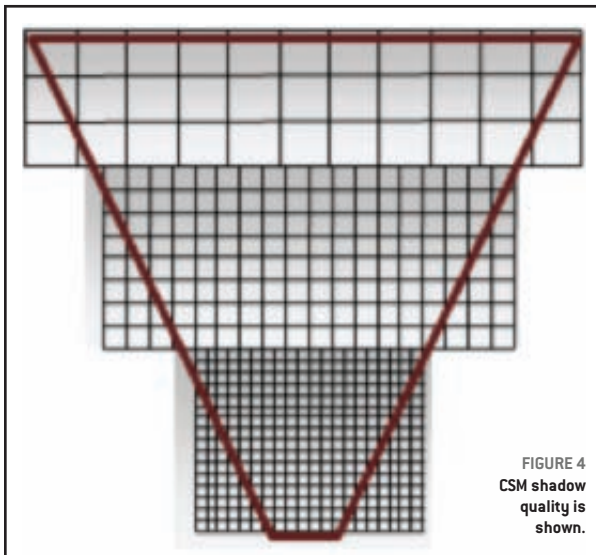


FIGURE 4 CSM shadow quality is shown.

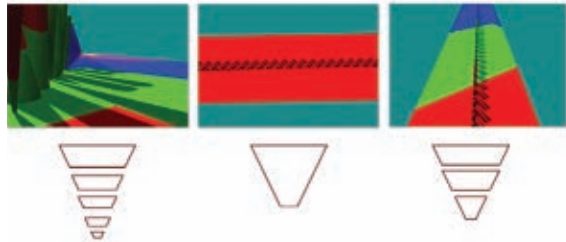


FIGURE 5 Different configurations require different frustum splits. When geometry has a high dynamic range in Z, lots of cascades are required (left). When the geometry has low dynamic range in Z, there is little benefit from multiple frustums (center). Only three partitions are needed when the dynamic range is medium (right).

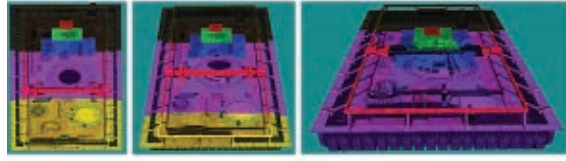


FIGURE 6 Cascade overlap increases as light direction becomes parallel with camera direction.



FIGURE 7 Fit to scene (left) vs. fit to cascade (right).

In Figure 3, quality is shown (left to right) from highest to lowest. The series of grids representing shadow maps with a view frustum (inverted cone in red) shows how pixel coverage is affected with different resolution shadow maps. Shadows are of the highest quality (white pixels) when there is a one-to-one ratio mapping pixels in light space to texels in the shadow map. Perspective aliasing occurs in the form of large, blocky shadows (left image) when too many pixels in view-space map to the same shadow texel. When the shadow map is too large, it is under sampled. In this case, texels are skipped, shimmering artifacts are introduced, and performance is affected.

Figure 4 shows cutouts from the highest quality section in each shadow map in Figure 3. The shadow map with the most closely placed pixels (at the apex) is nearest the eye. Technically, these are maps of the same size, with white and grey used to exemplify the success of the cascaded shadow map. White is ideal because it shows good coverage—a 1:1 eye space pixels and shadow map texels.

CSMS REQUIRE THE FOLLOWING STEPS PER FRAME.

1. Partition the frustum into subfrustums.
2. Compute an orthographic projection for each subfrustum. Tightly fit the frustum using the technique in Section 4 of this paper.
3. Render a shadow map for each subfrustum.
4. Render the scene.
 - a. Bind the shadow maps and render.
 - b. The vertex shader then does the following:
 - > Compute texture coordinates for each light subfrustum (unless the needed texture coordinate is calculated in the pixel shader).
 - > Transform and light the vertex, and so on.
 - c. The pixel shader then does the following.
 - > Determine the proper shadow map.
 - > Transform the texture coordinates if necessary.
 - > Sample the cascade.
 - > Light the pixel.

PARTITIONING THE FRUSTUM

¶ Partitioning the frustum is the act of splitting the frustum into subfrustums. One technique for partitioning the frustum is to calculate intervals from zero to one hundred percent in the Z-direction. Each interval then represents a near plane and a far plane as a percentage of the Z-axis. In practice, recalculating the frustum splits per frame causes shadow edges to shimmer. The generally accepted practice is to use a static set of cascade intervals per scenario. In this way, the interval along the Z-axis is used to describe a subfrustum that occurs when partitioning the frustum. Determining the correct size intervals for a given scene depends upon several factors.

ORIENTATION OF THE CAMERA WITH RESPECT TO THE SCENE GEOMETRY

¶ With respect to scene geometry, camera orientation affects cascade interval selection. Figure 5 shows some different cameras and their respective partitions. When the scene's Z-range is very large, more split planes are required. For example, when the eye is very near the ground plane, but distant objects are still visible, multiple cascades can be necessary. Dividing the frustum so that more splits are near the eye (where perspective aliasing is changing the fastest) is also valuable. When most of the geometry is clumped into a small section (such as an overhead view or a flight simulator) of the view frustum, fewer cascades are necessary.

ORIENTATION OF THE LIGHT AND THE CAMERA

¶ Each cascade's projection matrix is fit tightly around its corresponding subfrustum. In configurations where the view camera and the light directions are orthogonal, the cascades can be fit tightly with little overlap. The overlap becomes larger as the light and the view camera move into parallel alignment (see Figure 6). When the light and the view camera are nearly parallel, it is called a "dueling frusta," and is a very hard scenario for most shadowing algorithms. It is not uncommon to constrain the light and camera so that this scenario does not occur. CSMS, however, perform much better than many other algorithms in this scenario.

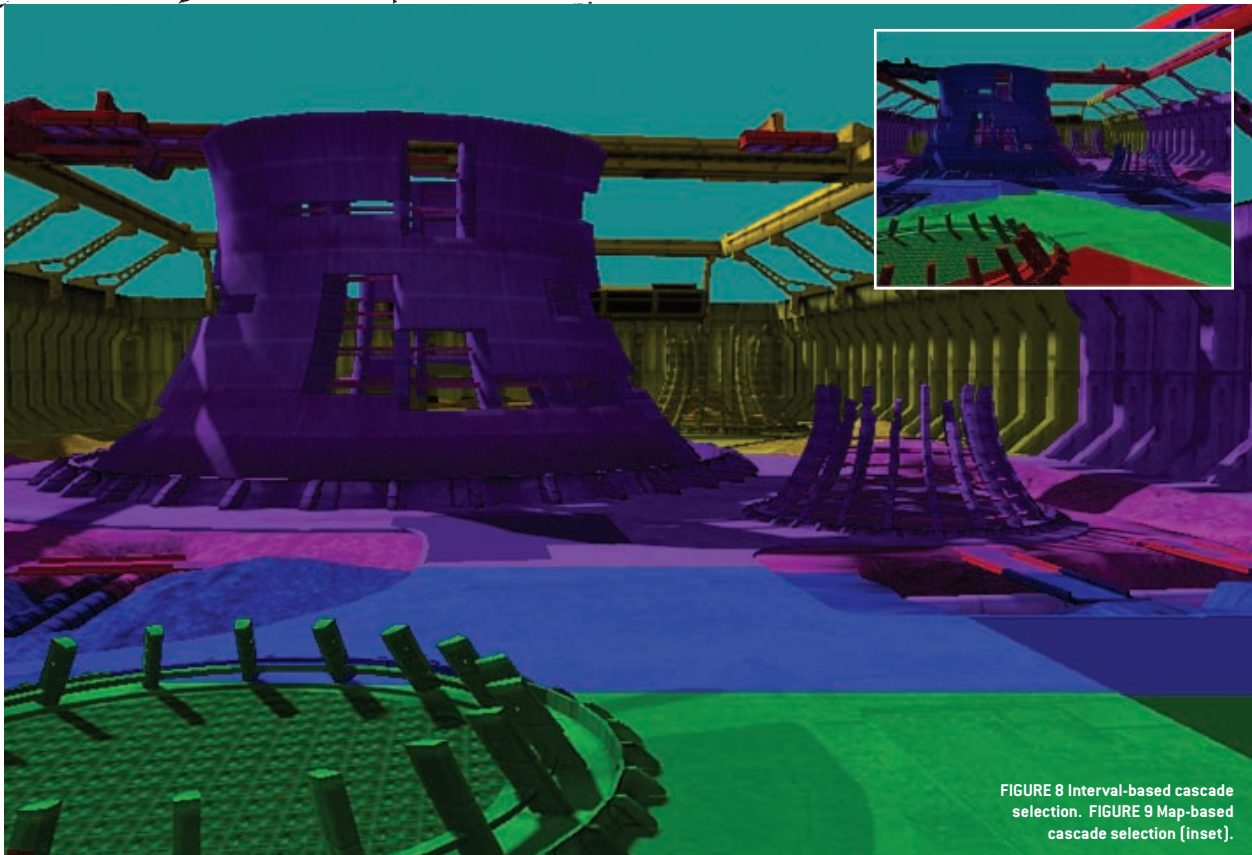


FIGURE 8 Interval-based cascade selection. FIGURE 9 Map-based cascade selection (inset).

CALCULATING A VIEW-FRUSTUM BOUND

¶ Once the frustum intervals are selected, the sub-frusta are created using one of two: fit to scene and fit to cascade.

Fit to Scene. All the frusta can be created with the same near plane. This forces the cascades to overlap (left in Figure 7).

Fit to Cascade. Alternatively, frusta can be created with the actual partition interval being used as near and far planes. This causes a tighter fit, but degenerates to “fit to scene” in the case of dueling frusta (right in Figure 7).

“Fit to cascade” wastes less resolution. The problem with “fit to cascade” is that the orthographic projection grows and shrinks based on the orientation of the view frustum. When the frustum grows and shrinks the silhouettes of objects can shimmer. The technique to combat shimmering edges given later in this article will not be as effective if the size of the shadow projection changes. The “fit to scene” technique pads the orthographic projection by the max size of the view frustum removing the artifacts that appear when the view-camera moves.

RENDER THE SHADOW MAP

¶ When I wrote my version of CSMS, I rendered the shadow maps into one large buffer to create a texture atlas. This is because PCF on texture arrays is a Direct3D 10.1 feature. For every cascade, a viewport is created that covers the section of the depth buffer corresponding to that cascade. A null pixel shader is bound because only the depth is needed. Finally, the correct viewport and shadow matrix are set for each cascade as the depth maps are rendered one at a time into the main shadow buffer.

RENDER THE SCENE

¶ The buffer containing the shadows is now bound to the pixel shader. There are two methods for selecting the cascade. These two methods are explained with shader code.

INTERVAL-BASED CASCADE SELECTION

¶ In interval-based selection (see Figure 8), the vertex shader computes the position in world-space of the vertex:

```
Output.vDepth = mul( Input.vPosition, m_mWorldView ).z;
```

The pixel shader receives the interpolated depth:

```
fCurrentPixelDepth = Input.vDepth;
```

Interval-based cascade selection uses a vector comparison and a dot product to determine the correct cascade. The `CASCADE_COUNT_FLAG` specifies the number of cascades. The `m_fCascadeFrustumsEyeSpaceDepths_`



FIGURE 10 Cascade seams. A visible seam can be seen where cascades overlap (left). When the cascades are blended between no seam occurs (right).

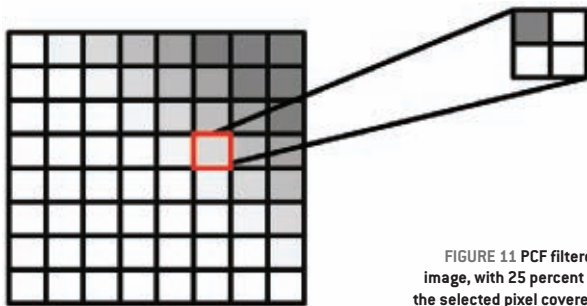


FIGURE 11 PCF filtered image, with 25 percent of the selected pixel covered.

data constrains the view frustum partitions. After the comparison the `fComparison` contains a value of 1 where the current pixel is larger than the barrier, and a value of 0 when the current cascade is smaller. A dot product sums these values into an array index, as below.

```
float4 vCurrentPixelDepth = Input.vDepth;
float4 fComparison = ( vCurrentPixelDepth > m_
fCascadeFrustumsEyeSpaceDepths_data[0] );
float fIndex = dot(
    float4( CASCADE_COUNT_FLAG > 0,
           CASCADE_COUNT_FLAG > 1,
           CASCADE_COUNT_FLAG > 2,
           CASCADE_COUNT_FLAG > 3 )
    , fComparison );
```

```
fIndex = min( fIndex, CASCADE_COUNT_FLAG );
iCurrentCascadeIndex = (int)fIndex;
```

Once the cascade is selected, the texture coordinate must be transformed to the correct cascade:

```
vShadowTexCoord = mul( InterpolatedPosition, m_
mShadow[iCascadeIndex] );
```

This texture coordinate is then used to sample the texture with the X-coordinate and the Y-coordinate. The Z-coordinate is used to do the final depth comparison.

MAP-BASED CASCADE SELECTION

¶ Map-based selection (see Figure 9) tests against the four sides of the cascades to find the tightest map that covers the specific pixel. Instead of calculating the position in world space, the vertex shader calculates the view-space position for every cascade. The pixel shader iterates over the cascades in order to scale and shift the texture coordinates so they index the current cascade. The texture coordinate is then tested against the texture bounds. When the X and Y values of the texture coordinate fall inside a cascade, they are used to sample the texture. The Z-coordinate is used to do the final depth comparison.

INTERVAL-BASED SELECTION VS. MAP-BASED SELECTION

¶ Interval based selection is slightly faster than map-based selection because the cascade selection can be done directly. Map-based selection must intersect the texture coordinate with the cascade bounds.

Map-based selection more efficiently uses the cascade when shadow maps do not align perfectly (as shown in Figure 9).

BLEND BETWEEN CASCADES

¶ VSMs (discussed later in this paper) and filtering techniques such as PCF can be used with low-resolution CSMs to produce soft shadows. Unfortunately, this results in a visible seam (see Figure 10) between cascade layers, because the resolution does not match. The solution is to create a band between shadow maps where the shadow test is performed for both cascades. The shader then linearly interpolates between the two values based on the pixel's location in the blend band. The shader performs a dynamic branch so that the vast majority of pixels only read from the current cascade.

2 /// YOUR SHADOWS HAVE HARD EDGES

PERCENTAGE CLOSER FILTERING (PCF)

¶ Filtering ordinary shadow maps does not produce soft, blurred shadows. The filtering hardware blurs the depth values, and then compares those blurred values to the light space texel. The hard edge resulting from the pass/fail test still exists. Blurring shadow maps only serves to erroneously move the hard edge, while PCF enables filtering on shadow maps. The general idea of PCF is to calculate a percentage of the pixel in shadow based on the number of subsamples that pass the depth test over the total number of subsamples.

Direct3D 10 and Direct3D 11 hardware can perform PCF. The input to a PCF sampler consists of the texture-coordinate and a comparison depth value. For simplicity's sake, PCF is explained with a four-tap filter. The texture sampler reads the texture four times, similar to how a standard filter would. However, the returned result is a percentage of the pixels that passed the depth test. Figure 11 shows how a pixel that passes one of the four depth tests is 25 percent in shadow. The actual value returned is a linear interpolation based on the subtexel coordinates of the texture reads, which produces a smooth gradient. Without this linear interpolation, the four-tap PCF would only be able to return five values: { 0.0, 0.25, 0.5, 0.75, 1.0 }.

It is also possible to do PCF without hardware support or extend PCF to larger kernels. Some techniques even sample with a weighted kernel. To do this, create a kernel (such as a Gaussian) for an $N \times N$ grid. The weights must add up to 1. The texture is then sampled N^2 times. Each sample is scaled by the corresponding weights in the kernel. The CascadedShadowMaps11 sample in Direct 3D uses this approach.

In the May 2010 Inner Product column "Plane-Based Depth Bias For Percentage Closer Filtering" I outlined a technique for computing a custom offset for large PCF kernels. This is necessary because it's not actually correct to compare neighboring pixels in the depth map (light-space) to the current pixel in view space.

VARIANCE SHADOW MAPS

¶ VSMs (see Variance shadow maps in Resources for more information) enable direct shadow map filtering. When using VSMs, all the power of the texture-filtering hardware can be used, as can trilinear and anisotropic filtering (see Figure 12). Additionally, VSMs can be blurred directly through convolution. VSMs do have some drawbacks; two channels of depth data must be stored (depth and depth-squared), and when shadows overlap, light-bleeding is common. Still, they work well with lower resolutions and can be combined with CSMs.

ALGORITHM DETAILS

¶ VSMs work by rendering the depth and the depth squared to a 2-channel shadow map. This two-channel shadow map can then be blurred and filtered just like a normal texture. The algorithm then uses Chebyshev's Inequality in the pixel shader to estimate the fraction of pixel area that would pass the depth test.

L I G H T

The pixel shader fetches the depth and depth-squared values:

```
float fAvgZ = mapDepth.x; // Filtered z
float fAvgZ2 = mapDepth.y; // Filtered z-squared
```

The Depth comparison is performed:

```
if ( fDepth <= fAvgZ )
{
    fPercentLit = 1;
}
```

If the depth comparison fails, the percentage of the pixel that is lit is estimated. Variance is calculated as *average-of-squares* minus *square-of-average*:

```
float variance = ( fAvgZ2 ) - ( fAvgZ * fAvgZ );
variance = min( 1.0f, max( 0.0f, variance + 0.00001f ) );
```

The `fPercentLit` value is estimated with Chebychev's Inequality:

```
float mean = fAvgZ;
float d = fDepth - mean;
float fPercentLit = variance / ( variance + d*d );
```

LIGHT BLEEDING

¶ The biggest drawback to VSMS is light bleeding (see Figure 13). Light bleeding occurs when multiple shadow casters occlude each other along edges. VSMS shade the edges of shadows based on depth disparities. When shadows overlap each other, a depth disparity exists in the center of a region that should be shadowed. This is a flaw in the VSM algorithm.

A partial solution to the light bleeding problem is to raise the `fPercentLit` to a power. This has the effect of dampening the blur, which can cause artifacts where depth disparity is small. Sometimes there exists a magical value that alleviates the problem:

```
fPercentLit = pow( p_max, MAGIC_NUMBER );
```

An alternative to raising the percent lit to a power is to avoid configurations where shadows overlap. Even highly-tuned shadow configurations have several constraints on light, camera, and geometry. Light bleeding is also lessened by using higher resolution textures.

Layered variance shadow maps (LVSMs) solve the problem at the expense of breaking the frustum into layers that are parallel to the light. The number of maps would be quite large when CSMS are also being used.

Additionally, Andrew Lauritzen, co-author of the paper on VSMS and author of a paper on LVSMs, has discussed combining exponential shadow maps (ESMs) with VSMS to counteract light bleeding, which you can find in Resources.

GRADIENTS WITH CSMS

¶ The combination of filtering and CSMS is fairly straightforward. However, it's fairly easy to accidentally introduce gradients within flow control. This can introduce a seam between the border of the cascade that cannot be filtered out (see Figure 14). Once in my own code, I had turned on anisotropic filtering with VSMS. The sample-anisotropic instruction has a built in derivative. The pixels in the quad along the seam were following different branches in the shader, and the derivatives calculated by the GPU hardware were invalid. This gave me a jagged seam along the shadow map.

The solution to this problem is to compute the derivatives on the position in light-view space; the light-view space coordinate is not

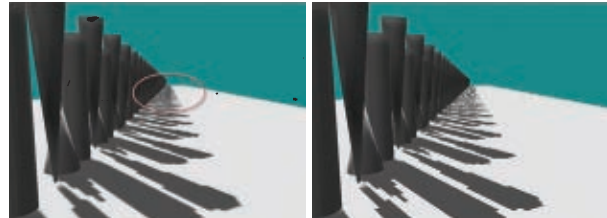


FIGURE 12 Anisotropic-filtering.



FIGURE 13 VSM light bleeding.



FIGURE 14 Seams on cascade borders due to anisotropic filtering with divergent flow control.

specific to the selected cascade. The computed derivatives can be scaled by the scale portion of the projection-texture matrix to the correct mip map level, as below.

```
float3 vShadowTexCoordDDX = ddx(vShadowMapTextureCoordViewSpace );
vShadowTexCoordDDX *= m_vCascadeScale[iCascade].xyz;
float3 vShadowTexCoordDDY = ddy(vShadowMapTextureCoordViewSpace );
vShadowTexCoordDDY *= m_vCascadeScale[iCascade].xyz;
```

```
mapDepth += g_txShadow.SampleGrad( g_samShadow,
vShadowTexCoord.xyz,
vShadowTexCoordDDX, vShadowTexCoordDDY);
```

VSMS COMPARED TO STANDARD SHADOWS WITH PCF

¶ Both VSMS and PCF attempt to approximate the fraction of pixel area that would pass the depth test. VSMS work with filtering hardware and can be blurred with separable kernels. Separable convolution kernels are considerably cheaper to implement than a full kernel. Additionally, VSMS compare one light-space depth against one value in the light-space depth map. This means that VSMS do not have the same offset problems as PCF. Technically, VSMS are sampling depth over a greater area, as well as performing a statistical analysis. This is less precise than PCF. In practice, VSMS do a very good job of blending, which results in less offset being necessary. As described above, the number one drawback to VSMS is light-bleeding.

VSMS and PCF represent a trade-off between GPU compute power and GPU texture bandwidth. VSMS require more math to be performed to calculate the variance. PCF requires more texture memory bandwidth, and

large PCF kernels can quickly become bottle necked by texture bandwidth. With GPU computational power growing more rapidly than GPU bandwidth, VSMs are becoming the more practical of the two algorithms. VSMs also look better with lower resolution shadow maps due to blending and filtering.

3 /// YOUR SHADOWS SHIMMER AND SHAKE WHEN ANYTHING MOVES

MOVING THE LIGHT IN TEXEL-SIZED INCREMENTS

¶ A common artifact in shadow maps is the shimmering edge effect. As the camera moves, the pixels along the shadows' edges brighten and darken. This is hard to demonstrate with still images, but is very noticeable and distracting in real time. Figure 15 highlights this problem and Figure 16 shows how the shadow edges should look.

The shimmering edge error occurs because the light projection matrix is being recalculated every time the camera moves. This creates subtle differences in the generated shadow maps. All the following factors can influence the matrix created to bound the scene.

- Size of the view frustum
- Orientation of the view frustum
- Location of the light
- Location of the camera

Every time this matrix changes, the shadows edges could change.

The pixels along the border of the shadow come in and out of shadow as the camera moves from left to right (Figure 15).

The shadow edges stay constant as the camera moves from left to right (Figure 16).

For directional lights, the solution to this problem is to round the minimum/maximum value in X and Y (that make up the orthographic projection bounds) to pixel size increments. This can be done with a divide operation, a floor operation, and a multiply:

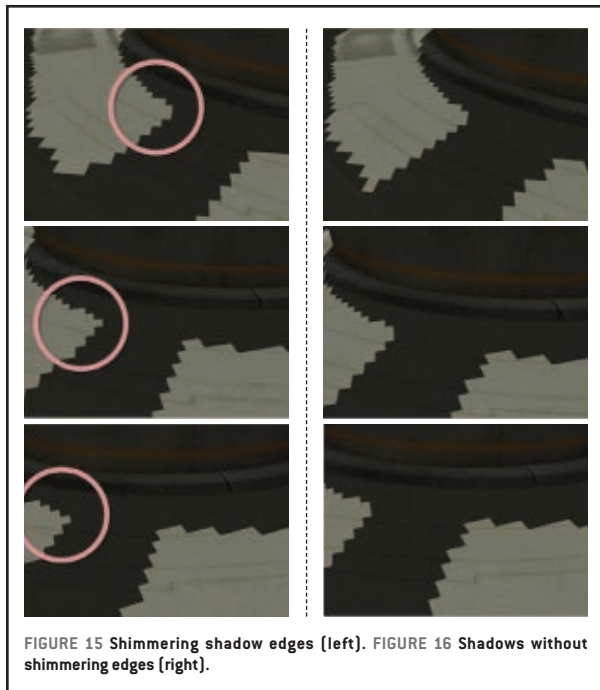


FIGURE 15 Shimmering shadow edges (left). FIGURE 16 Shadows without shimmering edges (right).

```
vLightCameraOrthographicMin /= vWorldUnitsPerTexel;
vLightCameraOrthographicMin = XMVectorFloor(
vLightCameraOrthographicMin );
vLightCameraOrthographicMin *= vWorldUnitsPerTexel;
vLightCameraOrthographicMax /= vWorldUnitsPerTexel;
vLightCameraOrthographicMax = XMVectorFloor(
vLightCameraOrthographicMax );
vLightCameraOrthographicMax *= vWorldUnitsPerTexel;
```

The vWorldUnitsPerTexel value is calculated by taking a bound of the view frustum, and dividing by the buffer size:

```
FLOAT fWorldUnitsPerTexel = fCascadeBound /
```

```
(float)m_CopyOfCascadeConfig.m_iBufferSize;
vWorldUnitsPerTexel = XMVECTORSET( fWorldUnitsPerTexel,
fWorldUnitsPerTexel,
0.0f, 0.0f );
```

Bounding the maximum size of the view frustum results in a looser fit for the orthographic projection.

It's important to note that the texture is 1 pixel larger in width and height when using this technique. This keeps shadow coordinates from indexing outside of the shadow map.

4 /// YOUR ATTEMPTS TO FIX SHADOW ACNE RESULTS IN PETER PANNING

Shadow acne (see Figure 17), a term synonymous with erroneous self-shadowing, occurs when the shadow map quantizes the depth over an entire texel. When the shader compares an actual depth against this value, it is as likely to be self-shadowed as it is to be unshadowed.

Another reason for shadow acne is that the texel in light space is so close to the depth of the corresponding texel in the depth map that precision errors cause the depth test to erroneously fail. One reason for this precision difference is that the depth map was calculated by the fixed-function rasterization hardware, while the depth being compared was computed by the shader. Projective aliasing can also look like shadow acne.

As shown in the left image in Figure 17, some of pixels failed the depth test and created speckled artifacts and moiré patterns. In order to reduce erroneous self-shadowing, the bounds on the near plane and the far plane for the light space view frustum should be calculated as tightly as possible. The slope scale-based depth bias and other types of bias are other solutions used to mitigate shadow acne.

PETER PANNING

¶ The term Peter Panning derives its name from the famous children's book character whose shadow became detached and could fly. This artifact makes objects with missing shadows appear to be detached from and to float above the surface (see Figure 18).

One technique for removing surface acne is to add some value to pixel position in light space; this is called adding a depth offset. Peter Panning results when the depth offset used is too large. In this case the depth offset causes the depth test to erroneously pass. Like shadow acne, Peter Panning is aggravated when there is insufficient precision in the depth buffer. Calculating tight near planes and far planes also helps avoid Peter Panning.

SHADOW MAP-FRIENDLY GEOMETRY

¶ Creating geometry that works well in shadow maps allows for more flexibility when combating artifacts like Peter Panning and shadow acne.

L I G H T

Hard edges are problematic for self-shadowing. The depth disparity near the tip of the edge is very small. Even a small offset can cause objects to lose their shadows (see Figure 19).

It might be tempting to model a door or a wall with a single polygon but this will almost certainly cause some peter panning near the base of the wall. Narrow objects such as walls should have volume. This will increase the depth disparity.

It's also very important to make sure that the direction the geometry is facing is correct; that is, the outside of an object should be back facing and the inside of an object should be front facing. This is important for rendering with back face culling enabled, as well as for combating the effects of depth bias.

SLOPE-SCALE DEPTH BIAS

¶ As previously mentioned, self-shadowing can lead to shadow acne. Adding too much bias can result in Peter Panning. Additionally, polygons with steep slopes (relative to the light) suffer more from projective aliasing than polygons with shallow slopes (relative to the light). Because of this, each depth map value may need a different offset depending on the polygon's slope relative to the light.

Graphics hardware has the ability to bias a polygon based on its slope with respect to the view direction. This has the effect of applying a large bias to a polygon that is viewed edge-on to the light direction, but not applying any bias to a polygon facing the light directly. Figure 20 illustrates how two neighboring pixels can alternate between shadowed and unshadowed when testing against the same unbiased slope. Due to the hardware's discretization of a continuous surface into a single depth, each pixel has 50:50 odds of erroneously being self-shadowed.

CALCULATING A TIGHT PROJECTION

¶ Correctly fitting the light's projection around the viewable scene is one of the most valuable things you can do for a title's shadow maps. This technique could easily go in section 1, because it is one of the best things you can do to increase the shadow map coverage and mitigate perspective aliasing. It's given here because setting the light camera's near and far plane tightly around the scene's geometry will increase the relative amount of precision and mitigate all bias related artifacts. Figure 21 illustrates that using a non-optimally fit projection results in more perspective aliasing.

The view in Figure 21 is from the POV of the light. The trapezoid represents the view camera's frustum. The grid drawn over the image represents the shadow map. The image on the right shows that the same resolution shadow map creates more texel coverage when it is fit more tightly to the scene.

Figure 22 illustrates frustums that are correctly fit. To calculate the projection, the eight points that make up the view frustum are transformed into light space. Next, the minimum and maximum values in X and Y are found. These values make up the bounds for an orthographic projection.

It is also possible to clip the frustum to the scene AABB to get a tighter bound. I would not advise this in all cases because the technique can change the size of the light camera's projection from frame to frame. Many techniques, such as those described in the section "Moving the Light in Texel-Sized Increments," give better results when the size of the light's projection remains constant in every frame.

CALCULATING THE NEAR PLANE AND FAR PLANE

¶ The near plane and far plane are the final pieces required to calculate the projection matrix. The more closely together the planes are, the more precise the values in the depth buffer.

The depth buffer can be 16-bit, 24-bit, or 32-bit, with values between 0 and 1. Generally, depth buffers are fixed point, with the values close to the near plane grouped more closely together than the values close

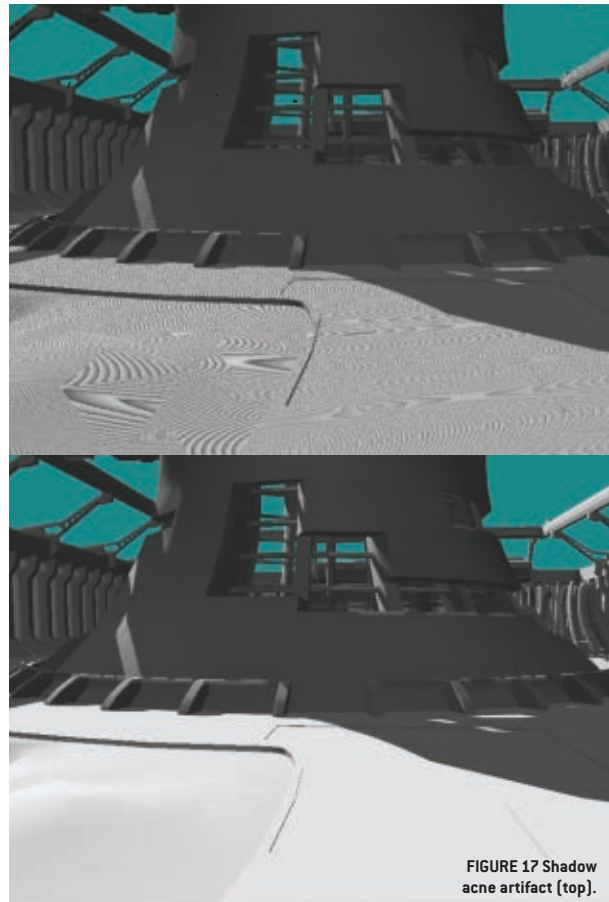


FIGURE 17 Shadow acne artifact (top).



FIGURE 18 A Peter Panning artifact. In the image at left, the shadow is detached from the object, creating a floating effect.



FIGURE 19 Sharp edges cause artifacts stemming from low-depth disparity with offsets.

to the far plane. The degree of precision available to the depth buffer is determined by the ratio of the near plane to the far plane. Using the tightest possible near/far plane could allow use of a 16-bit depth buffer. A 16-bit depth buffer could reduce the use of memory while increasing processing speed.

NO DARKNESS WITH

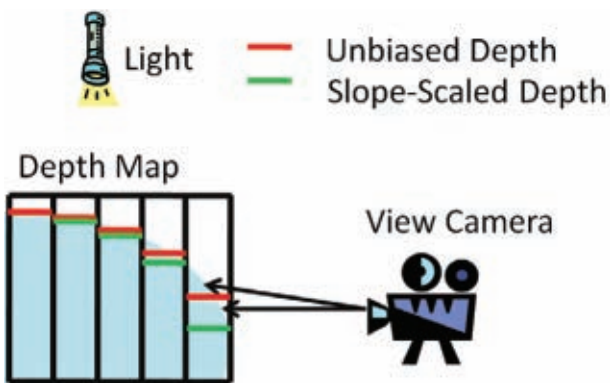


FIGURE 20 Slope scaled depth-bias compared to unbiased depth.

AABB-BASED NEAR PLANE AND FAR PLANE

¶ An easy and naive way to calculate the near plane and far plane is to transform the scene's bounding volume into light space. The smallest Z-coordinate value is the near plane and the largest Z-coordinate value is the far plane. For many configurations of the scene and light, this approach is sufficient. The worst case scenario, however, can result in a significant loss of precision in the depth buffer; Figure 23 shows such a scenario. Here, the range of the near plane to the far plane is four times larger than necessary.

The view frustum in Figure 23 was purposely chosen to be small. A small view frustum is shown in a very large scene consisting of pillars extending out from the view camera. Using the Scene AABB for the near and far planes is not optimal. The CSM algorithm described in the Cascaded Shadow Maps white paper must calculate near and far planes for very small frustums [see Resources].

FRUSTUM-BASED NEAR PLANE AND FAR PLANE

¶ Another technique for calculating the near and far planes is to transform the frustum into light space and use the minimal and maximal values in Z as the near and the far planes, respectively. Figure 24 illustrates the two flaws of this approach. First, the calculation is too conservative, as shown when the frustum extends beyond the scene's geometry. Second, the near plane could be too tight, causing shadow casters to be cropped.

LIGHT FRUSTUM INTERSECTED WITH SCENE TO CALCULATE NEAR AND FAR PLANES

¶ The proper way to calculate the near and far planes is shown in Figure 25. Four of the planes of the orthographic light frustum were calculated using the minimum and maximum of the X and Y coordinates of the view frustum in light space. The last two planes of the orthogonal view frustum are the near and the far planes. To find these planes, the scene's bounds are clipped against the four known light frustum planes. The smallest and largest Z-values from the newly clipped boundary represent the near plane and far plane, respectively.

The code that performs this operation is located in the CascadedShadowMaps11 sample. The eight points that make up the

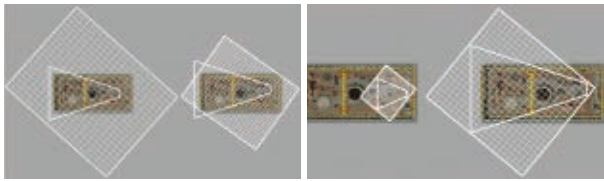


FIGURE 21 Arbitrary shadow frustum and shadow frustum fit to scene (left).
FIGURE 22 Shadow projection fit to view frustum (right).

world's AABB are transformed into light space. Transforming the points into light space simplifies the clipping tests. The four known planes of the light frustum can now be represented as lines. The scene's bounding volume in light space can be represented as six quadrilaterals. These 6 quadrilaterals can then be turned into 12 triangles for triangle-based clipping. The triangles are clipped against the known planes of the view frustum [these are horizontal and vertical lines in X and Y in light space]. When an intersection point is found in X and Y, the 3D triangle is clipped at that point. The minimum and maximum Z-values of all the clipped triangles are the near plane and far plane. The CascadedShadowMaps11 sample shows how to perform this clipping in the ComputeNearAndFar function.

There are two more techniques that could be used to calculate the tightest possible near and far planes. These techniques are not shown in the CascadedShadowMaps sample.

1. Even tighter near and far planes could be calculated by intersecting a hierarchy of a scene or individual objects in a scene against the light frustum. This would be computationally more complex.
2. The far plane could be calculated by taking the minimum of:
 - a. The largest depth of the view frustum in light space.
 - b. The largest depth of the intersection of the view frustum and the scene AABB.

This approach can be problematic when used with cascaded shadow maps. In the cascaded shadow map it is possible to index outside of a view frustum. In this case the shadow map might be missing geometry.

PANCAKING

¶ Pancaking is a technique that allows the near plane to be set all the way up to the camera's view frustum. When the scene is rendered, any geometry that would be clipped is instead moved to the near plane. This can be accomplished by turning off near plan clipping. Another technique would involve a custom geometry shader that did its own clipping. Moving the geometry to the near plane does not cause any problems because the depth test is a binary comparison.

The light frustum's near plane should be set to whichever gives a tighter bound: the near plane of the view frustum—or for large view frustums the intersection of the light frustum and the scene's bounding volume.

5 /// NOW YOU'VE BLOWN YOUR GPU BUDGET FOR SHADOWS

It's advisable to have a budget for each frame. Then timing markers can be inserted to log whenever you've gone over some features budget.

BACK FACE AND FRONT FACE

¶ Shadow maps should be rendered with standard back-face culling, a process that skips rasterization of objects that cannot be seen by the viewer, and speeds up rendering of the scene. Another option commonly seen is to render shadow maps with front-face culling enabled, which means that objects facing the viewer are eliminated. The argument for this is that it helps with self-shadowing, as the geometry making up the back of objects is slightly offset. There are two problems with this idea.

First, any object with improper front-face or back-face geometry causes artifacts in the shadow map. However, having incorrect front-face or back-face geometry will cause other problems, so it may be safe to assume front-face and back-face geometry is done correctly. It may be impractical to create back faces for sprite-based geometry such as foliage.

L I G H T

Second, Peter Panning and shadow gaps near the base of objects such as walls are more likely to occur because the shadow depth disparity is too small.

IS YOUR SHADOW MAP ACTUALLY TOO HIGH-RES?

¶ The first reaction to perspective aliasing is to see if there's budget to increase the shadow map size. It can sometimes be much easier to increase the shadow map to some huge number like 2k by 2k than it is to implement a cascaded shadow map solution. The problem with this is that you've got way too much resolution for those objects that are out in the distance. The GPU is going to be reading a chunk of shadow maps, and many of the threads are going to have to be swapped out because they can't share the cache. They're sampling too far apart from each other. Different architectures have different amounts of thread storage and cache available for these hard scenarios.

Low-resolution variance shadow maps can be blurred with a 2 pass separable convolution. A 256 x 256 variance shadow map can look surprisingly nice.

MIP MAPPED SHADOW MAPS

¶ The best solution to this problem is to use cascaded shadow maps, because CSMs also mitigate perspective aliasing. Another solution for shadow maps that are blowing the GPU's cache is to create your own mip-maps each frame for the shadow map. Each texel in the mip map should be created as a maximum of the 4 texels it covers. Blurring or averaging a depth map doesn't make sense.

The Get level instruction is then used to find out what LOD in the depth map the Quad of pixels would index into. The depth map is sampled with that level.

DEFERRED SHADOWS

¶ One of the more expensive parts shadow mapping is the filtering that must be performed. However, it only really matters for the edges of shadows. When pixels that are not on the edge of the shadow are filtered, a lot of needless work is being performed. The idea of deferred shadows is to render from the point of view of the view camera and simply write out "true" if the object is in shadow, or "false" when the object is not in shadow. This map is then bound as input for the final render. First sample the mask with filtering turned on. If anything other than all-white or all-black is sampled, run the expensive filtering such as PCF with a larger kernel.

The mask can be created at a lower resolution but fine details, such as shadows from chain link fences, will be lost. ¶

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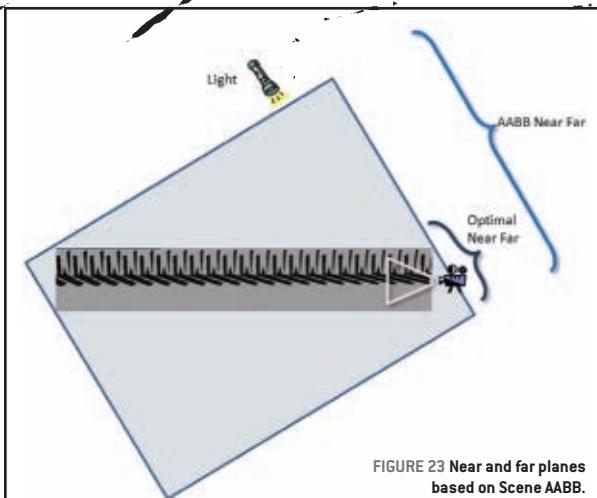


FIGURE 23 Near and far planes based on Scene AABB.

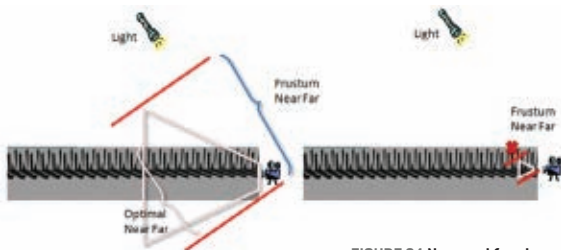


FIGURE 24 Near and far planes based solely on view frustum.

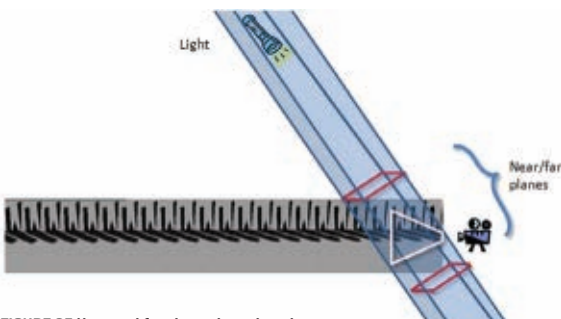


FIGURE 25 Near and far planes based on the intersection of the four calculated planes of the light frustum are shown, along with the scene's bounding geometry.

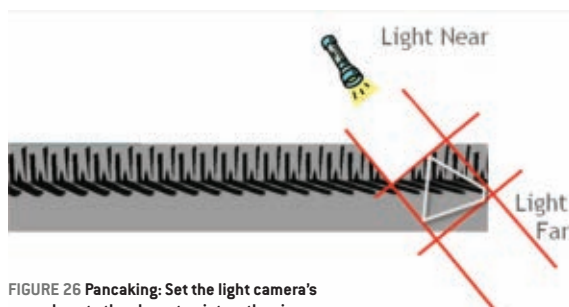


FIGURE 26 Pancaking: Set the light camera's near plane to the closest point on the view frustum. Next, flatten all the geometry that would be clipped.



SHATTER

/// Quebec City-based Beenox was founded in the year 2000 by a team of young guys with a passion for video games. We initially started off as a porting house, but after a few projects, the team invested a portion of its profits into developing a game engine and the tools to go with it.

In 2005 the studio was acquired by Activision, and we started thinking big. We wanted to start working on our own games and demonstrate to the world what we could do. We had everything we needed to get started: an engine, tools, and passion! But one thing was missing ... a team! So we hired about 50 people in a short period of about six months, and were given our first complete development project: BEE MOVIE GAME. The development of that game was a good learning experience for the studio.

Today, Beenox employs more than 330 employees split between two divisions, game development and quality assurance. In the 10 years since its foundation, Beenox has grown to be the biggest video game studio in Quebec City.

When the *Spider-Man* license arrived at Beenox, it was a great opportunity for our team to demonstrate what we could do. This was our chance! From the beginning, our objective was to create the best *Spider-Man* game ever. To get there, we took a huge chance with SPIDER-MAN: SHATTERED DIMENSIONS by creating a game with four completely different visual and gameplay themes.

We definitely figured out quickly that creating a game with a character that can web swing everywhere and crawl on any surface is pretty challenging. It was also challenge to know that we were creating a game based on a superhero loved by millions of fans. But we do love a challenge!

SPIDER-MAN SHATTERED DIMENSIONS

P O S T M O R T E M

SPIDER-MAN UNRAVELED DIMENSIONS



PUBLISHER Activision
DEVELOPER Beenox
LENGTH OF DEVELOPMENT
18 months
RELEASE DATE
September 7, 2010
LINES OF CODE
Game Logic: 526,000
Engine: 438,000
Tools: 380,000
Shared: 53,000
DEVELOPMENT TOOLS
Internal tools, CRI
PLATFORMS
Xbox 360, PlayStation 3,
Wii, and PC

WHAT WENT RIGHT

1] PROTOTYPE PHASE. The prototype was developed first and foremost around the combat and navigation. Basically we established very clearly what we wanted to prototype and how to do it. The designers were assigned to very specific mechanics and we had trained as many micro teams as we had mechanics.

Each team was assigned a key game mechanic to prototype, such as the combat (which changed greatly along the way), the web swing and the web zip (we even had web zip onto moving objects), interaction with objects (lifting objects with webs), first person combat (which Activision had some doubts in terms of being relevant to our genre, but which proved to be very popular with the fans), and four different spider senses.

The day we reached the prototype milestone, all those mechanics were working pretty well. We had nailed down plenty of the core mechanics quickly. As a positive side effect to this process, developing this type of prototype in such a short period of time (ten weeks) gave us plenty of credibility with Activision.

2] FOUR STRONG VISUAL DIRECTIONS. From the beginning of the project, we wanted a game with four visual themes in order to differentiate the game, and provide players with the opportunity to get to know other *Spider-Man* worlds. We conducted research into the different universes that the license offered, and created mock-ups for the styles we had selected. These mock-ups were presented to the technology department and technical artists to determine whether we could reliably recreate these graphical styles with our engine.

Subsequently, the technical art director and his team developed “recipes” for each universe which the team used as their guide when working on each universe. To help keep the different styles as distinct as possible, most of our artists focused on a single style in order to make sure they would be experts in the universe they were working on. We ultimately went with *Ultimate Spider-Man*, *Amazing Spider-Man*, *Spider-Man 2099*, and *Spider-Man Noir*.

3] COMMUNICATION WITH ACTIVISION AND MARVEL. From the get-go, our relationship with Marvel went really well. They really liked the concept of

showcasing four different versions of Spider-Man, and collaborated really well with us on the story and the involvement of the current *Amazing Spider-Man* writer Dan Slott, the necessity of some cosmetic changes, and the choice of villains.

Regarding the villains, especially for a really recent series like *Spider-Man Noir*, it was nearly impossible to come up with three distinct villains from the recent comic books, so Marvel was really open when we asked to use Hammerhead—a classic gangster-looking bad guy from its *Amazing* universe. Marvel was also open when we wanted to update some characters





for the future, like Hobgoblin and Scorpion, or simply create a brand new villain for the universe. In fact, it was Marvel that proposed to go with a female version of Doctor Octopus 2099, which turned out to be a great idea.

As it turned out, they were also very open to the cosmetic changes we proposed for the characters. For example, in the *Spider-Man Noir* sections, the license holders agreed to our proposition of modeling our in-game character on a concept by Marko Djurdjevic, the artist behind the design of the character. In that version of the character, Spider-Man Noir wears a short leather vest instead of the trench coat that is seen in the comic books. Also, they gladly accepted the under-the-armpit redesign of the web-foils of Spidey 2099 that we proposed. We believe that this design allowed us to craft a much better looking sequence in the game when Spidey 2099 has to use his foils to control his freefall.

4) SOLID TECHNOLOGY. Our technology was developed internally with very minimal use of middleware (we only use middleware for movie playback). This meant we had total control, and became masters of our own destiny. We never found ourselves in a situation where we were depending on a third party to solve a problem, and there was no “black box” whose operation was unknown to us.

Early in the project we established an organized and efficient release process for our technology. Releases were made regularly (usually about once a week), and patches between releases allowed us to correct major problems quickly without waiting for the next weekly release. Release notes also facilitated good communication of changes and bug fixes, while internal testers in the technology department ensured the quality of the tools and engines that were provided to production.

In order to spread out more evenly the workload between the team’s members, we tried to widen their area of expertise. This allowed us to assign more people to certain platforms or modules when needed, and reduced the risk of bottlenecks due to small numbers of people being able to make critical changes.

Developing our four distinct visual styles was greatly facilitated by the versatility of internal technology. We always tried to maintain great flexibility and not integrate code that was specific to the game in the tools and engines.

5) CROSS PLATFORM. Proper execution of the unique SPIDER-MAN: SHATTERED DIMENSIONS visual development was related to the clear direction of techniques and technologies used in each of the universes. We also laid out a methodology, nomenclature, and workflow that was well established and clear from the beginning of the project.

Each universe had a predetermined formula and each had its own dedicated team. This let the team focus on a single artistic direction and keep to one single formula throughout the project.

We established the same criteria for the Wii version using very different techniques. When the 360 and PS3 versions were stable and a large percentage of the art assets were implemented, we

immediately embarked on conversion of the levels for Wii. Tools were created to clean up the shader levels that were unusable on Wii in two clicks, such as normal maps, specular maps, emissive maps, cube maps, and others. Once finished, each texture was processed independently by adding missing details from the normal map, then reducing their size for the constraints of memory and resolution on Wii. This process let us have very quick iterations on each console as graphics were converted in parallel throughout the project.

WHAT WENT WRONG

1) LEVEL DESIGN NOT PROTOTYPED SUFFICIENTLY.

With all the efforts we made for the combat and the enemies, we overlooked one essential element of the game experience: the level design. More specifically, we overlooked how Spidey should have responded in large environments, as well as in smaller ones. Yes, we had developed the web swing and the web zip in sandboxes, but we did not test these skills in different environments.

We had developed the level design on paper, and even had environments ready to integrate when we started full production, after the prototype. Bringing our combat mechanics into the game environments this way presented a fair amount of problems. For example, the sizes of combat zones versus the number of enemies were considered early enough. Our platforms were often too small, giving the impression that the levels were empty. It was easy to test and demonstrate the concept of web swing in a test environment, but when the time came to navigate anywhere, at all heights, it became very

SPIDER-MAN MASTERED DIMENSIONS

SPIDER-FACTS

/// While web-swinging, Spidey can reach a speed of about 100 mph.

/// There are 743 individual lines and grunts for Amazing Spider-Man, 792 for 2099, 758 for Noir, 826 for Ultimate, and 2 for Spider-Ham.

/// The Quick-Charge upgrade was initially a bug in the combat system, but ended up being featured in the proper game due to its widespread usage and approval by the team.

/// While playing the prison section in Carnage's level, if you are a keen observer, you might notice that Electro and Deadpool are cellmates.

/// In Deadpool's last fight, Deadpool's dolls forms a heart-shaped pattern, and at one point a Beenox logo pattern.

/// A big inflatable Spidey statue was bought early on the project, and was used as a mascot throughout development. We even gave him his own desk as some point, with a [fake] computer. In order to better blend in with Quebec City, his name was changed to the French-Canadian version of Peter Parker: Pierre Paquette.

/// The eagle on the S.H.I.E.L.D. logo faces left in the Amazing Universe, and right in the Ultimate Universe. Too bad we didn't notice that difference before the last month of development...

/// Hidden newspapers in the Vulture level capture funny moments from the game's development.

/// When we started working on the game, Scorpion 2099 hadn't been featured yet in the comic, so we used early sketches and guidelines from Marvel.

/// If you pause the game any time during Deadpool's level, he will break the fourth wall.

/// The moving trucks in Electro's level are an homage to *Maximum Overdrive*; in this movie, the possessed Western Star truck even had the face of the Green Goblin mounted on its front grill.



complicated. Furthermore, we worked long after the prototype to refine the web swing physics. When we had achieved a web swing that everyone was happy with, we realized that we needed to change many of our environments to take these changes into account.

2) FOCUSED ON ONE TYPE OF ENEMY FOR TOO LONG.

Over several months we developed enemies that we called "small." This was our base enemy type, our cannon fodder that could be used for all purposes. We also had plans for other enemies such as mediums, heavies and captains. All the other enemies in the game had to be derivatives of the "small" enemies' A.I. with some more attacks.

When the time came to make other enemies, we realized that the looks, sizes and roles of the other enemies were very different from the smalls, and thus we needed to create several new A.I. for all our enemies, which were not planned for in our original schedule.

3) YOUNG DESIGN TEAM ON A LARGE-SCALE GAME.

At Beenox, we historically have staffed our production teams with new graduates. This worked very well for us when we were a port house. We have a very comprehensive internal technical training program, and this four-to-eight-week training course allowed us to quickly develop autonomous programmers. We followed the same process with many of our designers as well, and thus had a very young team when we began development on SPIDER-MAN.

We had one creative director and one lead game designer managing the creative and artistic vision for the project. The lead game designer was in charge of level design and game design. When creating more "kid"-oriented titles, this structure was solid, but with the integration of four different universes and a license such as SPIDER-MAN, it was clearly inadequate for a game of this size and scope.

We underestimated the amount of work it would take to get the creative director and lead game designer

on the same page about the vision of the game, first of all. From there, this had to translate into overall game design, and then into individual level designs that were in line with that vision. Due to the time and effort it was taking these two people to manage a young team while also designing the game, we ran into situations where the direction was not always crystal clear to the entire staff. On top of this, we were certainly starting to feel the pressure of our deadlines and the weight of the importance of our high-profile brand.

This created some frustration for the team, but once we identified and realized what was going on we were able to course correct and bring everyone back to focusing on the initial vision. However, at times, the upper management of the studio had to jump in and work with us to get the team back on track.

4) CONSUMER EXPECTATION EXCEEDED INITIAL PRODUCTION PLAN.

Many of Spider-Man's movements in the final game were not part of our original plans. The more the project moved forward and the more buzz we received, the more we wanted to raise the quality bar. We began to realize the importance of this game not only for the brand but for Beenox as a studio as well. We therefore made the decision to polish and adjust a large number of gameplay elements in order to deliver the highest quality game possible in our allotted production schedule. However, we underestimated the polish time in our original schedule, so the team worked extremely hard to polish the game and deliver a game beyond our original internal expectations. The numerous changes we made near the end of the project required great effort from the team, and a very hectic and demanding crunch.

The differences between each Spider-Man were really limited at the beginning, but we quickly realized that because players were playing different looking Spideys, they were also expecting different moves. That was the trigger to start pushing the envelope for each Spidey: amazing web shapes, ghost trails for 2099, more possibilities for Noir and lots of tendrils

for Ultimate. Also, in the Noir level, we removed some player-detections related to noise; players had a hard time understanding why they were getting detected by enemies while making noise close to the gangsters. As a side note, user tests were really useful for data mining; we were able to improve balance using data we collected during tests, like health (heroes and enemies), collectibles, and upgrades.

5) SOUND DESIGN: THE FORGOTTEN TEAM. Along the chain of production, many design choices occur, and just as many changes are made, if not more. When delays happen at any stage in the process, the last team in the line of production is the one trapped against the deadline wall. This was the audio team on SHATTERED DIMENSIONS.

As the entire development team iterated on every aspect of the game simultaneously throughout development, nothing was ever really final until the very end. Hence it was impossible for the audio team to start working on anything with final quality in mind, and it was very hard to determine what portions of the game could be worked at what time, with minimum risk. Eventually, when everything in the game reached final quality simultaneously, the amount of cumulated audio work was just too much for the team to handle. Enemy behavior, music, voice-over and final cut scenes all came on line very late in the production process—just as bugs from QA were starting to come in.

Keeping the audio team in the loop and planning accordingly was not an issue at the start of the project or when a major change came up. The real issue was the little changes, those types of things that happen almost every day. These issues were simply not addressed and thus accumulated into large problems at the end. The multidisciplinary team dedicated to mechanics and level design was not aware enough of the impact their changes had on the teams that followed them down the production line, namely the audio and the visual effects teams. They were very rarely warned of what was happening, and the mechanics and level designers didn't realize that the extra time spent on a feature was, in reality, eating into the schedule of other teams.

We tried using an automated tool to notify the audio team that something had changed. The animators had an option called "Animation Time Changed" that they could enable when they submitted data directly to source control. This option would automatically send an email to the audio team.

Unfortunately, this function was pretty much forgotten by everyone. A detailed scan of all of the modified animation would have prevented the audio team from missing anything, but most of the changes didn't impact audio, and it was very time consuming to investigate each animation individually.

The audio team will continue to be impacted by other teams' delays, but going forward, we can help by getting them more involved earlier in the design process. We have to fight harder to keep the rest of the team aware of their reality, especially since due to the nature of sound design work - the audio team sits in closed, sound-proofed offices which end up separating them physically from the rest of the team.

PARKER! MY OFFICE! NOW!

Our journey with SPIDER-MAN wound up being yet another very good learning experience. Our design team structure has been drastically changed since this project. Instead of having just one lead designer for the entire project, we now have teams dedicated to game design, level design, and narration design. In addition, we changed our recruitment strategy and are working to complement our young staff with more experienced people.

Our production process has also evolved. We now have a much longer pre-production phase in order to make sure that all game design and level design mechanics are as close as possible to the expected result before going too far down the line with full production. Our level design process has now many layers of approvals before we begin work on any final environment layout.

Finally, the journey to developing SPIDER-MAN: SHATTERED DIMENSIONS has been definitely a great experience for our young team. As we said earlier, it felt like a huge privilege to be given such an important license to work with. This was our chance to make it! This huge challenge gathered the team together and really has been a team effort. We had so much fun as a team developing the game! Now a couple months later, with the game released and the critics very enthusiastic about our work, we're more motivated than ever to take on another challenge. 🎮

MARTIN RHEAUME is the executive producer at Beenox. He worked on BEE MOVIE GAME, MONSTERS VS ALIENS, and many conversion projects. He has previously been a 2D artist at A2M and a 3D and AI programmer.



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31

ERIC · JUN RÖSSEL TAIRNE

good games bad design

castlevania iii's disappointment wells

A CLOSE READING OF THE CLASSIC SIDE-SCROLLING CASTLEVANIA GAMES CAN BE AN INSTRUCTIVE LESSON IN LEVEL DESIGN. BECAUSE THE SERIES' ACTUAL PLAY MECHANICS ARE LARGELY PROVEN, WITH ONLY MINOR TWEAKS TO THE WELL-ESTABLISHED TRUDGE-JUMP-KNEEL-WHIP SCREEN-TRAVERSAL FORMULA, WE HAVE A UNIQUE OPPORTUNITY, FREE FROM GAMEPLAY CONSIDERATIONS, TO EXPLORE THE EFFECTS OF LEVEL ENVIRONMENT ON PLAYER ENGAGEMENT.

There are two basic ways that video games communicate ideas: through the actions allowed the player, and through the environment on which the player may act. The player's every action changes the player's immediate relationship with the environment, which in turn shapes the player's potential for action. Let's say you shoot an asteroid. Although the immediate obstacle is gone, now you've several smaller rocks to deal with, moving faster and in different trajectories.

The more you do, and the more feedback the game gives you, the more you adapt your behavior. When an action results in success or a reward, you tend to repeat it. When you get an unpleasant result, you tend to avoid repeating yourself.





FIGURE 1 The staircase structure in on the right has little significance.

A successful game environment does four things:

- > it teaches about the player's relationship with the environment;
- > in doing so, it directs and focuses the player's behavior;
- > generally it obscures this manipulation from the player; and so
- > through the invoked behavior, it evokes in the player a certain mood or mindset.

If the player doesn't know why he picks the routes and actions he does, yet in picking those routes and actions he comes to adopt the intended perspective, you have successfully communicated. Think of all the moments in HALF-LIFE 2 where you think you're being clever under pressure, but you're actually choosing the only possible path; or how THE LEGEND OF ZELDA keeps you on track by making the woods scary and dangerous, so that you will tend to leave them until you're stronger and more experienced.

Is level design everything? Only if your game has something to say. If you're retreading old ground, and you expect the audience knows the routine, then you can toss them any old nonsense. Of course, then few of the player's actions will have real consequence, so the game will feel unresponsive and dull. Still, maybe if you add some flashy features or cutscenes you can distract the player for a while. If you're afraid of putting people off, you can patronize them with elaborate tutorials.

There's no fooling the outsiders, though. If your game fails to communicate on its own merits, then no one besides the fans will bother with it. And even within that audience, the conversation will narrow and turn from big, nourishing ideas to minutiae—as if the differences between one leveling system and the next really matters in themselves. This heads-down view leads us away from meaningful representation and toward thoughtless copying and repetition, abstracted and regimented genres, fractured markets, and eventually a whole medium that is impenetrable to outside eyes.



FIGURE 2 The empty space on the lower right is an example of a "disappointment well."

As in any human endeavor, sloppy or thoughtless design is perhaps more the rule than the exception. And that's fair enough, when that design is a part of a lousy game that no one is likely to take seriously. More worrisome are the otherwise good, solid games that a student of design may well look to for inspiration. Games don't have much of a critical history; their culture treats anything "good" as a model of perfection that everything new should strive to imitate down to the pixel. It's hard to break out of that mindset, and to look at design in terms of problems and solutions.

A solution, of course, only makes sense in context. In a game, each mechanism serves to illustrate to the player some concept, or to solve a logistical problem in the game's premise. Anything that serves neither of these purposes is extraneous—and the key to communication is if you don't need it, cut it out. It is in this spirit that some case models may be illustrative.

DRACULA'S CURSE

/// The first NES CASTLEVANIA is groundbreaking, rhythmic, and intricately designed. The second is a radical departure, expanded from the first game's themes but structured unlike anything before or since. CASTLEVANIA III is exactly like the first, except enormous. The game's purpose is to take up as much space as possible, so as to give the player a sense of grandeur. The trade-off is that from moment to moment, there isn't much attention to detail or flow, leading the player to waste time a) maneuvering between points of interest, b) exploring false leads, and c) replaying poorly balanced sequences.

Unlike either of its predecessors, there is little reward for being observant and exploring, and the game lacks those little reward beats and clear direction that builds momentum. The architecture is full of empty spaces, meaningless flourishes, and padding. Creatures are tossed around with little thought as to placement. The branching paths and multiple characters are new, but compared to the focused, driving architecture of the original CASTLEVANIA, there is little psychology to the design. So those ideas go to waste, as the game never clearly builds on them.

Let's break down the first level. Over about 21 screens, it meanders through a courtyard, up a ruined abbey, along a wall, down past a ghost town, and into a cemetery. The level divides into four blocks, each separated by a door; each block might consist of one-to-four horizontally or vertically scrolling areas, each area about three screens in size. We begin as our protagonist Trevor rises from prayer at an ornate shrine.

LEVEL 1-01

/// You walk to the right; what does the staircase structure signify? There is no compulsion or benefit to climb it. It does little to pace the level. The architecture is functionally dead, and yet appears to be the only feature of this room [see Figure 1]. When you've passed it, the room is over. What, if anything, have we learned of the game's controls, themes, premise, pacing, or atmosphere?



good games bad design

Instead: remember the staircase in level one of the original CASTLEVANIA? It was a branching choice: stay on the ground with the endless zombies, or climb up and take your chances with less predictable enemies. Maybe earn a reward in the process. Considering that CASTLEVANIA III is supposed to be all about branching paths, here's a missed opportunity to establish that right out of the gate.

LEVEL 1-02

/// So having learned nothing, you move on to the second room to find two lethargic skeletons and a double staircase, with a small platform at the kink. At the top of that staircase is a larger platform, with another staircase exiting the top of the screen.

Presumably, this screen serves to teach the player about stairs, in case the previous room was too vague. You can't get anywhere by jumping, so you need to find another route. Yet the actual arrangement is careless.

The screen is mostly empty, with a double-thick wall of blocks to the right. The wall is far enough from the "action" to feel odd. The emptiness of the composition draws attention away from the stairs, and toward another meaningless clump of bricks. In either of the game's predecessors, this would be a clue to a secret reward. Here, exploration for destructible bricks is fruitless.

This sort of misleading dead space is everywhere; so for shorthand, let's call them "disappointment wells." While we're here, the upper platform holds another, slightly less distracting, such well (see Figure 2).

Consider this: instead, have two entrances to the room. One door is high, the other low. Perhaps they could branch from that stairwell in level 1-01. Ideally from here, the level itself could further branch. Players could either climb the clock tower or head off to the right, perhaps through a cave or up a grassy hill. Toward the end of the level, the paths would merge. Then after beating the boss, the game would present a choice of entire levels. It does present us choice—the difference is that the player would have built up to that decision.

Or, let's say we keep the level structure intact. Instead, each route through this room would have its own sacrifice and payoff. If you come in through the bottom door, maybe there's an extra enemy or two. Maybe that provides the player with a flashy bonus or (better) an axe, to make the next section easier. Entering through the top door would lead directly to the chapel, but you would miss out on all the interesting stuff.

The chapel itself is mostly fine. Toward the top, there's that odd platform to the left, which lures the player to jump down, again to no purpose (see Figure 3). The platform might be salvaged if there were some associated bonus. The player can choose between going out of his way for a reward or just plodding forward, demonstrating again, on a small scale, the game's broader cost/benefit structure.

At the top of the stairs, a skeleton flies into our face. Why does the first enemy to pose any real threat leap directly at the player's position, and why is it so difficult to dodge? If forewarned, you can avoid it; the

first couple of times, it's almost a mandatory hit. What does this enemy placement teach us? Well, nothing. It's just obnoxious.

We also see two arbitrary floors, with a disappointment well to the right. Instead of leading up and right, to maintain the player's momentum, the stairs lead left. Why? If it's meant to continue the spiraling motion of the chapel, why force the player so far to the right to ascend?

The next two skeletons (not pictured) are placed well enough, though the one on the upper level might be better swapped for something with a more direct attack pattern. Down and to the left, we've another small disappointment well. Then over the sensible gap in the floor is one of the game's more inexplicable moments: an inaccessible two-block platform with a candle on top (see Figure 4).

There is no way to both destroy this candle and claim its contents. Why the platform? If it's just decoration, okay. It's clear the player can't jump to it; fair enough. So then why the candle? If you beat the game and enter a secret code, you can restart with the wall-climbing pirate Grant, who can leap high enough. Considering how many people will be distracted by the candle, and how very few will beat the game, much less enter a code afterward, this feels like a weird concession.

Now, if there were no platform and if the player happened to hang onto an axe from that first (hypothetical) split path, perhaps he could flick it here to gain a special reward for his foresight—maybe a guaranteed hit multiplier.

Down the stairs, to a pair of disappointment wells to the left and another to the upper-right (see Figure 5). More baffling empty space. The first swivel platform is well placed, acting in a positive role as a shortcut before the more sinister placement to come.

I'll point out here that this block has been dragging on for ages, and if a Medusa head knocks you down a pit here, you have to climb all the way back up the chapel again. And for what reward? Why, yet another disappointment well.

Granted, the lower level also serves as a safety net for the upper level, allowing you to adapt to the swivel platforms. But the layout makes this unclear; both levels are straight, and the bottom has a higher ceiling. The incidental placement of the stairs makes the paths look equally valid. If you want a safety net, perhaps wall off the bottom path but make the wall easy to scale from the inside.

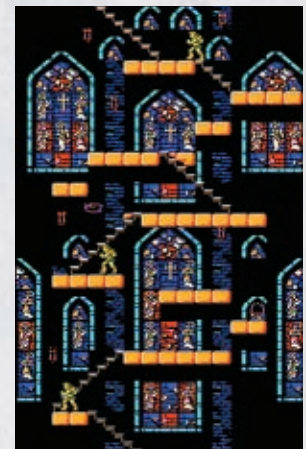


FIGURE 3 The small platform at the top left leads the player to jump down for no real purpose.

Castlevania III's disappointment wells

LEVEL 1-03

/// Finally another checkpoint, and a long straightaway. This area mostly serves to show off some neat background tiles. There are a couple of random pits that, due to the ground's inconsistent tiling pattern and the unexpected lack of a wall, aren't clearly flagged as pits. There might be something neat down there! There's a random elevated platform that you can't climb onto and that serves no other purpose (see Figure 6). This is a nice, relaxing beat. A shame it doesn't say anything useful. We're getting close to the end, and the level has yet to actively engage the player. In place of zombies, this would be a good place to practice with aerial enemies.

Down the stairs, we have an instant disappointment well, followed by the one true hidden reward in this level: a pork chop under the stairs (see Figure 7). After all that earlier misdirection, and the extra steps in claiming the prize, it feels a little underwhelming. Not only do you have to whip through two barriers, you also have to field a fleaman at the same time.

Incidentally, we have already seen random jumping skeletons—so why fleamen? They're the same thing, except more annoying. What do they serve to teach us at this tender stage of indoctrination? Imagine if Lakitu were in the first level of SUPER MARIO BROS. Same question with the long stretch of ground punctuated with a random CASTLEVANIA-brand dragon-head-cannon. Maybe it serves to show that some enemies take more than one hit. Probably not.

If the paths had split back in level 1-02, they might merge here. Since this is a town and we've paths to avoid the ground level, this would be a better place for those endless zombies from the previous area. The rhythm of zombie whipping would serve as a nice physical ramp-up for the boss.

This segment also shows a weird inconsistency to the game's collision. Sometimes when you jump up, as on the first stair structure to the right, Trevor's head will pass through the blocks, allowing you to jump normally. Sometimes, as with the following lower structure, he will hit his head or he can't jump at all. Why? The game is never completely clear.

LEVEL 1-04

/// A long, flat run-up to the boss. Nothing wrong here: it's a convention for the level architecture to grow long and quiet before a boss, to let you know that something big is coming up. As conventions go, it's a solid one—a simple trick of pacing and psychology that serves its purpose.

As for the boss area, though, it is very difficult to avoid being hit at least once. You have to walk past the middle of the screen before the boss even awakens. If you keep walking, you will be trapped at the right side of the screen and suffer many blows. If you double back, with a mind to playing follow-the-leader around the raised platform to the left, the boss will probably hit you at least once as you pass him. Not good, especially for the first major battle in the game; the player should have at least a chance of coming through unscathed (see Figure 8). Either move the "safe area" to the right, or build in a passage to allow the player to scurry back to the more advantageous position on the left.

BLOOD FROM A STONE

/// In a good design, you should be able to take any one beat and break it down into the game's basic themes. The minutiae reinforce the overall structure, and the overall structure lends purpose to the minutiae.



FIGURE 4 The small platform at the top far left is inaccessible to the player even though it has a reward in the form of a candle.



FIGURE 5 This segment features more empty space at the far left and upper right.



FIGURE 6 This portion features a poorly identified pit in the middle and another inaccessible platform on the right.



FIGURE 7 The empty space on the bottom left is another disappointment well.

What annoys me personally about DRACULA'S CURSE is that after the abrupt change of format in SIMON'S QUEST, this game reverts hard to the shape of the original game and ladles on the raw content, and yet it handles the content so ineptly that it makes play feel like work. I can excuse a conservative approach as an exercise of craft over art, but that laborious attention to detail is absent. Pound for pound, level for level, CASTLEVANIA III is a poorer game than the original, and there's far more of it to digest.

Which isn't to say that it's a bad game at all. The controls are as crunchy as any Konami game from that era. The music is splendid, if—again—broader than it is deep. The choose-your-own-adventure structure and character switching are neat gimmicks on their own. It's just a shame that it's all so uninteresting in conversation.

The best bits never amount to more than gimmicks, and from moment to moment, the game rarely acknowledges, much less rewards the player's efforts. You play because you're the player, and that's what a player does. The game shrugs and provides some things to play through. That's the sum of the relationship.

There's a place for empty relationships, but they'll never make the list of top romances. If you're starting from scratch, you might as well pursue something nourishing and make the world a little bit richer. ☹

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FIGURE 8 During the boss battle (taking place at the far right), players will find themselves trapped between the boss and the right side of the screen.



Learn more at <http://developer.gametree.tv>





GRAPHIC REMEDY

gDEBugger 5.7 for iPhone

GRAPHICS PROGRAMMING CAN

be the most rewarding kind of programming, because you get to see the results of your work immediately on the screen. However, as anyone who's done graphics programming can attest, it can also be one of the most frustrating kinds. Forget a single state change, or flip a sign on a transform, and you're likely get a black screen with no other explanation.

Some platforms have had graphics debuggers for years that allow you to step through graphics code and see the internal state at every step to help you zero in on the problematic spots. Up until recently, the iPhone wasn't one of those lucky platforms. Fortunately, Graphic Remedy is stepping up to fill that void with their OpenGL ES graphics debugger gDEBugger.

gDEBugger boasts an extensive list of features, with pretty much everything you could hope for in a graphics debugger: OpenGL error catching, state examining, asset memory reporting, profiling aids, and even "edit and continue" for shaders. Some of the functionality gDEBugger provides could be implemented directly in a game (fps counters, memory tracking, state reporting), but the big selling point is that you get all that functionality without having to add a single line of code to your program.

INSTALLATION

» Before you can do anything, you need to get a gDEBugger license. Graphic Remedy offers a seven-day trial license to get you started which installs automatically. If you are buying a full license, you will need to add the Graphic Remedy License Manager to your computer that allows you to install a license locked to your Media Access Control (MAC) address or a floating one. I

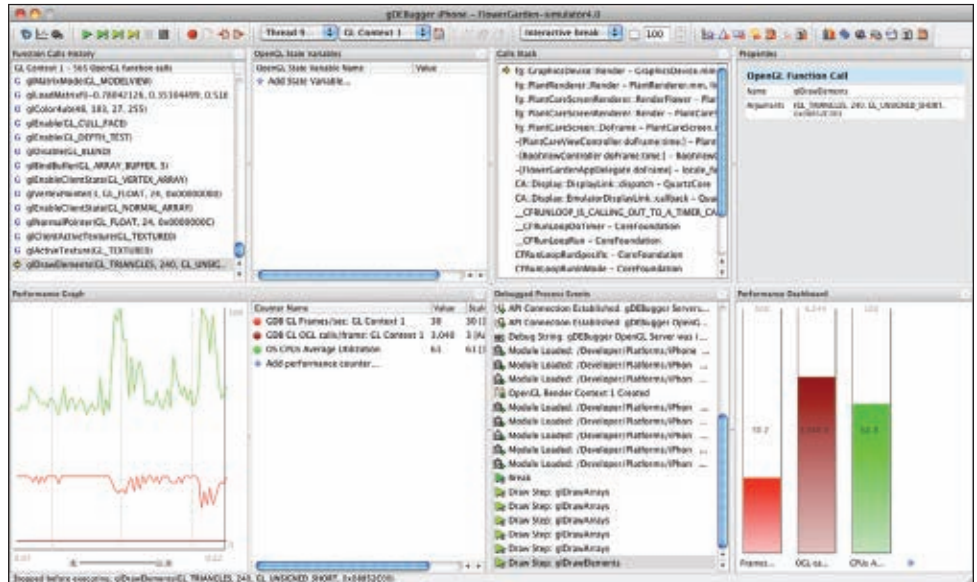


FIGURE 1 Main window showing performance counters and call history.

understand the motivation is to cut down on piracy, but I can't help but wish for a less restrictive approach. Most Mac OS applications I use on a daily basis don't have anything remotely approaching that level of copy protection.

The good news is that once you get over the hurdle of acquiring and installing the license, debugging your own OpenGL application is extremely straightforward. You don't need to create new project configurations or even link against specific libraries. Just launch gDEBugger, answer a couple of questions, select the xcodeproj file for your game, and off you go.

DEBUGGING AND ANALYSIS

» gDEBugger allows you to run and analyze your game on the device (iPhone, iPod touch, or even iPad) to get the most accurate results, or on the simulator for faster turnaround times and easier debugging.

Once your program is running from within gDEBugger, you can

pause execution and examine the OpenGL state at that point. You can see everything, from blending modes to texture states and bound vertex buffer objects. You can step execution forward to the next OpenGL call, the next

draw call, or the next frame among other events, and see how the state changes at each step. You also have the option to see the effect each draw call has on the render buffer as you step through it, which is extremely valuable when narrowing

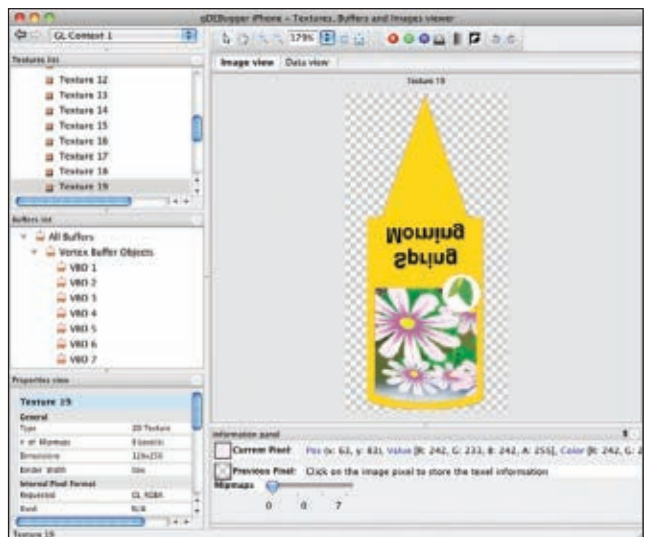


FIGURE 2 Texture information window.

down where a particular rendering technique went wrong.

With the program paused, you can also browse all assets loaded in memory (textures, vertex buffers, and render buffers), and get detailed information about their format and amount of memory used. gDEBugger will also render a preview of the textures that makes them much easier to identify, although the preview doesn't seem to work for PVRTC compressed textures. Vertex buffers are listed, but you aren't presented with a rendering of the mesh or even a byte dump of their contents. At least you can see the call stack for where each vertex buffer was created, which helps somewhat to identify each vertex buffer (unless you have a completely data-driven vertex buffer creation, in which case your call stack is going to be the same for all of them).

gDEBugger has an OpenGL call history showing past calls, and you can see what parameters were passed to each call. However, unlike other graphic debuggers, it doesn't let you go back through that history and examine the state at that point in time. While that might not sound like a big deal, once you've worked that way, it's hard to go back and only have the state available for the latest call. It makes debugging much slower and more cumbersome (and makes debugging single-frame glitches almost impossible). That feature alone would make gDEBugger more useful, and I can only hope they add it in an upcoming release.

One thing gDEBugger will do is give you some analysis of past OpenGL calls. That allows you to get a good high-level picture of the OpenGL usage for each frame. For example, it can report how many calls of each type there were per frame, or how well vertices are batched in render calls.

PERFORMANCE TUNING

» gDEBugger's feature set also has a number of functions to help with performance tuning. There are three different modes (Debug, Profile, and Analyze), depending on how much functionality is enabled and how much it affects performance. Obviously performance tuning is



FIGURE 3 Running performance experiments on FLOWER GARDEN with "no texture fetch" enabled.

only meaningful when running on the device itself, not on the simulator. Profile mode worked well for small, sample programs; however, when I tried to use it on a full game, gDEBugger increased CPU utilization on the device to the point of reducing performance down to just a few frames per second.

When you launch your game from the debugger, you see a set of plots updated in real time with the frame rate, as well as CPU and GPU utilization percentages. You can also add any number of other performance counters, from render counts to statistics, directly from the GPU. That part is fairly similar to the OpenGL reports you get from the Instruments tool provided by Apple.

gDEBugger goes way beyond that for performance analysis, though. One of my favorite features is the ability to run experiments on your game: you can selectively eliminate draw calls, raster operations, lighting operations, texture fetches, or even shaders. Running these kinds of experiments is a great way to identify the true

bottlenecks for performance in your game, and they're not something that is trivial to implement at the game level. Having them easily accessible in one location without having to do any extra work is a real time-saver.

As part of its detailed analysis of function calls for each frame, gDEBugger can also report redundant state calls as well as outdated or potentially slow function calls. For platforms like the iPhone, where the driver doesn't do anything to ignore redundant states, identifying those calls and removing them can provide a significant performance boost.

AND ONE MORE THING

» By now it should be clear that gDEBugger is a lot more than a simple debugger. It's a whole new way of interacting with OpenGL and the GPU. One of the most useful features is what amounts to an "edit and continue" for shaders. You can pause program execution at any time, display the shaders, make some changes, and continue

GRAPHIC REMEDY gDEBugger 5.7 FOR iPhone

Graphic Remedy
3 Mosinzon St.
Tel Aviv, 62965
Israel
www.gremedy.com

PRICE

- > gDEBugger iPhone Node-locked license: \$790 plus \$190 per year license maintenance.
- > gDEBugger iPhone Floating license: \$2,450 plus \$450 per year license maintenance.
- > gDEBugger iPhone Indie program node-locked license: \$190 per year

SYSTEM REQUIREMENTS

Mac OS X 10.5 or 10.6. 32-bit binaries are available for iPhone with support for both Intel (simulator) and ARM (device) binaries. Supports iPhone SDKs 3.2 and 4.0 on the device and with the iPhone Simulator as well as OpenGL ES 1.1 and 2.0.

PROS

- 1 Great OpenGL state display
- 2 Performance experiments very useful to narrow bottlenecks
- 3 Shader edit and continue

CONS

- 1 No browsing of past state history
- 2 Pricing
- 3 Overly complicated copy protection

execution with the new changes. That makes shader development much faster and easier.

PRICING

» A node-locked license that only works on the iPhone will set you back \$790 plus a \$190 fee every year (for maintenance and upgrades). That's pricey, but not totally unreasonable for large companies.

For us indies, that's most likely out of our price range by about an order of magnitude. Fortunately, Graphic Remedy has an Indie program that offers a node-locked license for \$190 per year. I understand the need to continue charging customers in order to keep up with the latest hardware and SDK releases, but I would have preferred it in the form of paid major upgrades, like most other software, instead of a yearly charge. ☹️

NOEL LLOPIS has been making games for just about every major platform in the last twelve years. He's now a one-man band making iPhone and iPad games.



product news

ONLIVE SDK FOR INDIE DEVS

WWW.ONLIVE.COM

/// Cloud-based gaming service OnLive announced it would make its SDK and development tools available to indie game developers.

OnLive highlighted that through the service, indie developers can create PC games that will be playable on televisions once the MicroConsole TV adapter launches later this year, without porting the game to a proprietary game console.

community features like leaderboards, achievements, friends lists, synchronous play, live chat, and more.

The network is cross-platform, too, so users with Android handsets will be able to interact with iPhone owners, as well as gamers on other smartphone platforms OpenFeint may support in the future.

Since its introduction more than 18 months ago for iPhone/iPod Touch and subsequently the iPad,

content in a web browser that uses the Adobe Flash plugin. Recently, Apple updated its policy and now allows developers to use third party development tools to create games and apps for its devices.

Flash game portals supported by the app at launch include Yahoo! Games, AOL Games, Facebook, and Kongregate, with— at time of writing, one game per service playable. User reviews on the iTunes App Store indicate that

gesture recognition to existing games, and a new user interface.

Other new features include a plug-in for the Unity 3D engine that lets Unity developers access all IISU SDK functions in real time and an updated plug-in for Adobe Flash developers that lets them take advantage of the middleware's functions.

Softkinetic's software supports "all major 3D camera manufacturers," the company recently said.

Softkinetic formed a studio for gesture-based games in 2009, and, along with its 3D camera technology sister company Optrima, is under the Belgium-based holding company In3Depth.

TAITO'S ARCADE DIGITAL DISTRIBUTION SYSTEM

WWW.TAITO.COM

/// At the recent 48th Amusement Machine Show in Chiba, Japan, arcade manufacturer Taito has revealed NESiCAXLIVE, a new digital distribution system for amusement arcades.

As with current distribution systems for PC and console, Taito aims to store games on its own remote servers, with arcade operators able to download titles direct to their cabinets via an internet connection. Currently, arcade operators must purchase the physical PCBs of any title they want to run.

Taito says the NESiCAXLIVE system provides operators with access to a backlog of titles which can be switched in and out according to player demand. The company also says that there will be a facility to store copies of games on a local server for quicker distribution to cabinets.

Nine companies are supporting the system, including SNK Playmore and Cave. The first title to be distributed via the system will be Arc System Works' BLAZBLUE CONTINUUM SHIFT II. Taito intends to develop the system into one where players can select the content they want to play.



There are a number of indie games already available on OnLive's service, including Dejobaan Games' AAAAAAAAAAAAAAAAAAAAAA!!! - A RECKLESS DISREGARD FOR GRAVITY, 2D Boy's WORLD OF GOD and Hidden Path's DEFENSE GRID: GOLD, among others.

OnLive's spectate mode allows users to view other users' gaming sessions, even if the viewer doesn't own that particular title.

OPENFEINT FOR ANDROID

[HTTP://OPENFEINT.COM](http://OPENFEINT.COM)

/// iOS developer Aurora Feint has launched OpenFeint, its mobile social gaming network, for Android devices, promising more than 20 supported titles that will release on the platform in the next month.

With OpenFeint's API, Android developers can now implement

over 3,000 games have integrated OpenFeint support, reaching more than 37 million players.

The mobile social network has faced increased competition recently, though, after the recent release of Apple's Game Center application with similar features.

ISWIFTER BRINGS FLASH GAMES TO IPAD

[HTTP://ISWIFTER.YOUWEBINC.COM](http://ISWIFTER.YOUWEBINC.COM)

/// A cloud-based streaming service that allows iPad users to play Flash games on the Apple device has been released on the iTunes App Store.

iSwifter streams Flash games from portals to its dedicated iPad application, in a similar way to console-focused services OnLive and Gaikai.

Apple's devices do not natively allow users to play games or view

there is a degree of lag associated with playing games through the app, a common hurdle for cloud-based services.

iSwifter is the product of tech incubator YouWeb, a support service for entrepreneurs that has produced gaming startups Aurora Feint, CrowdStar, and Siblingz.

IISU 2.5 GESTURE RECOGNITION MIDDLEWARE

WWW.SOFTKINETIC.NET

/// 3D gesture software provider Softkinetic this week released the latest version of its middleware, IISU 2.5.

Key new features of the updated middleware, available now, include Linux OS support (IISU previously only supported Windows), the new Interaction Designer tool that lets game designers more easily add

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START MAKING SENSE

MATCHING SCHEMA TO MECHANICS

/// First, read the following paragraph carefully.

"The procedure is actually quite simple. First, you arrange things into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities, then that is the next step. Otherwise, you are pretty well set. It is important not to overdo things; that is, it is better to do too few things at once than too many. In the short run, this may not seem important, but complications can easily arise. A mistake can be expensive as well. At first, the whole procedure will seem complicated. Soon, however, it will just become another facet of life."

Did the paragraph make any sense, or did it seem like a string of nonsense? It was most likely the latter, and the reason is that the text is completely devoid of context. Now try reading the paragraph again, but think of this simple phrase first: dirty laundry.

In this light the information should read differently and actually mean something. The text is simply a set of instructions about how to wash one's laundry. In fact, now that context has been established, reading the paragraph again without thinking about clothes is probably impossible.

SCHEMA THEORY

» This transformation is an example of schema theory, which tries to explain how our brains categorize the world. Essentially, a schema is a mental framework centering on a specific theme that helps us process and classify new information.

For example, a schema for dogs would include information about their bodies (four legs, hair, tail), their behavior (barking, drooling, cat chasing), and even their breeds (collies, spaniels, poodles). Further, the dog schema can contain traits from higher-level schemas, such as for mammals (warm-blooded, vertebrates, live births) and pets (domesticated, loyal, house-trained). Thus, when encountering a

dog, our pre-existing schema brings with it a wealth of information that informs us on what to expect from the animal.

However, schema are only useful if they are activated. That first paragraph was meaningless until the appropriate schema was triggered in the reader's mind by the simple phrase "dirty laundry." The text itself is useless without the schema, which is an important consideration for an author who wants to communicate effectively.

GAMES AND SCHEMA

» Game designers also need to communicate effectively—specifically, they have to lay out a set of rules and mechanics that the player must learn and master. This education process is one of the biggest challenges game developers face, and many games with fun systems have failed simply because few players make it past the learning curve. Many tools exist for solving this problem—well-paced tutorials, helpful tooltips, accessible UI—but perhaps the simplest approach is to activate one of the player's pre-existing schemas that is well matched with the game's underlying mechanics.

For example, the board game *Agricola* activates the player's farming schema to teach a fairly

complex economic engine. Players already understand the order of plowing a field, planting seeds, harvesting wheat, baking bread, and feeding one's family, which makes the complex interactions between the resources, fields, improvements, and actions easier to learn. Thus, one of the most important jobs of a game's theme is to help the player understand and remember the mechanics, which is another reason why a game's theme and mechanics should be well matched.

Another good example of the power of schemas comes from the related board games *Coloretto* and *Zooloretto*. Both games use the same underlying mechanic of set collection with penalties for acquiring too many different types of items. For example, in *Coloretto*, players gather cards of seven different colors, but only the player's three largest sets score positively; all other color sets score negatively.

The same mechanic is at play with *Zooloretto*, but with herding animals of the same species into pens instead of gathering identical colors. This difference gives the game a strong theme that activates the player's zoo schema, which actually justifies the scoring system. New *Coloretto* players need to be told explicitly that every color past their third will hurt them, while new *Zooloretto* players can see clearly from the board that they only have so many pens available (extra animals will remain useless in the barn). The zoo schema matters because the players' pre-existing knowledge about zoos—that animals of different species are placed into separate pens—makes the game easier to learn.

Furthermore, some themes will activate a player's schema more readily than others. In particular, historical or contemporary themes

have more resonant schemas than sci-fi or fantasy themes. Players can more easily guess how AGE OF EMPIRE's knights and archers function than how STARCRAFT's mutalisks or dark templars do. Indeed, most fantasy-based games tend to follow very well-established tropes (elves, goblins, dwarves) with which the player is more likely to be familiar. Those games that color outside the lines—such as the KOHAN series, which based its fantasy world on Persian mythology—often fall flat because players cannot use their pre-existing Tolkien schema.

REALISM VS. FUN

» Using schema as a tool to give players a window into a game system raises the question of realism, because the rules also need to accurately mirror the assumptions the players bring with them. If a baseball game gave the player four outs instead of three, the use of the baseball schema would not just be useless but actually counter-productive, because players would be constantly mixing up the exact rules.

Thus, realism matters and is an important tool for designers. However, realism has earned a bad name among game developers. For instance, fans who nitpick over small historical details that a game gets wrong are called "rivet counters." Indeed, Sid Meier famously said that "when fun and realism clash, fun wins."

However, in many ways, this choice is a false one. Realism that gives the player an easier learning curve makes a game more fun, not less. The danger from an overzealous pursuit of realism comes when the designer expects the player to bring significant outside knowledge to the game, limiting the potential audience. If a WWII

game contains realistic ratings for different flavors of German panzers, that's fine, but if the game expects the player to already know these ratings by heart, without in-game help, that's a problem.

Further, perceived reality is more important than actual reality. The most important question is how the player's schema is pre-built before starting the game. If a common misperception is widespread enough, better to support the players' expectations than to subvert them (unless, of course, the design itself has an educational goal).

For example, Sid Meier primarily based PIRATES! not on exhaustive historical records but on pirate movies, Hollywood's version of the era. Therefore, every pirate has a long-lost sister held captive by an evil Spaniard, and each tavern holds a mysterious stranger who might have a key piece of a treasure map. Similarly, Will Wright based THE SIMS not on actual domestic life but on a stylized sitcom version of it.

GENRE SCHEMA

» Schemas do not need to exist entirely separate from the world of games itself. Gaming veterans will eventually develop their own schemas for which designers must accommodate. More specifically, players will develop schema related

to how a genre is "supposed" to work: a schema for first-person shooters, platformers, fighting games, and even rogue-likes.

Just as people who encounter a new dog expect certain behaviors based on their dog schema, players who pick up a new real-time strategy game come with their own sizable RTS schema into which they expect the game to fit. The players might expect a god-level view, control of multiple units, a peon-based economy, base-building for military and technology, a high-level boom/turtle/rush game balance, and so on.

Games which eschew too many of these features can hopefully become critical darlings (MAJESTY, SACRIFICE, DRAGONSHARD), but they almost never achieve commercial success. Consumers are generally conservative when dropping \$60 on a new game, and the better they can understand a game before purchasing it—often by fitting it squarely into the framework of a genre schema—the more comfortable they will feel. Thus, genre schemas have a significant chilling effect on innovation within the industry.

Perhaps the best way to overcome the limitations of genre schemas is by providing the consumer a different yet stronger schema via the game's actual theme. For example, NINTENDOGS



did not fit well into a successful commercial genre, but the game's theme—taking care of a pet dog—activated the schema of consumers with so many clear possibilities that the title became one of the best-selling games of all time. The game sold itself to players primarily on the basis of what they already knew about dogs.

MAKING SENSE

» A certain breed of player that is unafraid to dive into unfamiliar territory does exist, such as the early adopters of iconoclastic cult games like DWARF FORTRESS and the DOMINIONS series. Most players, however, need to understand what a game is about before they even touch a controller. A schema

hook is required, either via the game's visible theme or some well-established genre conventions.

However, while the latter can successfully sell a game to faithful core gamers, only the former can expand gaming to a mainstream audience. Certainly, the Nintendo Wii is the greatest example of this fact during the current console generation. Aside from the accessibility of the controls, many of the best-selling games—such as WII FIT, MARIO & SONIC AT THE OLYMPIC GAMES, JUST DANCE, and yes, even the oft-derided CARNIVAL GAMES—all have very clear themes that easily activate consumers' schemas and expectations. Games about space marines and evil wizards do not have this advantage.

Still, finding a resonant theme is only half the battle; a game's mechanics must match the theme as well. The old "fun beats realism" saw has become such dogma that designers can easily fray the connections between a game's theme and its mechanics in the very subjective pursuit of fun. Starting a new game is always a leap of faith, and players have a right to expect their games to start making sense. 🗣️

(Credit for the laundry schema example belongs to the How to Play Podcast.)

SOREN JOHNSON is a designer/programmer at EA, working on browser-based strategy games at www.strategystation.com. He was the lead designer of CIVILIZATION IV and the co-designer of CIVILIZATION III. Read more of his thoughts on game design at www.designer-notes.com.





EPIC FAIL

THE ART AND SCIENCE OF FAILING SCRIPTS

If you're a working artist, you don't need EpicFail.com to tell you things don't always go as planned. Between fickle creative direction, busted builds, and impossible schedules, you've probably had more than your fair share of Fail. For the tech artist, though, that heaping helping of Fail comes with an extra thick dollop of unpleasantness: there's nothing that gives more heartburn to a technical artist than the nasty soufflé of inconvenience, production disruption, and sheer embarrassment that is a busted tool.

The jury-rigged world of scripts, in-house tools, and ever-evolving features is like an Italian sports car: impressive and sexy, but prone to unpredictable breakdowns. Every TA knows the sad refrain, "But it worked on my machine!" and it's lesser-known cousins, like "It works when you have your units set to centimeters, why do you have your units set to feet?" and "No, I never tested it on filenames with commas in them—why do you ask?" and the ever popular "Wait, you mean you installed Max onto your K: drive?"

TAs live with an astonishing variety of opportunities for things to go off the rails. Tech art relies on many uncontrollable factors, like buggy art software, ever-evolving custom tools, and—let's face it—slightly imperfect artists. In this environment, bugs and glitches are inevitable, no matter how slick your scripting skills may be. It's important, therefore, to think ahead to the inevitable problems before they occur. Sure, we'd all prefer it if everything just worked. Unfortunately, as we know too well, even big expensive software packages like Max and Maya aren't 100 percent bug-free. It's a bit naive to think that could be true of the scripts we cook up amidst the craziness of ongoing production. Bugs will happen. The only question for TAs (and their artist clients) is what we're going to do about them. There's an old military maxim to the effect that "failing to plan is planning to fail." To which the veteran tech artist might add "failing to plan to fail is planning to fail epically."

USER FAIL

» Failure comes in many guises, but any tech artist will tell you that



the biggest source of failures is us: the users. Any TA who wants to stay sane has to make sure to protect users from themselves. Users make mistakes: Lots of mistakes. Every input, no matter how simple, is a chance for an error. So, when you pop up that dialog box that asks for a new object name, always check right away for obvious boners like empty strings or forbidden characters. Never, ever pass user input along uninspected to another function where it might cause real harm. When you can, present only safe choices, and don't ask completely open-ended questions: A character rigging script that needs the name of a bone should probably present the user with a list of bones to choose from, rather than betting on the typing skills of

your average artist. A script that applies materials to selected objects should automatically ignore things like lights and cameras rather than crashing. An animation tool that applies an expression to an object should warn the user if the target is already animated. Most scripters apply these sorts of rules by instinct. A consistent, well-thought out plan is better than instinct, however.

Deliberately putting as much intelligence as possible into the user-facing side of your scripts is one of the best ways a TA can stay sane. Adding a couple of lines of validation code to the "Set AI Type" button takes a few minutes: debugging the level that is whited out because your tool accidentally marked a light as an

AI character, and it's now following the player everywhere, can take hours to sleuth out—let alone fix. If your inputs are well-behaved, maintaining the innards of your code is far easier.

PRINT FAIL

» Of course, Murphy's Law can't be suspended by a few extra lines of script. A C++ programmer is unlikely to accidentally pass a number to a function that expects a string, because the compiler will catch that mistake in advance. In MaxScript or Python on the other hand, it's all too easy. After user error, passing the wrong arguments between functions is the leading source of bugs.

The primeval TA trick for squashing bad value bugs is simply to litter your code with print statements. It's a crude way to track down rogue values and mistaken function calls, but even the most elite TAs resort to it on occasion. Print-based debugging can be made a lot more effective (and less annoying) if you devise a library of reusable debugging functions rather than just plopping prints into your code. Python users should gravitate toward the built-in `warn()` function and the standard logging module, both of which allow you to control (or staunch!) the flow of debugging info globally or locally. This is a huge step up from having to comment out all those dang prints. MaxScripters aren't so lucky, but a simple library of warning and logging functions, controlled by a global variable so you can turn them off when the job is done, is a great investment any for tech art team. It will also be popular with users who don't want their listener windows polluted by reams of incomprehensible debug text.

Print debugging is tried and true, but also old and lame: you can only see the variables that you have deliberately chosen to print out. This makes it easy to miss an important clue, or conversely to drown yourself in irrelevant information. Luckily MaxScript and Python both offer primitive debuggers (tough luck, alas, to those of you still writing Mel). Max's debugger and Python's pdb module both score poorly in the ease-of-use sweepstakes, and many TAs give up on the debuggers after some frustrating early experiments. They're both worth a second look, however—for two reasons.

First, a live debugger (unlike a print statement) allows you to inspect the entire namespace of a script while it's running. You can check the values of all the variables and also verify where exactly you are in the code you're running. Did that bad value originate inside the function where the error occurred, or did it come in from the code that called the function? What's the stack of functions that got us here in the first place? Secondly and more importantly, debuggers capture the entire state of the code at moment when an error occurs, giving you an accurate idea of what really happened. No need to print out every variable line by line: The crime scene is perfectly preserved for your forensics team.

Pythonistas have an even more powerful tool: external debuggers. Several popular Python editors include remote debugging functionality. Using PyDev (www.pydev.org), Wing (www.wingware.com) or Komodo (www.activestate.com), you can include a debug terminal in your script which will let you set breakpoints and step through your code one line at a time from outside of Maya with the same level of control and information that the big kids get in Visual Studio.

Although this takes a little setup it's an enormous step toward better TA productivity and tools.

FAIL SAFE

» OK, so you've protected yourself from your users and stepped through your code line-by-line to scrub it free of impurities. Guess what? You're still hosed. Script-based tools are always

at the mercy of the art packages they live within and the computers they live on. The assumptions you need to make for your code are often going to be wrong: Users will delete or rename things in the scene they really shouldn't touch. Files you need might be missing or locked or in use by some other program. No matter how hard you try, your code is going to run into cases you didn't anticipate. How well you handle these situations has a huge impact on how well your whole toolchain stands up to the stresses of production.

It's tempting to try to bulletproof your code with try/catch blocks. Catching exceptions is appealing because it lets you bail out of a problem without crashing—you can display a warning message, ask for help, or log an error rather than simply dropping dead. Unfortunately try/catches can be a dangerous addiction. Catches suppress errors, but they don't fix them. Unless you carefully design the catching code, you could end up hiding serious problems with your tools rather than confronting them head on.

Consider this example: you have a function which collects all the objects that have a certain attribute value. Once in a while you find an object which has the attribute set incorrectly. Say you ask for an RGB color value and get a string like "yellow" instead. The problem is rare and time is short, so what's the harm in wrapping this in a try/catch? Well, for starters, you're leaving bad data in the scene, which might break other scripts anyway. You're also lowering your incentive to track down the real source of the problem: without angry users showing up at your desk anymore, it's easy to forget this "solved" issue. Not only that, you're also slowing your code down: exception handling is noticeably slower than ordinary flow control (especially in Max). Finally, and worst of all, you could be inadvertently be hiding other errors—not just your known problem—with bad attributes. Perhaps another tool has a bug which causes it to pass null values or nonexistent objects to the collector function. You'll never know because you're hiding the problem inside your try/catch—and

most likely printing a wrong error message that will confound your debugging efforts.

The upshot? Don't be afraid to fail. In this situation, failing is the right thing: fail honestly rather than hiding errors inside try blocks. Fail early and fail often ... then find and fix the bugs that show up. This advice may raise some eyebrows among Python coders, who've probably heard of the famous "easier to ask forgiveness than ask permission" principle (i.e. "give it a shot and use try/except to stay out of trouble"). There's an equally important python principle to remember: "catch only appropriate errors." The language encourages you to catch specific exceptions.

With targeted catches, truly unexpected flaws are still brought to light, rather than swept under the rug. MaxScripters, unfortunately, have no language-level help in this regard. They're stuck with cumbersome manual testing using the `GetCurrentException()` function. In both languages, though, the important principles remain the same: use try-catches sparingly, limit them to the smallest practical bits of code, and let problems bubble up so they really get fixed!

FAIL BLOG

» All that said, catches have one very important function that should not be ignored: they are canaries in your personal scripting coalmine. Pretty much by definition, when you hit the catch part of an exception, you know something has gone badly wrong. You should take advantage of that knowledge to collect useful debug information that will help you find and fix the problem. A good error reporting system doesn't have to be complex. A simple text log uploaded onto a network share does wonders for your debugging (for example, when IT calls you up to find out why there are 10,000 files in your dropbox today it's a good clue that something was wrong with yesterdays checkin!). Automatically-generated emails are a great way to enhance your reputation for customer service. Users love it if you're standing over their desk offering to help a few

seconds after some scary error dialog appears. For big studios and big TA teams, logging errors to a heavy-duty database can provide really valuable insights into the weak spots in the toolset. If your studio uses a web-based bug tracking system like FogBugz or Jira, you can even submit bugs automatically from right inside your exception handlers.

No matter what avenue you choose a strong, standardized debug toolkit is an invaluable help in your struggle with the forces of Fail. Rather than manually collecting things like computer names, software versions, operating system and environment variables in every crash handler, you should create a standard function to collect and package the relevant data and use it everywhere. Not only will this make it easier to parse the data looking for patterns ("Hey wait a sec—all these crashes are on 64 bit machines!") it lets you enrich your debug info as new problems arise. When it turns out that the language settings on your outsourcer's machines are breaking your tools, it's easy to add another couple of lines to your debug info script tool once than to manually check for it in hundreds of different spots.

TECH FOR ART'S SAKE

» Less technically-inclined artists may look at the some of this stuff and wonder where the art is. In the modern games business, success in the airy realms of artistic expression depends on the ability of a select few technical artists and tools programmers to fight an unending, overwhelming battle against the forces of Fail. It's not a battle that can ever be completely won—but fighting the good fight makes a huge difference to our teams and our games. So get out there and start failing! ☺

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THE LAG ISSUE

RESPONSIVENESS IN CURRENT AND FUTURE GAMES

Responsiveness is an oft misunderstood but particularly important performance characteristic of modern games. It is considerably more difficult to measure than frame rate, so is typically ignored during game development. Response lag has a nonlinear negative effect on a game's control-ability. Humans have a surprisingly poor ability to consciously perceive total lag in games beyond a certain threshold; but even lag below this threshold of perception can have a negative impact on player performance and gameplay. Responsiveness is especially important within the emerging space of cloud gaming, where the entire game runs on a remote server farm. In this article, I will analyze the components of response lag and how to reduce it.

TOTAL RESPONSE TIME

» Response lag is the net delay resulting from the full chain of events starting with a player initiating an action with an input device and ending with the game displaying a frame responding to that input on the TV or monitor. Every step in this processing pipeline can add lag, and the overall response time is the accumulation of a large number of small delays.

Response lag was investigated by Mick West in several Gamasutra articles in which he used a high speed digital camera to measure total response time frame-by-frame. Although time consuming and limited to roughly low frame-level accuracy, this remains the only technique that I am aware of to measure actual response times.

The measured response times for current console games vary considerably—from a low of 50 ms for GUITAR HERO 3 on Xbox 360 up to 166 ms for GTA IV on PS3. These are ideal base latencies using wired controllers and a CRT monitor—flatscreen TVs and LCD monitors can add additional delays, as can typical wireless controllers. In a more real-world setup, GTA IV's lag can easily exceed 200ms. Judging by their purchase decisions, most gamers don't appear to notice or care too much about latencies at this range, and it stands as a reasonable upper limit.

The thresholds where latency first has a subtle negative effect and then transitions from subtle to noticeably annoying are context-dependent. Games that require precision timing

in the player's inputs, such as fast paced music, rhythm, and fighting games, have some of the most stringent requirements. Even if the player doesn't yet consciously notice the lag it can lead to mistimed moves and much frustration. Latency is surprisingly less noticeable in camera controls and aiming in shooters—probably because the entire scene is shifting and there is more visual complexity for the brain to track.

Gamepad controls hide some amount of latency versus the mouse. The mouse allows for a wide dynamic range of rapid precision motions while a gamepad's analog joystick only allows a limited range of motion. As a result gamepad control schemes are usually derivative-based, and add additional apparent latency themselves, somewhat masking the system response latency. For these reasons console shooters are actually some of the most latency tolerant. As GTA demonstrates, latencies up to 200ms are quite playable, if perhaps not ideal. Mouse-based shooters appear to be only slightly more sensitive.

On the other side of the spectrum, the most latency-sensitive type of game interaction is also the simplest: moving a 2D mouse cursor. The cursor's small size on the screen combined with the expected rapid precise positional control make this the worst case for latency. The cursor is small, the eye naturally tracks it, and your brain easily notices the discrepancy in the cursor's predicted motion. Thus, simple 2D user interfaces have some of the hardest latency requirements.

The cursor latency problem is an old known problem in graphics and has been tackled with hardware cursors. Instead of rendering the mouse cursor normally and thus subjecting it to the full processing delay, the operating system and graphics board can short circuit most of this path by direct immediate mode rendering of the system cursor into the front buffer. This was perhaps more important when games ran at lower frame rates, but it resurfaces now in the era of cloud computing. When games use the system cursor, the client software can render it locally.

Most gamers, and even many game developers, do not appear to be aware that a typical 30fps console game has about 4 to 5 or more frames of delay, and thus a latency of around 130–160 milliseconds. We are accustomed to thinking of latency in terms of internet ping times, where even 100ms may be considered a high ping. It is a somewhat odd notion that the response time

or “ping” from a game running on a computer or a console right next to you can be comparable to the network ping of a server across the continent. But odd or not, it is true.

The single largest factor in total response time is simply the frame rate. As most of the delays are the result of inter-frame buffering of the flow of processing between different threads and devices, the response time is roughly inversely proportional to the frame rate. The response time is roughly N/Fr , where N is the delay in frames based on the game's architecture. A typical simple app may have a delay of three frames, corresponding to the delay of one frame of processing on the CPU, one frame of rendering into the back buffer on the GPU, and one frame copying to the display front buffer. A more complex game will take advantage of multiple processors and can incur additional delays due to pipeline buffering between threads. An engine based on a deep-pipelined multi-threading model running at 30 fps can easily approach 200 ms of total latency.

LATENCY IN CLOUD RENDERING SYSTEMS

» Cloud gaming systems such as Onlive or Gaikai add additional latency in terms of the time required for video compression and network transmission. In an earlier article, “Gaming in the Cloud” (November, 2009), I speculated that simply running all games at 60fps would cut the base latency in half, and allow server-side games to have total response times similar to the local console versions running at 30fps. This was put to the test recently on Richard Leadbetter's blog on the Eurogamer site, Digital Foundry, where they tested a handful of Onlive titles using West's camera technique.

Surprisingly, they do not mention the network ping to the Onlive data center they were connecting to, which adds some uncertainty about their measurements. Nonetheless, the results were described as “pleasantly surprising,” with measured latencies ranging from 150ms to 200ms for most games—comparable to typical 30fps games running locally. Some, such as UNREAL TOURNAMENT, stayed consistently on the low end of this range, while others varied considerably.

Overall their measurements show that server-side rendering can be as responsive as local gaming, and can fit into the same acceptable response time windows where delay

Game response latency is something of a misunderstood and under-appreciated issue in modern game design. Some of the sources of latency are outside the developer's control, but a good bulk of typical processing delay stems from the game engine itself.



is unnoticeable to the player. These response times are obviously somewhat dependent on the end user's connection, but with a reasonable ping in the 30ms to 60ms range, an end user should generally not be able to tell the game is running remotely (or at least, not by latency alone).

Deploying a network of geographically distributed data centers is a necessity for cloud gaming services to minimize the latency cost of the last mile, but this network ping time represents only about 15–30 percent of the total response time for typical server-side rendered games. The bulk of the potential response time still comes from the internal latency of the

game itself. Simply optimizing a title to run at a consistent 60fps instead of 30fps is a simple and obvious route to trimming the game's base latency down to under 100ms. Further gains must come from engine architecture improvements. A multiplatform game designed to run at 30fps on the console can benefit from a low-latency design on all platforms.

LATENCY IMPACT OF THREADING ARCHITECTURES

» Games have base latencies that are well more than a single frame because of the pipelined data flow between all of the various device

components comprising the overall game system. The input device(s), CPU(s) and threads, GPU(s), and final display device all generally operate independently and in parallel. Some of these components, such as the end user's monitor or television, are outside of the developer's control. Early flatscreen displays added significant (dozens of milliseconds) of additional latency, although this appears to be much reduced in newer devices that have moved to 120 and 240hz. The bulk of the base latency lies in the pipeline flow between CPU threads and between the CPU and GPU, and this is where the wide variability in game response times comes from.



The data flow from user input to final rendered frame can be decomposed into a graph of dependent sequential operations. The exact flow will vary from game to game, but at a high level the typical stages will include gameplay event processing, AI, animation, physics, rendering setup on the CPU, and finally actual rendering on the GPU.

The best case design from a latency standpoint is a non-pipelined or wide data-centric architecture where the numerous processing stages all run sequentially but in parallel across N threads, with each thread performing the same tasks in lockstep on different subsets of the data. The worst case design for latency is a deeply pipelined code-centric architecture where N CPU threads each handle a separate related subset of the temporal workflow. The deep architecture can often have an additional latency of around N , whereas a pure wide architecture would add little to no additional latency.

The typical extra latency from pipelining is not strictly inherent to a pipelined data flow, but comes from the practical necessity of buffering data between pipeline stages. As each stage is dependent on some of the results of previous stages, the results of one stage must be buffered and subsequent stages are temporally offset in a staggered fashion. In a worst case scenario, these buffers can last an entire frame.

Let's consider a simple example architecture that some games use for the PC and PS3. This is a system with two main threads—one for rendering, and another main thread for gameplay and most everything else. The rendering thread can start work as soon as it receives its first processed objects from the game thread. This could in theory happen very soon in the game thread's frame update loop, but in practice the rendering thread in such architectures will mostly run a frame behind. The game thread will only have the final positions and states of objects ready to send to the renderer after it has finished evaluating everything potentially effecting that object: input, AI, animation, and physics. An AI on the other side of the map could decide to shoot a bullet into an onscreen object, changing its visual state.

GPU COMMAND BUFFERING

» The rendering tasks that a CPU render thread typically performs are more independent and suitable to immediate flow through processing. The render thread will typically take a list of simulated game objects and perform frustum culling, LOD management and decomposition into renderstates and drawcalls on each object independently. In theory the render thread could fill the GPU command buffer near immediately

and add little additional delay. Unfortunately some common low level rendering optimizations and behind the scenes driver components can conspire to add one or more frames of latency between the CPU render thread and the GPU itself.

A frequent low-level rendering optimization involves sorting draw calls to reduce render state switches. This adds a serial temporal dependency on draw call sequences that can add additional delay. In the worst case the renderer will first generate and buffer an entire frame of draw commands into its own internal buffer, sort

The single largest factor in total response time is simply the frame rate. As most of the delays are the result of inter-frame buffering of the flow of processing between different threads and devices, the response time is roughly inversely proportional to the frame rate.

them all at once at the end, then finally send this reordered sequence to the GPU. This can add over a full frame of lag in the worst case. A better design is to batch and sort only small sequences of draw calls and be careful to flush the buffer to the GPU every few milliseconds.

The operating system and/or driver layer will add another layer of buffering between the CPU and the GPU. Render commands in DirectX are buffered on the CPU in an internal command buffer, and then occasionally flushed over to the device. On the PC this internal command buffer can reach several frames in size. This makes sense if you want to smooth out frame rate and permit automatic multi-GPU parallelization by piping alternating frames to sequential GPUs, but it can cost multiple frames of latency. Fortunately for cloud-gaming systems, this behavior can be controlled in the drivers.

VSYNC

» A final latency pitfall is the typical rendering option of vertical blanking synchronization to eliminate unsightly tearing artifacts. VSync is something of a necessary evil. Unfortunately its implementation in the Direct3D standard leaves much to be desired. Direct3D provides a simple option to enable VSync in the `PresentInterval` flags passed in during device creation. But internally VSync is implemented as a blocking operation on the GPU. If the game is running fairly consistently at high frame rates above the display's refresh rate (typically 60Hz), the blocking wait for the vsync period effectively just caps the frame rate down to 60 and all is well.

In the worst case the game is running consistently at just slightly under 60fps, so each frame is taking slightly longer than 1/60th of a second for the GPU to produce. In this worst case VSync can effectively halve the frame rate down to

30fps and double the latency, as every stage in the processing pipeline ends up stalling on the next. In the real world the penalty is usually less than this worst case, but it remains as a significant problem.

The ideal solution is asynchronous triple buffering where the GPU is free to produce frames as fast as it can and the display is independently free to consume frames as fast as it can. In this scheme the display thread displays a whole frame for its full refresh period, and then grabs the most recent completed frame to display next. If the GPU is running well ahead this may result in

skipped frames, and if the GPU is running behind this will result in some repeated frames, but it will never result in the display of half-finished torn frames. This asynchronous buffering solution is not directly available in Direct3D, but can be implemented as a custom solution.

LAG'S SONG

» Game response latency is something of a misunderstood and under-appreciated issue in modern game design. Some of the sources of latency are outside the developer's control, but a good bulk of typical processing delay stems from the game engine itself. Avoiding simple pitfalls, paying close attention to pipeline stages and minimizing unnecessary buffering can reduce base latency to just a few frames, instead of four or five.

Optimizing for a consistent 60fps with some padding for Vsync can result in further large savings, especially on the PC. In the world of server-side rendering, these optimizations can make the difference between a game that is as smooth as a local console experience even on a suboptimal internet connection and a suboptimal gaming experience. Looking toward the future, game engines can benefit from wide parallel threading models as opposed to deep pipelining. The data-wide threading model is not only advantageous from a latency perspective, it is also the more natural choice for scaling to the very large number of threads that computing systems—whether GPU or CPU oriented—appear to be moving toward. 🎧

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THE STATE OF THE UNION

CHANGE IS IN THE AIR AT THE AMERICAN FEDERATION OF MUSICIANS

UNLIKE FILM AND TELEVISION, the major players in the game industry aren't centralized within Los Angeles. However, for game composers, changes currently taking place in the City of Angels could ripple across the map. At the center of these changes is the American Federation of Musicians, the labor union of professional musicians in the United States.

THE MORE THINGS CHANGE

» Until the last few years, the video game industry's relationship with the American Federation of Musicians (AFM) was mostly defined by what it lacked. Reuse fees in the original AFM game contract drove publishers and developers to seek out live musicians in locations such as Seattle, London, and Eastern Europe while the AFM talent pool sat unused, hamstrung by a contract that seemed to not understand the very nature of the industry for which it was written.

However, in 2007, the efforts of a small army of game professionals came to fruition in the form of a revised AFM game contract and a vigorous attempt by the AFM to establish itself with publishers and developers as the new go-to source for world-class talent. In the years that followed, the result was a boom in AFM recording sessions, with union houses such as Skywalker Sound seeing an influx of AAA game scores being recorded on their main stages.

The AFM, though, is a democracy, and as happens with democracies, changes in the administration can bring changes in administrative policy. In June, previous AFM president Thomas Lee was not reelected and in his stead, the members elected Ray Hair to the group's top spot. Also out was Savina Ciaramella, the AFM's previous liaison for video games,

and one of the persons who worked on the initial changes to the video game contract. In her place is now Dick Gabriel, longtime member of the AFM and a musician who has performed with Elvis Presley, Chuck Berry, and The Beach Boys.

Changes haven't been limited to staffing. Though it's still too early to tell what (if any) broad changes to the video game contract might take place under the new administration, one change has already been made.

The new administration has changed the way they handle assumption agreements. The AFM's assumption agreement is a half-page addendum which essentially states three separate points: pension and welfare payments due from the initial recording sessions will be paid in a timely manner, the AFM is free from any finger-pointing or legal issues which result from the music that is recorded, and special considerations or payments due in the future as stipulated in the contract will be honored by the signee.

In the past, the signee of the AFM contract and assumption agreement was often the composer who was writing and then recording the music. As such, the publisher/developer entered into a contract with the composer who then entered into an agreement with the AFM. Notoriously skittish publishers were therefore benefiting from the agreement while never actually being directly tied to the AFM. As of July and the new administration, however, a change in policy has come down stating that assumption agreements will only be accepted when signed by the game's publisher.

I contacted new AFM President Ray Hair and asked him for an explanation regarding the change in policy.

"For decades, members of the American Federation of Musicians have benefitted from the AFM's



direct contractual relationship with the major employers in live television as well as in the theatrical and television film industries," says Hair. "We began to cultivate similar direct relationships in the video game industry several years ago with product scored for Sony, EA, Ubisoft, and numerous other game producers. It is the AFM's policy to contract directly with game publishers or owners—the true purchasers of musicians' services—or to contract with an approved third party who has obtained an assumption agreement with the product owner, because the owner retains responsibility and maintains control over the use and sale of the recordings. The AFM is concerned when an agent or someone other than the party ultimately responsible for the product enters into an agreement for which it has no direct control."

The AFM, therefore, is looking to have video game publishers fall more in line with the standards and practices of the film and television industries that they've dealt with for decades, and make the ultimate owners of the music—the publishers—responsible for the

terms laid out in the assumption agreements. With the AFM now mandating a direct legal relationship with publishers, though, composers are already seeing publishers shy away at the notion of being the signee on the legal agreements. With the legal departments of publishers refusing to be signees, what would have been AFM sessions are again beginning to be replaced with overseas sessions.

THE MORE THINGS STAY THE SAME

» With the new administration still settling in at the AFM, further changes may be in store for the video game agreement. What's clear is that the landscape is already different. On the one side is the AFM, with its interest in moving game publishers closer to a film and television studio model. On the other side are game publishers, with their desire to remain closer to a software development model. Working somewhere in-between are composers who will have to learn how to navigate the new terrain. 🎧

JESSE HARLIN has been composing music for games since 1999. He is currently the staff composer for LucasArts.

GDC 25 BEHIND THE SCENES OF GDC LECTURE SUBMISSIONS

/// The 25th annual Game Developers Conference—celebrating a quarter-century of existence giving inspiration and practical take-away by developers for developers, is being held in San Francisco's Moscone Center next February 28 through March 4, 2011.

Last year, then-board member Simon Carless discussed the background of how talks get picked for GDC, explaining at the time:

"I know that in some conferences [both outside the game industry and in], the Advisory Board can take a much smaller role in actually directly picking the content.

"But one of the reasons that Game Developers Conference is so well respected, I believe, is that all of the talks are either empirically chosen from submissions, or carefully and specifically invited by the official GDC Advisory Board. The GDC organizers don't pick your talk—key members of your own peer group pick your talk.

"So rather than being hands-off 'advisors,' multiple Advisory Board members grade every single submitted talk. They also discuss submitted and invited talk specifics via email, phone, and during the course of multiple in-person meetings. Finally, they coach and mold conditionally accepted GDC talks into a better end product."

GDC is doing the same this year, and after submissions that ended in August, GDC 2011 lecture selection has again been extremely competitive, with more than 800 submitters vying for the opportunity to present at the next Game Developers Conference.

GDC continues to be very serious about the review process for GDC talks. This year, 5,555

ratings/internal comments were made on potential GDC 2011 talks by the Advisory Board. The Board includes senior developers and execs from most of the major companies in the business, from Blizzard through Bungie to Playdom and beyond. They then gathered in-person for an intensive weekend of meetings in Silicon Valley in September to decide which talks made it.

Unfortunately, organizers can't comment on why individual submissions were accepted or rejected, due to the massive amount of submissions and the complexity of the process. But GDC submitters should be aware that rejections are often due to multiple reasons, many of which have nothing to do with the professionalism or quality of the talk submitted.

Either a narrower subject matter area or competing submissions falling within the same focused topic may mean that the GDC Advisory Board can't approve every talk that may otherwise pass muster for the show, given the venue's limited time and space for talks.

GDC has now compiled several constructive comments that it feels reflect how the GDC Advisory Board sees submissions, which will be sent out to all unsuccessful submitters going forward:

- Although the first phase GDC submission gives you limited space, how well did you get to the meat of what is being discussed? If you can be very specific on the kind of practical, real-world facts and take-aways that GDC attendees will get from your talk, the Board will appreciate your submission all the more.

- The Board is keen to get talks that are focused, but it's worth considering how many members of the GDC audience will get direct take-aways from your talk. For example, if your presentation on glider aerodynamic simulators only has concrete lessons for people working on hardcore glider sims, then the Board may consider that not enough attendees will benefit from it, technically excellent though it may be.

- Obviously, it's best if you submit something based around a topic for which you are a proven practitioner or success, with relevant industry history. Say you've been making acclaimed RPG titles but you're very excited about your new FPS that hasn't yet launched. Although you may be excited about your FPS, a talk about lessons from those successful RPGs may be more to the Board's liking.

- If you've previously spoken at GDC, be aware of what your evaluation score(s) were, the comments from attendees, and try to address those in your new submission. The Board will look at previous ratings and comments and consider whether your submission might address those.

- If you're submitting a panel session, the full list of participants and their background/suitability will greatly increase the chances of the Advisory Board being interested in hearing more about it.

GDC 2011 SUMMIT LINE-UP ANNOUNCED

/// Game Developers Conference organizers have announced additional Summits for GDC 2011, including a new GDC Smartphone Summit and the return of the Social & Online Games Summit. The organizers have also opened up a call for Summit lecture submissions until October 14th.

The GDC Summits take place Monday, February 28 and Tuesday, March 1, 2011, the first two days of the historic 25th annual Game Developers Conference. They offer deep-dive content on a variety of notable game industry topics, ahead of the main conference which runs Wednesday, March 2 through Friday, March 4.

This year, the conference is introducing the GDC Smartphone Summit, which brings top developers from around the world to share knowledge and concrete takeaways on the smartphone and related platforms.

The summits also include the vibrant Social & Online Games Summit, with a packed agenda devoted to social network games, free-to-play web titles, and microtransaction-powered online games.

In addition, the 2011 Serious Games Summit is being built around two themes, with day one focusing on health and healthcare, covering research and the many commercialized games in the health & wellness space that have launched the past few years. Day two will be devoted to the rising trend of 'gamification'—the concept of building game-like incentives into non-game applications to address issues like productivity, health, and marketing.

The Summit roster is rounded out by the extremely popular AI [artificial intelligence] Summit, plus a revamped Game Education Summit, and the return of the Game Localization Summit—with a number of notable Monday and Tuesday tutorials also to be announced in the near future.

Each individual GDC Summit has its own specialized set of expert advisors from that particular submarket, including notables like Playdom's Steve Meretzky (Social & Online Games Summit), the Institute for the Future's Jane McGonigal (Serious Games Summit), Disney Mobile/Tapulous' Bart Decrem (GDC Smartphone Summit), and Intrinsic Algorithm's Dave Mark (AI Summit).

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CHRIS CHARLA CLAWS SEATTLE

FORMER F9E BUSINESS DEVELOPMENT HEAD MAKES MICROSOFT MOVES

Chris Charla has had a long and varied career in the game industry, starting with a career in journalism (as editor-in-chief of Next Generation), moving on to Backbone as a producer, then parent company Foundation 9 Entertainment as the director of business development. Most recently, he's migrated up the west coast from his beloved Oakland to Seattle, where he will now work as portfolio director for XBLA at Microsoft. We caught up with Charla to find out why and how he made the shift.

Game Developer: *What made you decide to move from business development to publishing?*

Chris Charla: Ultimately it was the same thing that made me move from production to biz dev—an insatiable desire to learn new things! But also, I can go from working to help one (big) developer succeed, to working to help lots of different developers succeed, and that's a really good feeling. And I love XBLA. My whole career has been about small games, which I really like a lot more than gigantic games, and so the combo of small, focused experiences and the power of the Xbox 360 hardware is just an unstoppable combo for me.

GD: *As a creator, do you see opportunities to flex those particular muscles in your new venue?*

CC: I think if you're creative you use that in whatever you do. Right now I'm really more of an enabler, in terms of what I'm doing professionally though—helping developers position themselves for success on the platform, and being part of the team that's trying to help XBLA take over the world. I do get a free XNA Creators Club account though, so ...

GD: *What advice would you have, in the broader sense, for companies looking to submit their first XBLA title?*

CC: Look at some of the top XBLA games—LIMBO, TRIALS, CASTLE CRASHERS, SPLOSION MAN—those are all very focused designs. They all have one concept distilled down to its essence and polished to perfection. It's not a place for

“kitchen sink” design. The other thing is, as a designer, you know that every person who buys your game has an always-on broadband connection to the Internet. That's a really powerful luxury versus box software creators who have to plan for an offline experience as well. Don't be afraid to explore that space! Lastly, show your new game concepts early and often!

GD: *It may be a bit early to tell, but is there any trepidation about moving from being a large-ish fish in a medium-sized pond, to a medium-sized fish in an enormous pond?*

CC: Nah. The MGS group in general and the XBLA group in particular is pretty small and self-contained, so it doesn't feel big. It's amazing how much of a scrappy start-up vibe there is, because we have that feeling in the group that we're helping build part of the future of entertainment with a tight-knit team. But at the same time there's just these bonuses you get from working inside a big company, like the fact that we get to work with some of the coolest developers on the planet, and also there is this mega-corp backing you up with vast amounts of research and data, so it's pretty sweet. I mean, we have a PhD-staffed user experience team that works on every XBLA game we do. No one else does that. Maybe for their \$20M games, but not on XBLA. That's just awesome.

GD: *Isn't the Bay Area like, way cooler than Seattle? How do you deal with moving to an entirely new state for work?*

CC: I'm focusing on the positives, like how green and lush the environment is here, and how good the Japanese food is, and how it always smells like Christmas from all the pine trees. There are things I miss about the Bay Area, of course, like the friends, family, superior produce, higher-quality drivers and less traffic. Seattle is cool though. It has Shorty's which is a bar/arcade, and not even Oakland has that. Plus I've heard it snows here sometimes which will be cool. And it may be slightly more satisfying to see the A's beat the Mariners here than back in Oakland!



new studios

Former APB lead character artist Jimmy O'Ready has launched character and concept art studio Montynero, the first start-up to rise from the ashes of developer Realtime Worlds.

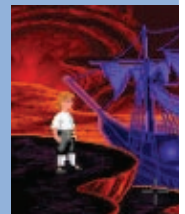
Brad Johnson, former programmer on LARA CROFT: GUARDIAN OF LIGHT, has started a new iPhone studio called Be-Rad Entertainment.

Several veterans from Polish developers CD Projekt and Metropolis Software have formed 11 Bit Studios, a new developer focusing on digitally-distributed games.

Rolf Kloppel, veteran of online game publisher Frogster, has founded Neonga, a company specializing in free-to-play titles for the European market.

who went where

Though it's been nearly two decades since they last collaborated, fellow MONKEY ISLAND humor pioneers Ron Gilbert and Tim Schafer will be teaming up again at Schafer's studio, Double Fine.



The Academy of Interactive Arts and Sciences announced former Sunleaf Studios CEO Martin Rae will take the reigns as president of the organization, replacing former president Joseph Olin.

Warner Bros. has appointed mobile media veteran Greg Ballard as the company's new Senior Vice President for Digital Games, Digital Distribution and Interactive Entertainment, overseeing the company's digital distribution, mobile, MMO and games on-demand titles.

KATAMARI DAMACY and NOBY NOBY BOY creator Keita Takahashi has left Namco Bandai, and has expressed interest in pursuing work outside of the game industry.

Disney named Playdom CEO John Pleasants co-president of Disney Interactive Media following the departure of former division head Steve Wadsworth.

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STUDENTS GONE PRO

AND YET IT MOVES BEGAN LIFE AS A STUDENT PROJECT AT THE VIENNA UNIVERSITY OF TECHNOLOGY. AFTER THE PROTOTYPE ENJOYED A WARM RECEPTION FROM PLAYERS WHO PICKED UP ON THE GAME'S CLEVER ROTATING WORLD MECHANIC AND ITS UNIQUE PAPER COLLAGE ART STYLE, THE TEAM DECIDED TO GO PRO. CALLING THE COMPANY BROKEN RULES INTERACTIVE MEDIA, THE TEAM SPENT THREE YEARS POLISHING THE GAME AND HAS SINCE RELEASED COMMERCIAL VERSIONS FOR THE PC, MAC, AND LINUX, AS WELL AS A WIIWARE EDITION. WE SPOKE WITH PROJECT LEAD FELIX BOHATSCH TO FIND OUT MORE ABOUT THE JOURNEY FROM STUDENT TO PROFESSIONAL.



Jeffrey Fleming: *What tools were you using to build AND YET IT MOVES as a student project?*

Felix Bohatsch: From the beginning we made AND YET IT MOVES with Torque Game Builder. At first it was really nice, because TGB is great for prototyping. But making a full game is a whole different story, and the more the project grew, the more problems we had with TGB. But we stuck with it to the end. Even AND YET IT MOVES WiiWare was done using TGB, but in a heavily modified version.

JF: *What led you to the decision to make a commercial version of the game?*

FB: During the University course we finished a prototype with two levels and submitted that to the IGF in 2007. We were part of the Student Showcase 2007, and showed our prototype to all the people at GDC. Being there was really great and gave us a big boost in press coverage and motivation. AND YET IT MOVES was also a finalist at IndieCade 2007 and 2008. Both festivals showed us that many people really liked our game mechanics and enjoyed playing the prototype. This helped us decide to take our chances and build a full, commercial version.

Also, indie gaming was getting bigger every minute, Steam was already hot, and all game consoles had their own online market, so the promise of successful indie game development was there. We felt it

would be a waste of an opportunity to leave AND YET IT MOVES in the prototype phase.

Once we made this decision, the money question came up. Luckily we are based in Vienna, Austria and we have good creative-industry-subsidies. Gaming was a hot topic there as well, so after a lot of paperwork we managed to get a comfortable sum. This meant we could focus all our non-study time on developing AND YET IT MOVES.

JF: *What was the most difficult aspect of going pro?*

FB: The most difficult aspect is running your own business. We are all developers who love to make games, but we have no one on the team who loves to organize a team, do business, or PR. This means we have to split these roles up, which takes a lot of time away from actually designing and developing a game. This can be quite frustrating!

The upside of having our own game company is that we can make the games we like to make. We are a small business—we're five people at the moment—so we have more freedom with what we want to try out or experiment. But what's sometimes really stressful is chasing money. Even if we can work on whatever we want, we have to keep an eye on the financial side. Suddenly business decisions influence our game design, and all of a sudden we're not as free as we originally thought. Finding a balance

between making money and doing what we love is really hard.

Also, I found that running a business also means it's really hard to stop thinking about your business. Finding a good work-life balance and being able to enjoy your free time is another hard challenge!

JF: *How did the creation of the WiiWare version go? Was it easy to port?*

FB: It turned out great, but it did take longer than we expected and it's mostly been a technical challenge. We had never worked on a console so we were not used to such a strict environment where you have to watch everything you put into the game. More importantly, we had never really optimized on the PC and Mac version—which resulted in quite high system requirements—but it wasn't such a big problem on these platforms. Going to Wii, with its underpowered hardware, meant we had to do a lot of rewrites and performance improvements. We had to dig really deep into TGB for Wii and improve it in many ways to get AND YET IT MOVES running smoothly on the console. We learned a lot about programming though, and now feel that we are able to deliver our games on any hardware that is out there.

JF: *Was your approach to art direction any easier to implement in the game than a polygon-based look?*

FB: From an artistic standpoint, definitely. That design mostly arose out of necessity. We are a team of computer science students, so we lacked a specialized visual game artist. We looked for a style we liked that we would be able to produce. The roughness and analog feel of a world set in a paper collage provided just what we wanted,

without the necessity of artists building it.

But from an implementation standpoint, I think it was more work than a traditional polygon-based look. Our levels took a lot of time, as all pieces had to be manually placed. We started by ripping apart a lot of paper and scanning it in.

With a base set of pieces of paper in different forms and sizes we built the levels, which proved to be a quite tedious task. Making the levels look good took a lot of effort, so next time we might go for a different look. But then again, all the work paid off, as the art style made AND YET IT MOVES stand out, and lots of people dig it.

JF: *Do you have any hard won advice for other student development teams who are considering going pro?*

FB: The most important thing when you start developing an idea for a game is to focus on the key gameplay mechanic. If you already have a setting or a genre for your game, think of what can be added to it to make it a fun and unique experience. Don't try to make the next HALO or a huge MMO.

Focus on what is realistic to finish and don't try to compete with the big players. You can't stand-up against a team of 300 people, so instead do what's difficult or even impossible for them—be innovative and experiment.

It's actually quite scary how much work a good game is. We worked for three years—part and full time—on AND YET IT MOVES and most people still complain that it's too short. Even indie games need a lot of polish nowadays and this will take a lot of time, so subtract from your design and only keep what is absolutely necessary.

—Jeffrey Fleming

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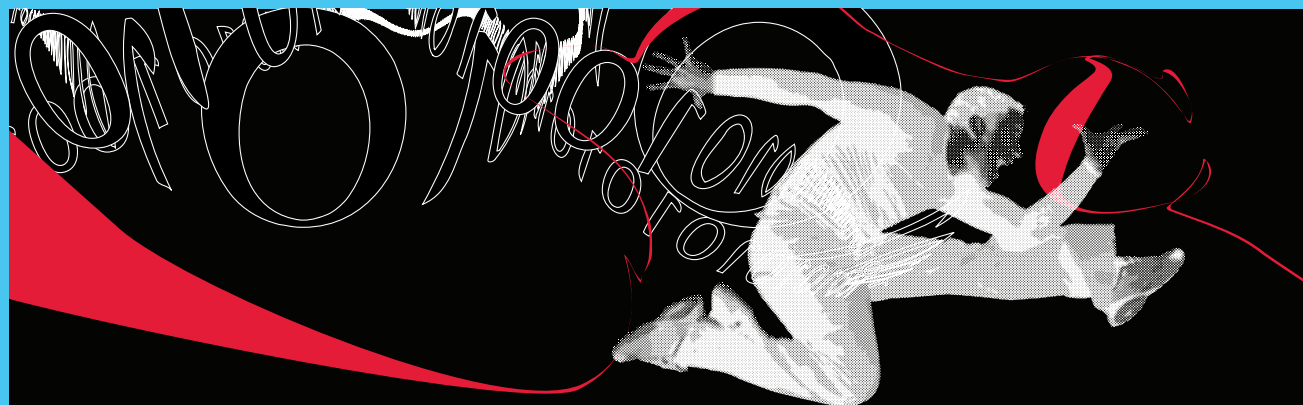
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THE 25TH ANNUAL GAME BOSS CONFERENCE

A REPORT FROM THE SHOW FLOOR

THE INTERNATIONAL VIDEO GAME Boss Association recently held its 25th annual show at the bottom of the 99-story Bonus Dungeon, and as usual Game Developer magazine was on hand to report from the convention.

A VETERAN HAS HIS SAY

» Kicking off the conference was a keynote speech from well-regarded longtime villain Bowser, whose talk titled “Bowser: I’m Still the Best,” was an oft-cited discussion point during the rest of the week.

“I’ve seen a lot of shifts in the boss industry in the last 25 years,” Bowser noted, “but one thing has never changed: the fact that I’m awesome.”

Bowser then launched into a stinging criticism of modern character design as practiced by today’s triple-A industry.

“Look at this beautiful, iconic design,” Bowser said, pointing toward a PowerPoint slide with a picture of him on it. “I look great! Everyone knows that it’s me—Bowser—when I come to kidnap Princess Peach and take over the Mushroom Kingdom once and for all!”

Bowser then advanced the slide, showing a screenshot of a complex electromechanical lobster-like object from *FINAL FANTASY XIII*.

“Okay, look at this thing. What is that, even?” Bowser asked, to laughter and applause. “I can’t even tell if it’s facing me or away from me! Come on, people. Just put me in there instead!”

STICKING TOGETHER

» The night before the expo floor opened, the Spider Queens in the Video Game Industry SIG held a casual mixer at a nearby bar. Spider Queens from *DARKSIDERS*, *OKAMI*, *LORD OF THE RINGS ONLINE*, *DOOM 3*, and other titles shared stories from the front lines, discussed attack patterns, and pledged to support each other in issues of mutual interest.

“Over the next several years it’s going to be important for us to

challenge some of the long-held notions about Spider Queens,” said one, who was named, simply, The Spider Queen. “You know, we tend to be this sort of reliable but generic enemy, one that’s just a stepping stone for the player before he or she moves on to the real boss. We hope to change that. We also want more realistically nuanced leg animations, better-voiced screams and wails, and more attention paid to our spider-silk effects.”

DIRECTIONS FOR DIALOGUE

» A well-attended talk on the second day was Boss Dialogue: Beyond Taunts, Put-Downs and Catchphrases, given by *DIABLO II*’s mid-boss Duriel. In his speech, the giant, clawed, maggot-bodied creature exhorted his colleagues to re-examine some of the clichés that video game bosses have come to rely upon over the years.

“Those tired old phrases like ‘You won’t get past me,’ or ‘Ha! This is where your journey ends’—we can do so much better than this,” he said. “I urge you all to get involved with the process early on, ask questions, and advocate for what you think is the smarter thing to say. That’s the only way we’re going to change the current situation.”

During the question and answer period, a hooded chainsaw zombie from *RESIDENT EVIL 4* stood up and attempted to challenge the hard-hitting Lesser Evil.

“So, I totally appreciate the points you’ve made, and I mean no disrespect,” he said, “but I was listening to you talk, and just felt compelled to ask: wasn’t, like, your only line in *DIABLO II* ‘...Looking for Baal?’ I mean, how do you reconcile that with the kinds of things you’ve told us today?”

“Sure. I’m not saying I’m perfect in every regard,” Duriel responded. “At the same time, I’d argue that the line is quite context-sensitive: it shows that I know about the player’s goals and about the world I occupy. Of course, we didn’t have



ILLUSTRATION BY STEFAN POAG

a lot of time during production on *DIABLO II*, but I did put as much effort as I could afford into that speech. And I do think it paid off.”

BUT ARE WE DOOMED?

» Spirited discussions aside, there was no escaping the air of soul-searching at this year’s show. The expo seemed more subdued than it has in past years, with only the bottom three floors of the Bonus Dungeon occupied this year as opposed to as much as five in years past. Talks with titles such as *Mettle Madness: Are Normal Maps Making Us Too Ugly?* and *Moving Past the Traditional Eye Laser Sweep* pointed towards a community at a crossroads, still struggling to define its place in a rapidly changing world.

One panel in particular seemed to capture the somber mood. Do Bosses Still Matter in the Social Game Era? reflected on the worries that casual, Facebook-style social games are eroding the conventional place of the boss in video game design. But the discussants—the “alien baby” Nihilanth from *HALF-LIFE*, Lavos from *CHRONO TRIGGER*, and Akrid X from *LOST PLANET 2*—mostly sat around without much to say, except for an occasional gurgling sound.

After a particularly protracted silence, Lavos appeared to sum up everyone’s feelings when he opened and closed his tripartite jaws, then said, “Gwwwwrrrrrrlbp!”

MATTHEW WASTELAND writes about games and game development at his blog, *Magical Wasteland* (www.magicalwasteland.com).

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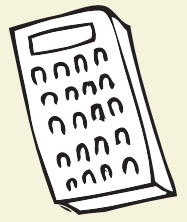
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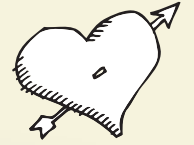
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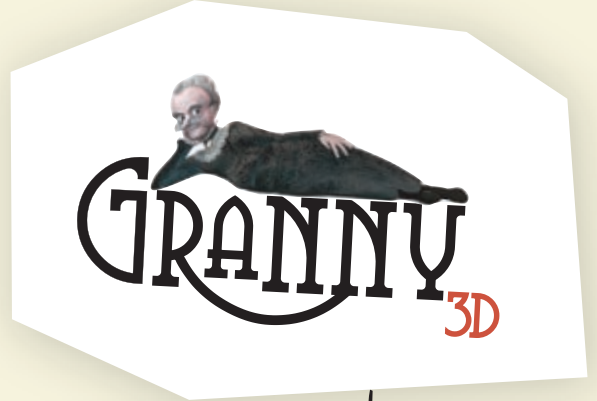
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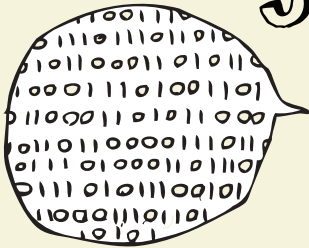
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