

# game developer

THE LEADING GAME INDUSTRY MAGAZINE

▶▶ **ARRESTED DEVELOPMENT**

NEW HUMOR COLUMN FOR  
MAXIMUM AMUSEMENT

▶▶ **PIXEL PUSHER**

USING FACIAL STRUCTURE  
TO LOWER ART BUDGETS

▶▶ **EVERYTHING IS ILLUMINATED**

AMBIENT OCCLUSIVE SHADING  
FOR SHADOWY CHARACTERS

**POSTMORTEM:**  
**INFINITY WARD'S**  
**CALL OF DUTY 4**





**CREATE**

In *Assassin's Creed*, Ubisoft used Autodesk® 3ds Max® software to create a hero character so real you can almost feel the coarseness of his tunic.

**ANIMATE**

Autodesk® MotionBuilder™ software enabled the assassin to fluidly jump from rooftops to cobblestone streets with ease.

**INTEGRATE**

Using Autodesk® HumanIK® middleware, Ubisoft grounded the assassin in his 12<sup>th</sup> century boots and his run-time environment.

**HOW UBISOFT GAVE  
AN ASSASSIN HIS SOUL.**

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## POSTMORTEM

### 24 INFINITY WARD'S CALL OF DUTY 4

CALL OF DUTY 4 is one of the most critically acclaimed games of 2007, and the authors make no secret of their pride in the product. Still, there are many important lessons in here, from sticking to your ideals for a game (even if you aren't completely in charge of the series), to maintaining focus when alluring new IPs loom.

*By Zeid Rieke and Michael Boon*

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## FEATURES

### 6 TOP 50 DEVELOPERS

This list attempts to empirically rank the top 50 developers in the world, which released games in 2007—no simple task. Ranking is based on game sales, review scores, and developer responses. This is the first in an annual series of rankings, but the top five indicate that it takes more than releasing the most titles to get into the top spots. Now fight on for 2008!

*By Trevor Wilson*

### 19 AMBIENT OCCLUSIVE CREASE SHADING

Ambient occlusion can be expensive and artist-intensive. For their new MMO, the authors wanted a screen-based approach for whatever happened to be in the scene at the time, without additional artist input. Ambient occlusive crease shading is the result of their search, and winds up being a very cheap, but pleasant-looking alternative.

*By Megan Fox and Stuart Compton*



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## WHO'S AFRAID OF GAMESTOP?

**SHAMEFULLY, ALMOST EVERYONE IN THE INDUSTRY** seems to be afraid of retail. I spoke with a number of people at the DICE Summit recently, and while some agreed that digital downloads are making headway, nobody sees it replacing retail.

One trend I've noticed in talking to people about this issue is that there's a tinge of fear of retailers, GameStop in particular, as though that relationship needed protecting. We don't want to badmouth them or ignore them because we don't want to make them mad. But how much do they really do for us these days? GameStop makes the vast majority of its profits off used games, as we all know, of which game developers make nothing, and it's the largest shop in which to purchase electronic entertainment.

To encourage consumers to buy used games, GameStop often has limited stock of new releases—when was the last time you were able to buy a large new release from GameStop without a preorder? Did you then drive a few miles to a Best Buy or a Target and see the game in piles? It doesn't take a genius to see what's happening here, when GameStop makes 50 cents on the dollar for a used game, versus 21 cents on the dollar for a new one. Since GameStop and Game Crazy are the only major retail outlets in which consumers can resell games, those outlets will be the ones selling them used, no matter where consumers bought them.

### WHY BE NICE?

Why then do publishers and developers by extension, so carefully defend GameStop and their ilk? Why not move to digital distribution? Why aren't downloads the dominant model for PSP games? Nobody is returning Xbox Live Arcade or PlayStation Network titles, and consumers aren't complaining either, because the games only cost between \$5 and \$15 apiece. On top of that, consumers can try the game before buying it.

Circuit City has recently hinted that it will begin selling more used games. This likely means more games sold, but less profit for the industry itself. So why is everyone afraid to bash retail? Now is the time to do something about this. Some games already can't even make it into GameStop, and are only sold online in places like Amazon.com. Why then, do we kowtow to GameStop, and indeed, let their buyers choose what games may grace their shelves?

To boil down a very complex issue, it seems to me that it's because we let them. It's not possible to outlaw used game sales, I can't pretend that. It's been attempted in Japan—almost any import Dreamcast game or early PlayStation 2 game will have a "not for resale" warning on the back, but it gets resold anyway. Retailers rely on developers and publishers for content, but they make more money off the games than we do, in many cases.

Further, it is publishers who decided to distribute games only to larger retailers, largely for cost reasons, thereby concentrating the power of retail. Perhaps there are some extra feelings of commitment in there. But you don't stay in a failing relationship for the sake of tradition, do you?

### COLD FEET

Industry leaders seem to be wary of moving online for a few reasons; not everyone has a game-capable PC, downloads can be large and slow, and then there's piracy. But console game downloads are also becoming quite viable (WARHAWK), with full games released on all major consoles now, even on the PSP. People will wait for downloads, and broadband penetration is better than ever, besides. As for piracy, how many people are pirating WORLD OF WARCRAFT? Or Steam? (I must note that in other cases, piracy is rampant—see Heads Up Display on page 5 for more.)

My developer friend Thomas Grové has an idea for a content delivery portal for PCs in which a single person, or group of persons with a little money put together a non-profit portal. This portal would take only 5–10 percent of the games' revenue (or whatever it took to maintain minimal staff), and give the rest to the developer directly. In this scenario you could charge much less as a developer and still make decent money if your game is any good. It would move developers from being work-for-hire to work-for-profit. If someone had the time, energy, or resources to accomplish this, it would be the defacto delivery platform for game content and service the industry as a whole more than it would service a specific company. I'm not totally sold on this idea, but it's a step in the right direction. That's what we should be thinking about now—how can we get content into the hands of consumers without giving a third party a big piece of the pie? I'm asking you. I'm not the creative genius here, I just ask the questions.

—Brandon Sheffield

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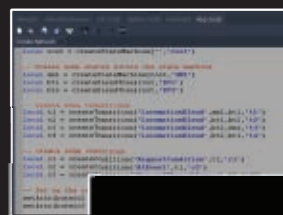
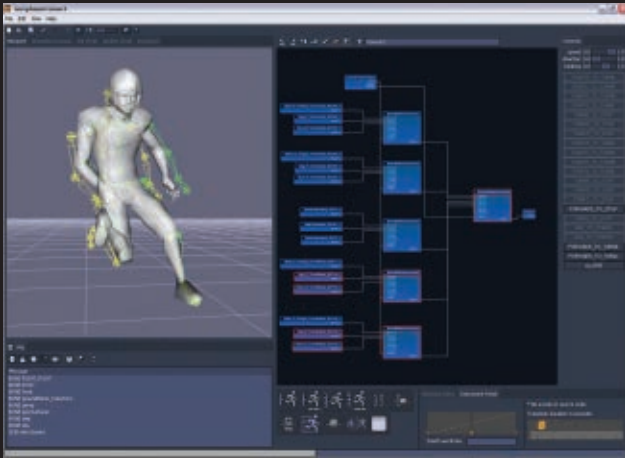
advanced animation system

morpheme is the industry's first graphically authorable animation engine. morpheme consists of morpheme:runtime: an advanced runtime animation engine for PLAYSTATION®3, Xbox 360™, Wii™ and PC. morpheme:connect: a highly-customizable 3D authoring application.

morpheme gives animators and developers unprecedented control over the look and feel of their animations in-game: blends, transitions, compression, etc. can all be previewed and modified graphically in morpheme:connect and live on the target platform.

morpheme:runtime ships with full source code and integrates seamlessly with euphoria, NaturalMotion's Dynamic Motion Synthesis technology.

For more information, visit [www.naturalmotion.com](http://www.naturalmotion.com)



## scripting

Full Lua scripting for automating tasks, adding AI logic or polling game pads for real-time input



## timeline

Graphical mark up of animation data to add one-shot and duration events, for highlighting footfalls, sound effects, etc.



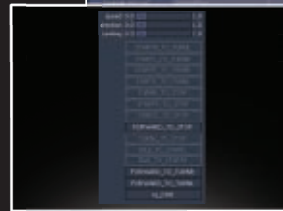
## node palette

Advanced blend notes for dragging and dropping into transition network. Fully customizable node types through C++ and scripting



## animation browser

Easy browsing and selection (drag & drop) of source animation. Animation list is automatically updated to reflect changed source files

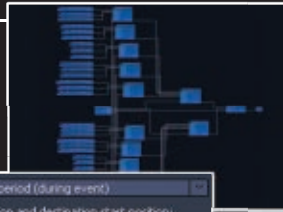


## transition requests

Exposure of custom transition messages. In-tool emulation of interaction between morpheme:runtime and game AI system

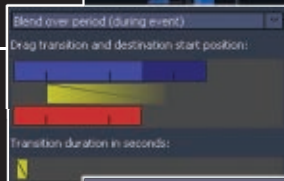
## blend tree

Advanced graphical tools for building complex blend trees. Real-time visualization of animation source contribution through node highlighting



## blending

Graphical control of transition blending between states in the transition graph



## multiple characters

Visualization of multiple runtime characters in morpheme:connect for easy authoring and analysis of character interaction



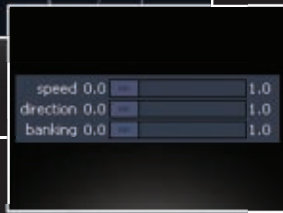
## network

Advanced graphical tools for creating and visualizing transition networks through drag-and-drop



## control parameters

Exposure of custom high-level controls for entire animation system. Real-time manipulation through sliders or game pad controller



## OVERHEARD AT DICE



### Min Kim

**Director of Game Operations for Nexon America (MAPLESTORY)**

on popular misunderstandings of the free to play, pay for items model.

"I don't want to discount people, but I don't think they're doing the right research, because I see the misconceptions people have about what our business is. If they were to ask the right questions we'd probably tell them, or at least if they'd go and experience our games. A lot of people talk about us and say, 'Hey, this can't work, or doesn't have the right balance,' et cetera, and when I ask them, 'Have you played it? Have you seen it?' and they're like, 'No, but [I know] it's like this!'"

"I think a lot of people think it's a product and that it's going to turn into a cash cow, so you make the product that you finish, and then you open it up and start selling some items in it, and then you get a continued steady revenue stream, and that's not what it's about. You've got to constantly feed in content to keep players engaged. It's about social experiences—again it's a service, not a product—and there are various things people just don't get.

"I think that people just now getting into it don't realize they need to have a live team. After you develop the product and it goes into commercial service, you need a live team to provide content for that. A lot of people look at it like 'let's make it, and then let's do something else. Let's move on to the next project.' You can't do that."



### Roger Hector

**Vice president of product development of Namco Bandai Games America (AFRO SAMURAI)**

on the failures of Sega's Saturn console while he was at STI, which paints a powerful allegory [the editor's words, not his] for contemporary consoles.

"One of the real failures that took place was that Sega was in a rush to get this hardware out, and there were no tools, there was no documentation. A lot of the basic stuff that you really need in order to develop something wasn't there for a long time. Outside developers were totally left out to lunch. They didn't stand a chance. We had the small advantage of at least being able to pick up the phone and at least call Sega and ask some questions. But we didn't have documentation or anything either. It was very hard to develop for.

"Another fundamental problem with Saturn was that it was a fairly complex system by design, and it was intended to have a high ceiling above it in terms of what could ultimately be accomplished. The strategy was that Saturn might be a little harder to work with initially, but longer-term, with more and more use and developer expertise, developers could get more and more out of the Saturn than a comparable PlayStation. That was the theory. The reality was it was hard to work with. It took a long time to get there, and without sufficient help and support available, Sega also pretty much lost a lot of the ongoing support of third parties."



### Joe Ybarra

**Senior vice president of strategic operations for Cheyenne Mountain Entertainment (STARGATE MMO)**

on why the company has four internal teams before releasing a single product.

"If you look at what it takes to be a real player in our industry, part of what's made the better companies successful is that they have scale. And part of that is of course if you build a project like [Cheyenne Mountain's MMO STARGATE WORLDS], and you've got a lot of people working on it, and the project ships—what do you do with all these people, regardless of whether it's successful or not?"

"Typically speaking, if you have a one-product company, this typically means a lot of people are either laid off or they have nothing to do during preproduction. So when you have multiple studios it gives us the ability to shift people and resources around, and to get better leverage over what we have, so to that extent it's a good idea.

"As far as the quantity is concerned, a lot of that goes back to the investment strategy in our company. In order for investors to get the return on investment that they'd like, we really have to have more than one product. And given that these products take a very long time to build, and you're looking at a five-year plan to deliver the content to the audiences, you really do have to have multiple projects going on, and that's really what fuels the expansion of our organization."



### Masaya Matsuura

**CEO of NanaOn-Sha (PARAPPA THE RAPPER)**

on the current stagnancy of music in games.

"Most games these days seem to use gorgeous orchestral soundtracks. While they may generally be lovely to listen to, if we really think about it isn't it all a bit lacking in imagination?"

"Thinking about it from a visual perspective, while films are basically just watched, games are interactive. The duties involved and objectives set are also different, so film and games cannot really be the same. On the other hand, music is basically the same in movies or games. Despite this wonderful opportunity to advance music with this new medium, it seems unlikely that new and bold ideas will come about.

"It's actually not unreasonable to think that unimaginative forms of expression will slowly die out as a new form of entertainment matures.

"Just looking at the past 10 years we can see that there have been drastic changes in the way we use music. From now on, if we do not make great efforts to ensure progressive use of music in representative mediums, we could be faced with a steep decline."



# CASUAL GAME PIRACY



## RUMINATIONS BY REFLEXIVE

**IN A RECENT COLUMN FOR GAMASUTRA,** Reflexive's director of marketing Russell Carroll revealed a 92 percent piracy rate for *RICOCHET INFINITY*, one of his company's flagship titles. The company was confronted with a queasily high piracy rate after comparing downloads and sales with the number of people playing the game online. "As we sat and pondered the financial implications of such piracy, it was hard not to get past the magnitude of the number itself: 92 percent," Carroll wrote.

Combating piracy is a constant issue for the casual games industry, which relies almost exclusively on Internet distribution for its products. "Search for any casual game through Google, add the word 'crack', and the search engine will help you find and illegally acquire every casual game you can imagine," added Carroll.

The easiest way for a user to defeat a poorly designed digital rights management (DRM) system is by exploiting loopholes in the program such as deleting a demo's time limit or making changes to hidden .exe files. The next step up in difficulty is to utilize a separate keygen program that has been reverse-engineered to generate valid serial numbers for the game. The final method involves "cracking" the game by altering its code base that disables the DRM, enabling it to be distributed online DRM-free.

Because Reflexive uses its own internally developed DRM rather than licensing it from a third party, the company has been able to closely correlate updates to its DRM with game

sales. After looking at the numbers, Carroll argued that making improvements to a game's DRM system can result in higher sales but wondered whether a pirated copy is in fact a lost sale.

### FIXES OR FOLLIES

Closing up loopholes that could be exploited and making changes to Reflexive's serial number system to render existing keygen programs obsolete had the most dramatic effect on sales, pushing them up 70 percent. However, the fixes also resulted in 33 percent fewer downloads. Further tightening of the company's serial number algorithms to counteract keygen programs resulted in slightly lower sales but had no effect on downloads. Working to make existing cracks obsolete had little effect on sales or downloads. After the release of *RICOCHET INFINITY*, Reflexive made its software installers game-specific to further neutralize keygen programs, bringing sales up 13 percent while reducing downloads 16 percent.

By examining the reduction in downloads along side increased sales, Reflexive concluded that its DRM fixes resulted in one additional sale for every 1,000 fewer pirated downloads. "Though that doesn't make a 92 percent piracy rate of one of our banner products any less distressing, knowing that eliminating 50,000 pirated copies might only produce 50 additional legal copies does help put things in perspective," Carroll concluded.

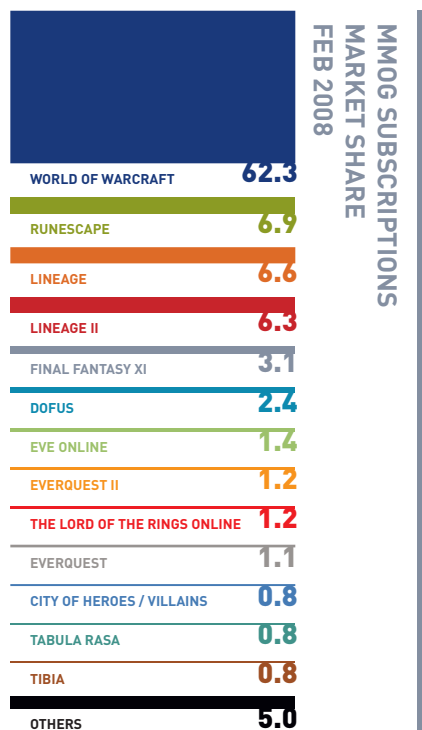
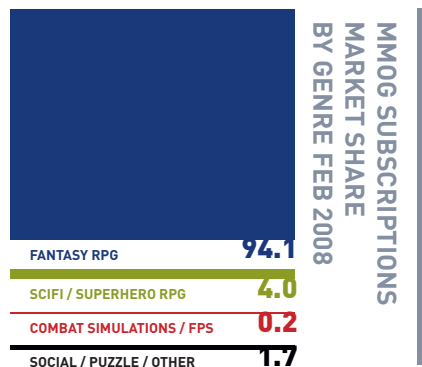
—Jeffrey Fleming

## MMO BREAKDOWN

**TOTAL ACTIVE MMOG SUBSCRIPTIONS** HAVE reached more than 16 million in North America as of January 2008, according to MMOG analyst Bruce Sterling Woodcock of MMOGchart.com, showing the importance of the MMO to the future of the game industry. This does not fully take to task the hugely growing free-to-play MMO market.

Shown here are two charts, also current as of January 2008, representing the marketshare for many of these subscription-based titles, as well as a breakdown of subscription-based MMOs by genre. With *WORLD OF WARCRAFT*'s announcement of breaking the 10 million subscription barrier, this means the rest of the market is battling for that 6 million plus against each other. Is this really an MMO market, or is it a Blizzard market?

—Brandon Sheffield



## CALENDAR

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**Penguicon Science Fiction and Open Source Software Convention**  
Troy Hilton  
Troy, Mich.  
April 18–20, 2008  
Price: \$40  
[www.penguicon.org](http://www.penguicon.org)

**CGAT '08—Computer Games & Allied Technology**  
Springleaf Tower  
Singapore  
April 28–30, 2008  
Price: \$960 (SGD)  
[www.cgames.com.sg](http://www.cgames.com.sg)



# DEVELOPERS

» WELCOME TO THE FIRST ANNUAL TOP 50 DEVELOPERS FEATURE! We've gathered all sorts of data on all sorts of developers from around the world, and we've combined that with the results of an opinion survey conducted by our Web presence, Gamasutra.com. For each developer, we've considered the following: U.S., U.K., and Japanese sales charts, number of games released, and average Metacritic review score, all for games released in 2007. Companies that did not release games in 2007 were not considered for this ranking. Our anonymous survey asked readers to score developers from 1 to 10 on overall reputation and to offer any comments they may have. Plus, it asked readers with direct experience with developers to rate them on their overall experience, pay and perks, professionalism and competency, and how likely the respondent would be to work with—or at—that developer again. The result is the only empirical ranking out there. Enhanced and full feedback, charts, and stats are available for this report at [Gamedevresearch.com](http://Gamedevresearch.com). Let's get started, shall we?

CONTINUED ON PG 8





gamedeveloper  
**FRONTLINE**  
FINALIST '07

*"ReplayDIRECTOR rocks. I doubt we'd have found it otherwise. It turned out to be an occasional array overwrite that would cause random memory corruption..."*

■ Meilin Wong, Developer, Crystal Dynamics



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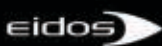
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CRYSTAL  
DYNAMICS



XBOX 360



XBOX



# DEVELOPERS

CONTINUED FROM PG. 4

## 50. BIG HUGE GAMES

(AGE OF EMPIRES III: THE ASIAN DYNASTIES, CATAN)

**BIG HUGE WAS TASKED IN 2007 WITH CREATING AN EXPANSION** pack for the hit RTS AGE OF EMPIRES III. It also produced an Xbox Live Arcade version of CATAN, a respected and popular board game. The two titles combined to achieve an average review score of just above 80 percent for the studio. Its performance last year seems to bespeak a studio on the verge of greatness, and employees commenting in our survey spoke of how they "love it" at the company: "They listen to people and tailor your job to fit your skills." This Maryland studio has recently been acquired by THQ.

## 49. OBSIDIAN ENTERTAINMENT

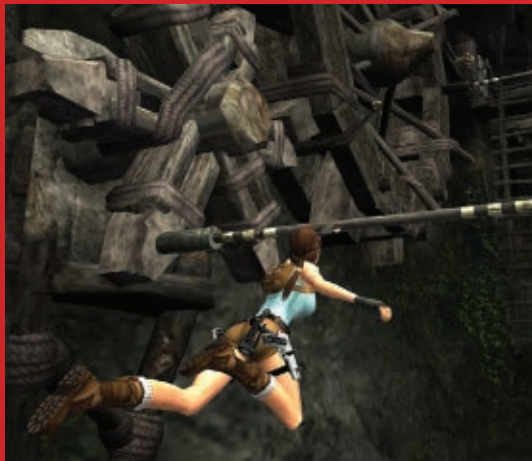
(NEVERWINTER NIGHTS 2: MASK OF THE BETRAYER)

**LAST YEAR THIS INDEPENDENT DEVELOPER FOLLOWED UP ON** its hit PC RPG sequel NEVERWINTER NIGHTS 2 with a new expansion pack, which was quite favorably reviewed and well-received by fans. Our survey reflected this, as the studio scored high in both the reputation-related and specific categories. Obsidian was also praised by employees for its leadership, its "professional yet relaxed environment," and "great perks."

## 48. CRYSTAL DYNAMICS

(TOMB RAIDER: ANNIVERSARY)

**CHARGED WITH REVIVING THE TOMB RAIDER SERIES, THIS** SCI/Eidos-owned San Francisco developer went on to further demonstrate that it had what it took to not only fix, but also improve upon the original work done by Core Design. The studio released a multiplatform update to the first TOMB RAIDER game titled TOMB RAIDER: ANNIVERSARY to good reviews and respectable sales.



Crystal Dynamic's TOMB RAIDER: ANNIVERSARY.

## 47. SUMO DIGITAL

(VIRTUA TENNIS 3, BROKEN SWORD: THE ANGEL OF DEATH)

**EARLY IN 2007, THIS ENGLISH DEVELOPER WITH TIES TO THE** departed Gremlin Interactive released BROKEN SWORD: THE ANGEL OF DEATH, which it developed as an outsourced project for Revolution Software. And in March, Sumo continued its excellent

relationship with Sega by releasing ports of VIRTUA TENNIS 3 for Xbox 360, PSP, and PC. These ports were the studio's biggest sales and critical successes for the year. Studio employees commenting in our survey had good things to say about their time at the company, especially the "nice, laid back atmosphere," and the fact that "the games are really cool!"



NINJA GAIDEN SIGMA from Tecmo.

## 46. TECMO

(NINJA GAIDEN SIGMA)

**TECMO'S ONLY MAJOR WESTERN RELEASE LAST YEAR WAS** NINJA GAIDEN SIGMA, its PlayStation 3 reworking of its Xbox hit. It did make a brief appearance on international sales charts, but Tecmo's major seller for the year was its Japanese-only detective DS title NISHIMURA KYOTARO SUSPENSE. SIGMA and SUPER SWING GOLF SEASON 2 did work together to bring the developer a respectable overall critical opinion though, and fans of the Tokyo studio and its internal Team Ninja gave it overall high marks in our reputation survey.

## 45. SPORTS INTERACTIVE

(FOOTBALL MANAGER, OUT OF THE PARK BASEBALL)

**THIS HIGHLY-SPECIALIZED SEGA-OWNED LONDON DEVELOPER** only released one title in the U.S., but its hardcore text-based simulation OUT OF THE PARK BASEBALL 2007 was a resounding critical success here. It raked in a huge 97 percent average review score, beating out the studio's two 2007 U.K.-only FOOTBALL MANAGER titles, and bringing the Sega-owned studio's review average up to 86 percent. At home, the similarly text-centric FOOTBALL MANAGER 2007 and 2008 both sold well for Sports Interactive.

## 44. SEGA OF JAPAN

(MARIO & SONIC AT THE OLYMPIC GAMES)

**THE HOME STUDIOS FOR TOKYO-BASED SEGA (THOSE EXCLUDING** Sonic Team, AM2, and AM3) had a rather quiet year and focused mostly on the Japanese market. At home, the latest LET'S MAKE A J-LEAGUE SOCCER TEAM! title and the ancient-China card-battler SANGOKUSHI TAISEN DS did well. But the international-friendly MARIO & SONIC AT THE OLYMPIC GAMES sold well the world over and brought



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# DEVELOPERS

the most success out of Sega's 2007 lineup. It was also the only title reviewed in the West, and managed a relatively inoffensive 69 percent average.

## 43. RETRO STUDIOS

(METROID PRIME 3: ECHOES)

NINTENDO'S AUSTIN STUDIO PUT THE FINISHING TOUCHES ON its third METROID PRIME game in 2007, this time with controls adapted specifically for the Wii and more of a focus on character interaction. The studio's efforts did not go unnoticed, garnering 90 percent review average, great sales (over a million as of the end of December), and high marks on our reputation survey.

## 42. MASSIVE ENTERTAINMENT

(WORLD IN CONFLICT)

MASSIVE HAS BEEN AROUND FOR QUITE A WHILE, BUT IN 2007

the Swedish developer gained a good deal of well-deserved attention for its fast-paced RTS *WORLD IN CONFLICT*. It grabbed a sterling 89 percent review average and made a respectable showing on the PC sales charts. Massive also did well on our survey, with favorable scores in all categories and positive comments from our readers. One reader spoke of a "very friendly atmosphere" with "lots of very smart people," and another spoke of his or her "ability to speak up about anything to anyone."

## 41. AMAZE ENTERTAINMENT

(SHREK THE THIRD, THE LEGEND OF SPYRO: THE ETERNAL NIGHT)

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Entertainment, Amaze itself consists of several smaller studios, acquired over the years. The bulk of its projects this year were portable titles based on current movie franchises like *SHREK* and *PIRATES OF THE CARIBBEAN*. Most of Amaze's 2007 lineup was met with indifference from reviewers, but an 80 percent review average for a latter-day Game Boy Advance version of *THE LEGEND OF SPYRO: THE ETERNAL NIGHT* proved to be the biggest surprise for this developer.

## 40. FIRAXIS

(SID MEIER'S PIRATES!, CIVILIZATION IV: BEYOND THE SWORD)

A NEW CIVILIZATION IS DUE FOR RELEASE IN LATE 2008, BUT

2007 was somewhat quiet for Take Two-owned Firaxis. Last year saw a PSP port of the 2004 update of Sid Meier's classic swashbuckler *PIRATES!*, as well as a second expansion pack for the empire-building sim *CIVILIZATION IV*. Both were treated kindly by critics, making for an 84 percent review average for the Maryland studio. Firaxis also received many kind words from respondents to our survey, who called their time at the company a "great experience" in two separate instances and praised the company's creativity.

## 39. EA UK STUDIO

(HARRY POTTER AND THE ORDER OF THE PHOENIX, BURNOUT DOMINATOR)

HARRY POTTER WAS DEFINITELY THIS SATELLITE STUDIO'S FOCUS for 2007, as *ORDER OF THE PHOENIX* was prepared and released for a grand total of eight different platforms in time for its associated movie's release in June. It sold extremely well, but



Pawapuro Production's *MLB POWER PROS*.

critics were mostly indifferent to it. *BURNOUT DOMINATOR* did better by reviewers but didn't manage to put in a showing with sales charts. Survey scores for this studio on both reputation and specific categories were similarly ho-hum.

## 38. PAWAPURO PRODUCTION

(MLB POWER PROS)

THIS SOMEWHAT OBSCURE, INTERNAL KONAMI TEAM MADE its U.S. debut in 2007 with the charmingly cute *MLB POWER PRO* games, which both scored over 80 percent with U.S. reviewers. In Japan, the team published a variety of baseball games during the calendar year and created a formidable presence on Japanese sales charts. *JIKKYOU POWERFUL PRO BASEBALL 14*, the latest in a long running series of baseball games with roly-poly players, sold the best out of the bunch.

## 37. MAXIS

(THE SIMS 2: CASTAWAY)

THE SIM-FOCUSED EA STUDIO SPENT 2007 HARD AT WORK ON *SPORE*, but even so, released expansions for its market-defining *THE SIMS* and *THE SIMS 2* this year, to decent reviews. But what really helped Emeryville-based Maxis stay on the chart was continuing sales of back catalog titles, including 2003's *SIMCITY 4: DELUXE EDITION*, and 2004's *THE SIMS 2*.

## 36. CODEMASTERS SOUTHAM

(DIRT)

WITH A FOCUS ON EUROPEAN-FRIENDLY TITLES, SUCH AS RALLY sims (COLIN McRAE: DIRT) and cricket games (BRIAN LARA INTERNATIONAL CRICKET 2007), English developer Codemasters saw better sales in the U.K. than in the U.S. in 2007, but decent reviews overall, averaging 72 percent. With McRae's tragic death in September, it remains to be seen what will become of Codies' flagship rally series.

## 35. TOSE

(DRAGON QUEST MONSTERS: JOKER, FINAL FANTASY TACTICS: THE WAR OF THE LIONS)

THIS STUDIO BASED IN KYOTO PREFERS TO KEEP OUT OF PUBLIC view, but it has made it onto our list this year, for better or



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## DEVELOPERS

worse. TOSE handled development duties on Square Enix's DRAGON QUEST MONSTERS: JOKER, which has sold like gangbusters in Japan (more than a million copies to date). The furtive developer did well by U.S. reviewers with its ports of FINAL FANTASY VI to Game Boy Advance and FINAL FANTASY TACTICS to PSP, and DOM: JOKER scored respectably as well, giving TOSE an 85 percent average score for the year.

### 34. LEVEL 5

[ROGUE GALAXY, JEANNE D'ARC]

FUKUOKA, JAPAN-BASED LEVEL 5 IS A FAMILIAR NAME TO RPG fans, and 2007 saw the studio continue to ply its core competency. Its Western releases of ROGUE GALAXY and JEANNE D'ARC both did well with reviewers. But something new is in store for Western DS owners: the PROFESSOR LAYTON games, a series of casual-friendly puzzle games with a storybook feel, are set to arrive in the US in 2008. Two of the games already sold well in Japan's portable-friendly market in 2007.

### 33. BEENOX

[BEE MOVIE GAME, SPIDER-MAN 3 PC]

IN 2007, THIS QUEBEC BASED SUBSIDIARY STUDIO OF ACTIVISION moved from a focus on PC ports to being a full-fledged multiplatform developer. Its first major project was BEE MOVIE GAME, the PlayStation 2, Xbox 360, and PC versions of which were handled by Beenox. While review scores for those games and the studio's PC port of SPIDER-MAN 3 were average, we received no small amount of positive comments on working conditions at the developer. Respondents described Beenox as a "very promising company" and called it "more a family than a business" with "awesome attitude geared towards employees."



Relic's COMPANY OF HEROES: OPPOSING FRONTS.

### 32. RELIC

[COMPANY OF HEROES: OPPOSING FRONTS]

THO'S VANCOUVER subsidiary studio this year delivered an expansion pack to its successful 2006 real-time strategy game COMPANY OF HEROES. The standalone OPPOSING FRONTS received a rather nice 86 percent review average. Several

commenters praised the level of quality Relic brought to the RTS genre, and the studio was described as "professional, talent driven," and "ambitious." However, two commenters mentioned a recent change of management and—as a result—an apparent talent drain.

### 31. TRAVELLER'S TALES

[TRANSFORMERS: THE GAME, LEGO STAR WARS: THE COMPLETE SAGA]

THIS BRITISH TEAM HAD TWO MAJOR MULTIPLATFORM RELEASES in 2007. June's TRANSFORMERS: THE GAME sold quite well, but took a critical drubbing. LEGO STAR WARS: THE COMPLETE SAGA—a compilation of the original two games—did much better in

reviews and brought the studio's average up to around 66 percent, but hasn't yet registered sales like the first two. Commenters had little to say about the developer—which has been around since the Amiga days, and gave it rather modest reputation scores.

### 30. TURN 10 STUDIOS

[FORZA MOTORSPORT 2]

PART OF MICROSOFT GAME STUDIOS, THIS REDMOND, WASHINGTON-based internal studio followed up 2005's Xbox driving game FORZA MOTORSPORT with a sequel that succeeded both critically (with a 90 percent review average) and commercially. And despite Bungie's departure from the MGS umbrella, Turn 10 head Alan Hartman has stated that the studio's not going anywhere, which should guarantee Microsoft consoles a counterpart to Sony's GRAN TURISMO for the foreseeable future.



EA Black Box's SKATE.

### 29. EA BLACK BOX

[SKATE, NEED FOR SPEED PROSTREET]

EA BLACK BOX, LOCATED IN VANCOUVER NEAR EA'S CANADA campus, did well this year thanks to consistent sales of its NEED FOR SPEED titles in both the U.S. and Europe. The new skateboarding title, SKATE, proved a welcome success (and a "welcome surprise," as one commenter put it), with good sales and a friendly response from critics. An inside commenter told us cryptically: "Ouch. Never again." Ouch, indeed! What's that all about? Reviews for the studio's games were mostly respectable, averaging 73 percent.

### 28. SCE STUDIOS SANTA MONICA

[GOD OF WAR II, CALLING ALL CARS]

IN 2007, THIS STUDIO DELIVERED A CORY BARLOG-DIRECTED sequel to its 2005 hit GOD OF WAR. The public and critics both gave GOD OF WAR II a reception similar to the original. It was a sales success and received reviews averaging 93 percent. Barlog and famed developer David Jaffe both left the studio within the last year, but it doesn't appear that Sony needs to worry about losing its flagship franchise, with another GOD OF WAR title already announced.

### 27. NAUGHTY DOG

[UNCHARTED: DRAKE'S FORTUNE]

THE SANTA MONICA-BASED SONY COMPUTER ENTERTAINMENT subsidiary released its impressive and highly cinematic adventurer UNCHARTED: DRAKE'S FORTUNE in November to excellent

reviews—but somewhat less commercial notice. The survey was kind to Naughty Dog though, with readers granting high marks and expressing their support for the studio’s “fantastic vision and clarity when designing a title,” and calling UNCHARTED “the best game of the year in 2007.”

## 26. BETHESDA SOFTWORKS

(OBLIVION, THE SHIVERING ISLES)

**BETHESDA LED OFF THE YEAR WITH A PLAYSTATION 3 PORT** of its multimillion-selling first-person RPG THE ELDER SCROLLS IV: OBLIVION, and later supplemented the original release with a new expansion pack, THE SHIVERING ISLES. Good review scores for these, as well as strong European sales of the 360 version of OBLIVION gave the Maryland-based developer a nice boost. Survey commenters grouched a bit about internal processes at the developer, but another remarked that Bethesda “makes games they’d love to play themselves” and has “cool facilities.”

## 25. REALTIME WORLDS

(CRACKDOWN)

**THIS NEW SCOTTISH STUDIO FROM VETERAN DAVE JONES PUSHED** the sandbox genre forward with its go-anywhere hit CRACKDOWN. The commercial success of the game may have been helped by the inclusion of an online beta version of HALO 3, but Realtime Worlds delivered the goods with CRACKDOWN, which earned decent review scores. The developer was popular in our survey, receiving high marks from happy employees, one of whom mentioned the company’s “great atmosphere, work ethic, and passion for the games being made.”

## 24. EA LOS ANGELES

(COMMAND & CONQUER 3: TIBERIUM WARS, MEDAL OF HONOR AIRBORNE)

**THE FORMER WESTWOOD STUDIOS BROUGHT OUT A MULTIPLATFORM** sequel to one of Westwood’s signature series, along with two MEDAL OF HONOR sequels. COMMAND & CONQUER 3 and MEDAL OF HONOR AIRBORNE both scored highly and sold well, but reviews of the PlayStation 2/Wii MEDAL OF HONOR: VANGUARD brought down the studio’s average (despite decent sales). Survey commenters had varying opinions on EA LA. One praised the “good work environment and consistent quality level,” but felt “slightly segregated from other departments.” Another noted a tendency toward crunches without sufficient compensation.

## 23. NINTENDO EAD TOKYO

(SUPER MARIO GALAXY)

**NINTENDO’S ONLY JAPANESE INTERNAL STUDIO NOT LOCATED** IN its home city of Kyoto, Nintendo EAD Tokyo, was responsible for this year’s long-awaited smash hit SUPER MARIO GALAXY. That one title gave the studio the highest average review score out of any in our survey: 97 percent. Commenters had specific praise for GALAXY, but expressed an interest in seeing a new MARIO somewhat more often: “Every MARIO is a great game, but only one every six years?”

## 22. CRYTEK

(CRYSIS)

**THE FIRST RELEASE IN THREE YEARS FOR THIS GERMAN DEVELOPER,** the PC hardware-intensive first-person shooter CRYSIS managed

a 91 percent review average and successful sales to match. Crytek’s focus on pushing technology forward earned it positive comments from our readers. Specific commenters gave the studio high marks and had good things to say about their time at the company, calling it “great to work with, highly creative, and innovative with a focus on high production values.”

## 21. EA REDWOOD SHORES

(THE SIMS 2 EXPANSIONS, MYSIMS)

**IN 2007, EA’S MAIN BAY AREA STUDIO HANDLED ROUGHLY HALF OF** the console versions of THE SIMPSONS GAME, the super-cute MYSIMS, the Wii and PlayStation 3 ports of THE GODFATHER, and several expansion packs for THE SIMS 2. Sims-related titles were the developer’s mainstay, selling extremely well throughout the year. The studio’s average review score was passable (just less than 70 percent), and it received middling marks on our reputation and specific survey questions.

## 20. NEVERSOFT ENTERTAINMENT

(GUITAR HERO III, TONY HAWK’S PROVING GROUND)

**THE LONGTIME TONY HAWK DEVELOPER INHERITED THE** GUITAR HERO series from Harmonix this year, and while review scores of GUITAR HERO III didn’t quite reach the high bar set by the first two games, sales of the game were certainly nothing to sneeze at. The sequel sold well across all console platforms, with the PlayStation 2 version doing best in the charts. Neversoft also released the latest iteration of TONY HAWK, but while the 360 version scored well, the series generally slumped critically and commercially.

## 19. HUDSON SOFT

(Mario Party 8, Mario Party DS)

**AN INDUSTRY STALWART AND THE FIRST THIRD PARTY DEVELOPER** on the Nintendo Entertainment System, snowy Sapporo, Japan-based Hudson Soft continued along quietly, updating its flagship MARIO PARTY series for Wii and DS. Both versions sold extremely well in all territories as MARIO PARTY is particularly suited to these platforms’ audiences. A DS entry in Hudson’s long-running MOMOTARO DENTETSU party series also sold well strictly in Japan. Mediocre



MARIO PARTY 8 from Hudson Soft.





# DEVELOPERS

review scores couldn't keep the developer down too much, partly thanks to a reasonably diversified portfolio of releases.

## 18. EPIC GAMES

(UNREAL TOURNAMENT 3, GEARS OF WAR PC)  
**TECHNOLOGY VENDOR AND SHOOTER-FOCUSED DEVELOPER EPIC** also made its core competencies its focus this year. Continuing U.S. and overseas sales kept the company's Xbox 360 killer app GEARS OF WAR significant. Review scores were high for the PC version of GEARS and all versions of UNREAL TOURNAMENT 3, giving the North Carolina developer an 85 percent average. Epic received no lack of praise in our survey. One respondent asked us to "imagine a world without Unreal Engine 3 and realize how many games we'd be losing," and another called the company "top quality, highly professional," and "innovative."

## 17. GAME FREAK

(POKEMON DIAMOND/PEARL)  
**POKEMON AFTER POKEMON! THIS SECOND-PARTY DEVELOPER TO** Nintendo continued to do what it does best in 2007, and POKEMON DIAMOND and PEARL—the first mainline series entries published for the Nintendo DS—were once again critical darlings and sales juggernauts worldwide. The series shows no sign of fading, and gained Tokyo-based Game Freak an average review score of 85 percent.

## 16. SQUARE ENIX

(FRONT MISSION, FINAL FANTASY VII CRISIS CORE)  
**THIS TOKYO-BASED DEVELOPER/PUBLISHER FOUND MOST OF** its success this year in Japan and Europe. Portable software—including the FINAL FANTASY VII spinoff CRISIS CORE—did extremely well in Japan throughout the year, and FINAL FANTASY XII sold well in European markets. Its highest-scoring homegrown title was the DS remake of FRONT MISSION, its classic Super Famicom robot-battling strategy title. The PSP remakes of the first two FINAL FANTASY games did not fare as well, leaving the developer with a 65 percent review average.



BEAUTIFUL KATAMARI from Bandai Namco Games.

## 15. BANDAI NAMCO GAMES

(ACE COMBAT 6, BEAUTIFUL KATAMARI)  
**A LOW REVIEW AVERAGE OF 61 PERCENT KEPT THIS MERGED** developer/publisher slightly more than a shade away from greatness, but its release schedule was strong, and its Nintendo-published "eye training" casual game FLASH FOCUS for DS was a knockout seller. Bandai Namco's combination of original Namco properties and Bandai-related anime licenses combined to be

a strong sales combination in Japan, and while DS software constituted most of Bandai Namco's hits, the next-gen ACE COMBAT 6 also made a good showing.

## 14. HARMONIX MUSIC SYSTEMS

(ROCK BAND, GUITAR HERO II)  
**THE XBOX 360 RELEASE OF HARMONIX'S GROUNDSWELL** hit GUITAR HERO II, along with continuing sales of the original PlayStation 2 version, brought immense commercial success for this Massachusetts studio. Although the EA-distributed ROCK BAND, Harmonix's reinvention of the genre, had a slow start at retail, it has achieved critical success commensurate with the first two GUITAR HERO titles, bringing Harmonix an 86 percent average for the year.

## 13. 2K BOSTON

(BIOSHOCK)  
**THE STUDIO FORMERLY KNOWN AS IRRATIONAL GAMES** delivered a resounding critical and commercial hit for publisher Take-Two with the chilling first-person shooter BIOSHOCK. An average review score of 96 percent and many glowing comments in our survey indicate a pair of teams that are "concerned about originality" and created "a well-polished, solid game experience" that "combines narrative depth with accessibility, paving the way for others." Fellow studio 2K Australia is also bundled into this ranking.

## 12. UBISOFT MONTREAL

(ASSASSIN'S CREED, TMNT)  
**UBISOFT'S MAINSTAY STUDIO SPLIT ITS PROJECTS BETWEEN** movie licenses (SURF'S UP, TMNT) and homegrown hits (ASSASSIN'S CREED and a new RAINBOW SIX). Critical reception was split between these—the original titles generally received favorable scores, but the licensed titles dragged down this developer's average. Both sides brought commercial success, however, with ASSASSIN'S CREED and TMNT both selling well. Last year's RAINBOW SIX VEGAS also made a strong showing in U.K. charts.

## 11. BUNGIE

(HALO 3)  
**LAST YEAR'S HIGHLY-ANTICIPATED HALO 3 DELIVERED ON ITS** promise and brought critical and commercial success to this Washington-based developer. Survey respondents gave Bungie high marks and praised innovations in HALO 3, calling its Forge and playback features "industry-changing." A commenter with direct experience with the studio called the team "very fun" and "dedicated and driven." And though Bungie parted ways with its former owner Microsoft in October, the developer is not yet finished with the HALO series.

## 10. BIOWARE

(MASS EFFECT, JADE EMPIRE: SPECIAL EDITION)  
**DESPITE ONLY HAVING ONE NEW RELEASE THIS YEAR, THE** Edmonton, Alberta studio rides high thanks to oodles of praise from survey responders, high review scores, and notable sales of its latest sci-fi RPG, MASS EFFECT. Responders commented on BioWare's "great long term strategy" and "smart diversification of projects," while specific comments called the studio "professional, cutting edge, futurists, with great leadership, and humanitarian."

CONTINUED ON PG. 14



# Unreal Technology News

by Mark Rein, Epic Games, Inc.

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 Front Line Award for Best Engine for the past three years, and Epic was awarded Best Studio at the 2006 Spike TV Video Game Awards. Epic's "Gears of War" won overall Game of the Year in 2006, and sold over 4 million units on Xbox 360. Epic recently shipped the PC version of "Gears of War" for publisher Microsoft Game Studios, as well as "Unreal Tournament 3" for PC and PlayStation 3 for publisher Midway.

## Upcoming Epic Attended Events:

### E3 2008

Los Angeles, CA  
July 15-17, 2008

Please email:  
mrein@epicgames.com  
for appointments.



## UNREAL ENGINE 3 WINS BEST ENGINE FOR THE THIRD CONSECUTIVE YEAR

Unreal Engine 3 has won the Front Line Award for Best Engine for the third year in a row. We are once again extremely proud and flattered to take home the 2007 honors, which were awarded by the editors of CMP's *Game Developer* magazine in January.

Epic would like to thank the editors for this recognition, and we would like to thank our customers for shipping such great, award-winning titles. We look forward to offering developers and publishers around the world the best possible game engine for cross-platform development for years to come.

## NATURALMOTION JOINS EPIC'S INTEGRATED PARTNERS PROGRAM

NaturalMotion and Epic announced an agreement to incorporate *morpheme*, the industry's first graphically authorable animation engine for PLAYSTATION®3, Xbox 360™ and PC, into Unreal Engine 3. Per the agreement, NaturalMotion will join Epic's prestigious Integrated Partners Program (IPP), and its technology will be immediately available to any publishers or developers licensing Unreal Engine 3.

*morpheme* builds on the existing Unreal Engine 3 character system by offering unique features for constructing very complex animation setups. Its external tool, *morpheme: connect*, enables developers to preview and modify elements in real time through the strategic application of state machines and blend trees. Like other components of Unreal Engine 3, *morpheme's* existing animation nodes can be extended to provide game-specific functions. Future feature sets developed by NaturalMotion will be incorporated into Unreal Engine 3 per the partnership.

"Unreal Engine 3 is already an inspired game design platform, offering much of the bleeding edge technology developers need," said Torsten Reil, CEO of NaturalMotion. "By adding *morpheme* to Epic's suite, more studios will be able to take advantage of NaturalMotion's pioneering animation technology, allowing for a whole new generation of games with astonishingly realistic characters and animations."

"With *morpheme*, the implementation of character animations within the game can finally be driven by our animators instead of our engineers," said Stephen

Palmer, vice president of product development at Gearbox Software. "The brilliant folks at NaturalMotion have recognized that artists need to have more control of this fundamentally artistic process, and have created a world-class animation system and tool-chain to support that concept."

## EIDOS INTERACTIVE LICENSES UNREAL ENGINE 3 FOR HIGHLANDER GAME

Eidos recently announced *Highlander* for Xbox 360™, PLAYSTATION®3 and PC. The game is an extension of the popular *Highlander* movie and TV series that tells the tale of an Immortal swordsman, Owen MacLeod. Written by David Abramowitz, the *Highlander* TV series' writer and show runner, *Highlander* takes MacLeod on a journey across multiple lands from first century fiery Pompeii to futuristic New York.

*Highlander*, scheduled for release later this year, will take advantage of the latest Unreal Engine 3 tools and technology.

## LATEST ENHANCEMENTS TO UNREAL ENGINE 3

In case you missed Epic at the recent Game Developer's Conference in San Francisco, here's the scoop on the latest improvements and features available in Unreal Engine 3.

Epic's engine team has made many performance and memory optimizations to Unreal Engine 3, with a special focus on PLAYSTATION®3, in addition to adding dynamic ambient occlusion, a crowd system and a fracturing tool and runtime.

Epic has also upgraded the engine's build process, content pipeline and profiling tools, as well as security-related features for shipping PC games. The Unreal Editor has been polished considerably, with particular attention to Matinee cinematic tools.

Lastly, Epic has built into Unreal Engine 3 notable character lighting and shadowing enhancements, support for distributed cooking, DirectX 10 support, as well as 32-bit and 64-bit ActorX support for the latest versions of 3ds Max, Maya and XSI.



Eidos is developing *Highlander* for Xbox 360™, PLAYSTATION®3 and PC using Unreal Engine 3.



For UE3 licensing inquiries email:  
[licensing@epicgames.com](mailto:licensing@epicgames.com)

For Epic job information visit:  
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# DEVELOPERS

CONTINUED FROM PG. 14

## 9. EA TIBURON

(MADDEN NFL 08, NASCAR 08)

**EA'S STALWART DEVELOPER OF FOOTBALL TITLES CONTINUED ITS** success this year with the latest in the MADDEN and NCAA series. Both were extremely strong sellers, and TIGER WOODS PGA TOUR 08 also proved successful [EA Tiburon developed the PlayStation 3 and Xbox 360 versions]. Review scores for the latest NASCAR title and its SUPERMAN title were substandard, but that's the only dim spot in the critical reception received by this Florida developer's lineup. One commenter in our survey who joined the studio after the much-publicized "EA Spouse" incident talked about a "great experience with work-life balance."

## 8. CAPCOM OSAKA STUDIO

(LOST PLANET: EXTREME CONDITION, MONSTER HUNTER FREEDOM 2)

**CAPCOM'S DEVELOPMENT STRATEGY FOR NEXT-GEN CONSOLES** and portables showed success this year with immense sales of LOST PLANET for Xbox 360 and the latest PSP iteration of MONSTER HUNTER. A Wii revision of RESIDENT EVIL 4 and PHOENIX WRIGHT sequels also brought retail success. The company's high place on this year's ranking was helped in no small part by good review scores and a well-diversified multiplatform lineup.

## 7. INSOMNIAC GAMES

(RESISTANCE: FALL OF MAN, RATCHET & CLANK FUTURE)

**THIS SONY SECOND-PARTY STUDIO RECEIVED RESOUNDING** praise on our survey, both for the quality of its games "that are tapped into what gamers and the public want to play" and for its working environment, where "everyone is given an opportunity to contribute, grow, and benefit regardless of position or job title." Reviewers certainly agreed on the quality of the Burbank, California developer's titles, with RATCHET & CLANK FUTURE earning an 88 percent overall average score. Strong sales of RESISTANCE helped cement Insomniac's place in the top 10.

## 6. KONAMI JAPAN STUDIO

(WINNING ELEVEN: PRO EVOLUTION SOCCER, DANCE DANCE REVOLUTION UNIVERSE)

**STRONG SALES OF SPORTS TITLES AND AN EXTREMELY HEALTHY** stable of homegrown releases gave Konami a nice boost this year. Its WINNING ELEVEN soccer titles sold perennially in the U.K. and made impressive showings on Japanese charts. In Japan, sales of anime-licensed portable software offered supplemental support, as did decent review scores in the West. Reputation votes for Konami reached an 8.5 average, but specific survey marks were middling to poor.

## 5. VALVE CORPORATION

(PORTAL, TEAM FORTRESS 2)

**THE HALF-LIFE DEVELOPER'S ATTENTION TO INNOVATION AND** quality gained it the highest reputation scores on our survey, with respondents praising its "outstanding development culture and games that set the bar." THE ORANGE BOX, the multiplatform compilation that was the Bellevue developer's only retail release this year, was heaped with critical praise, found success in the charts, and garnered a 93 percent average review score for the year.

## 4. EA CANADA

(FIFA SOCCER 08, NBA STREET: HOMECOURT)

**THE FIFA SOCCER FRANCHISE HAD A YEAR-ROUND PRESENCE** on European charts, which made EA Canada the most successful of EA's internal studios this year. EA Canada, which is headquartered in a suburb of Vancouver, also handles several of EA's other key sports series, including NBA LIVE, NHL, and NCAA MARCH MADNESS. The development schedule seems to come at a price though—EA Canada didn't receive many comments in our survey, but those we did receive gave little praise to working conditions at the developer. Critical reception was high, though, meaning something must be going right.

## 3. BLIZZARD ENTERTAINMENT

(WORLD OF WARCRAFT: THE BURNING CRUSADE)

**THIS IRVINE, CALIFORNIA DEVELOPER'S GORILLA-IN-THE-ROOM** MMO continues its market dominance, thanks in no small part to its new expansion pack, THE BURNING CRUSADE. A momentary lack of diversity hasn't hurt the studio's critical reception, with the expansion pack garnering a 91 percent average review score. One survey commenter seemed impatient with the company, calling it "highly secretive" and noting that the studio "takes three to four years per game." But another put a different spin on things: "[Blizzard] takes the time it needs to make the game it wants to, and it pays off."

## 2. INFINITY WARD

(CALL OF DUTY 4)

**THE RESOUNDING CRITICAL AND COMMERCIAL SUCCESS**

CALL OF DUTY 4 helped push this Encino, California-based studio into the number two spot. We recorded high scores and healthy praise for Infinity Ward's working conditions, professionalism, and attention to quality: "I've never worked at a better company. People at work constantly say things like, 'If I won the lottery, I'd still want to work at Infinity Ward.' I think most if not almost all of us here feel the same way."



Nintendo's Wii SPORTS.

## 1. NINTENDO

(BRAIN AGE 2, WII PLAY)

**NINTENDO'S KYOTO HOME STUDIOS DOMINATE THIS YEAR'S LIST,** thanks in no small part to incredible sales of a healthy lineup of DS and Wii software, notably WII PLAY, WII SPORTS, and two BRAIN AGE games. These titles rarely left Japanese and European sales charts, demonstrating Nintendo's mastery of the casual games market. Survey comments heaped praise upon the Japanese giant for its focus on quality, and this was reflected in high review scores all around.



DEVELOPER	RANK	SKUs DEVELOPED	AVERAGE GAME	REPUTATION
		2007	REVIEW SCORE	RANKING
Nintendo	1	13	78%	9
Infinity Ward	2	3	94%	8
Blizzard Entertainment	3	1	91%	9
EA Canada	4	35	72%	7
Valve	5	3	93%	9
Konami Japan Studio	6	30	73%	8
Insomniac Games	7	1	88%	8
Capcom Osaka	8	19	74%	9
EA Tiburon	9	15	74%	6
Bioware Edmonton	10	2	86%	9
Bungie	11	2	83%	8
Ubisoft Montreal	12	22	64%	7
2K Boston	13	2	95%	8
Harmonix	14	4	86%	9
Bandai Namco Games	15	24	61%	8
Square Enix	16	14	65%	9
Game Freak	17	2	85%	-
Epic Games	18	3	85%	8
Hudson Soft	19	8	60%	-
Neversoft Entertainment	20	8	76%	8

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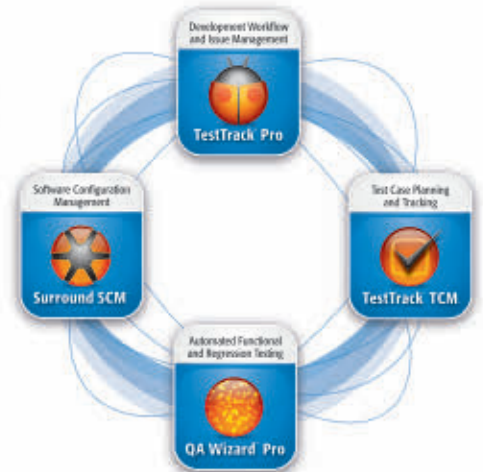


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# AMBIENT OCCLUSIVE CREASE SHADING

» **NEW ART TECHNOLOGIES TEND TO EVOLVE ALONG A PARTICULAR** path. At first it's a struggle to use the technology at all, with early innovators playing double duty as both artist and scientist. Just as the early photographers were all chemists, early work in computer graphics was driven by engineers. From there, field advances and improvements in tools and techniques allowed the artist to break from the science and simply go for whatever "looks right," rather than what the rote equations produce.

In computer graphics, we're finally moving away from the imitative to the illustrative. In other words, we're starting with the question, "How would I like this to look?" instead of "How do I make this look like the real thing?"

For our project, we knew that lighting would play a key role in the art style. We wanted a real-time approach to rendering that would resemble the work of Maxfield Parrish, N.C. Wyeth, or Georges De La Tour—soft, non mechanical edges and objects defined as much by shadow as by highlight.

Figure 1 (page 20) shows how our scene looked originally, and Figure 2 is how we wanted it to look (and how it finally did look), with the creases on the gazebo roof defined by their shadows, and the rocks and leaves in the rear rounder than ever.

Global illumination or even ambient occlusion would have given us this result, but the techniques we investigated were simply too comprehensive and costly. Most relied on some level of raycasting that—while very realistic and impressive—ran on only the latest of graphics cards, and often only barely. Furthermore, almost everything in our scenes is in motion or otherwise fully dynamic, so painting or burning in the shadows wasn't an option.

We sat for a bit and toyed around with various concepts. Given that our title, IDYLLON, is a massively multiplayer game

with significant variation in art resources, any artist time spent tweaking ambient occlusion (AO) parameters per-object would have quickly spiralled out of control—so we immediately rejected that approach. Further complicating matters, many of our objects are indeterminate compositions of other sub-objects, making even inner-object offline precomputation nearly impossible. We needed something that worked purely with whatever was on screen, no matter what its composition or type. We began working in the direction of screen-based approaches, and we had a bit of an ace in the hole.

## THE APPROACH

IDYLLON uses an approach to rendering called deferred shading. There are many articles on the subject, including an excellent treatment in *GPU Gems 2* written by the S.T.A.L.K.E.R. development team, but I'll cover it briefly here. The idea is that instead of rendering all shapes affected by a light, once per light, you render all visible geometry in a single first pass. Per-pixel you write out color, position, normal, material properties—everything you need to render and light that pixel. Lights are then rendered as shapes, with the pixel shader for those light shapes reading in the appropriate mesh data for that pixel and lighting the result. Lights are rendered one after another, the results alpha-blended appropriately, and on it goes—but the point is that it allows some interesting tricks.

In coming to grips with what this allowed, we realised that we had all the data necessary to identify a "crease," an area where nearby pixel surfaces faced each other. We also realised that we might shade these areas such as you would in a sketch. This led to the creation of our algorithm, an entirely

---

**MEGAN FOX** is lead prototype developer at IDYLLON. A recent graduate of the University of Colorado at Boulder with a BS in mathematics, she is an author and self-taught programmer.

**STUART COMPTON** is director and cofounder of IDYLLON, a new online social world currently in development. He has been in the computer game industry for more than 20 years, working on titles for Sierra Studios, Microsoft, Sony, and others. Email them at [mfox@gdmag.com](mailto:mfox@gdmag.com).

---





FIGURE 1 The gazebo is rendered without ambient occlusion.



FIGURE 2 The same scene as Figure 1 is shown with the added detail of ambient occlusion.

artistic solution never meant to be realistic, yet still producing attractive and fairly “real” looking results.

What we came up with is ambient occlusive crease shading, an algorithm that produces an artistic approximation to ambient occlusion. It gives a typical real-time rendered scene with most of the depth and warmth of ambient occlusion, but without the typically extreme cost. It requires absolutely no precalculation as it is entirely screen-based, though our implementation does rely on some of the data available to a deferred shader—namely, position and normal data per pixel. In cases where that is not available, notably in a more traditional rendering engine, the same or similar data can be extracted by back-projecting the per-pixel depth data. The depth data itself gives you per-pixel positions with a bit of matrix math, and a certain amount of normal data can be recovered by extrapolating the surface described by said depth data. The results derived from this replacement data aren’t ideal, but should be more than sufficient for rough AO rendering.

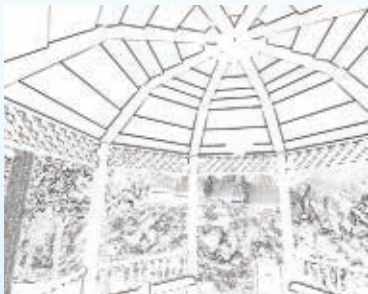


FIGURE 3 An ambient occlusion buffer of the gazebo is shown.

The basic approach is fairly simple. All the work is done in screen space so that we can treat individual pixels as approximations of occluding surfaces and avoid expensive raycasting or similar passes not otherwise useful in rendering. Especially in a deferred shader, we use only the data we already have. We assume that we only want to shade creases that face us; that is, the normals on either side of the crease should face us. Also, we want only “inner” creases that block light, not “outer” creases or points that would tend to receive more light.



FIGURE 4 A blurred ambient occlusion buffer of the gazebo is shown.

To determine one from the other, we simply check the facing of the normals: Inner creases have normals that face each other and intersect if taken as rays, while outer creases have normals that face away from each other and have no intersection. Finally, the amount of occlusion should be relative to the degree to which the two

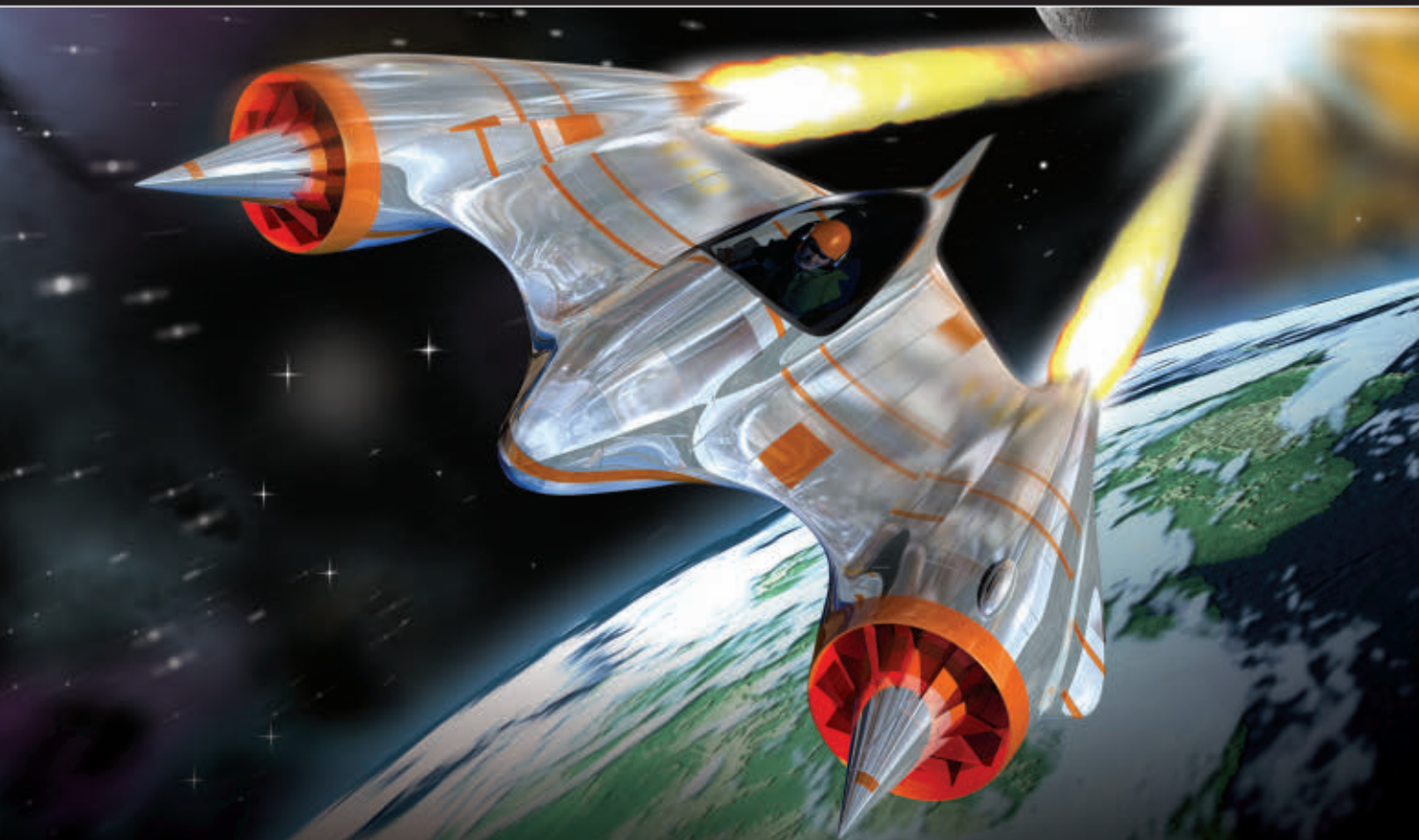
crease surfaces are facing each other, and should also be relative to the distance between the occluding surfaces.

## IMPLEMENTATION

To begin, we set up a full-screen pass that sources the per-pixel position and normal data (however you choose to determine that). Per-pixel in this pass, we sample both the center pixel and a neighborhood of surrounding pixels, collecting both the position and normal per each. The neighborhood can be sampled noisily, though we went with a uniform pattern for reasons I’ll explain in a moment. With each neighbor position, subtract from it the position of the center pixel and then normalize the result. Dotting the neighbor normal against this gives us the amount by which the neighbor faces the center. Doing the same with the center normal versus the center-to-neighbor vector gives us the center’s facing versus the neighbor. Multiplying the two values then gives a rough AO contribution from that neighbor, which we scale based on the distance between center and neighbor. Average all the results together and we get an approximation for the center pixel’s ambient occlusion—though there are a few tricks left.

You’ll want several artist tweak factors that apply the occlusion coefficient per light component, as this is very much an artistic approach. The more tweakable it is, the better. We gave the artist seven values total per scene: the three light + AO component scalars (a pixel’s AO coefficient can affect each color component differently), a bias value (biases the dot product to produce a more or less shadowed appearance), a range attenuation value (a fall-off coefficient dependent on the distance between center and neighbor), and an averager (the divisor when averaging the results of all neighbor pixels). While it’s tempting to assume that you want a straight average of all the contributions to a given pixel, or that range attenuation can handle all averaging, in practice neither alone is sufficient for pleasing results. Only by balancing all factors is this approach stable enough to get the final result we need.

The final implementation has a few more differences, as we hit a few snags. Most notably, we found that using the neighbor normals (that is, trying to determine not only how much the center faces the neighbor, but how much the neighbor faces the center, which is necessary to determine a true crease)

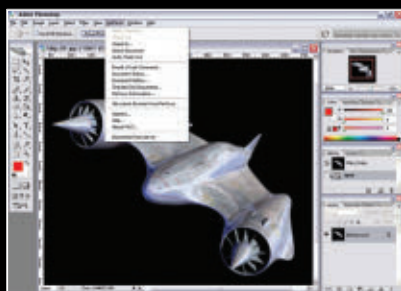


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was overkill. It produced dramatic normal-crease shadows, but almost completely obliterated the proximity shadow without severe overamping. Proximity shadows are the shadows resultant from nearby geometry, such as the bit of darkness in the crease between a table leg and the floor or the back of a couch and the wall; they are fairly desirable when it comes to warming the appearance of a scene. However, the addition of the second term does an incredible job of picking out surface detail in the normal map, and this ends up making the overall appearance more realistic. This is a case in which you should try both and determine which is closer to the desired look, though you may run afoul of a particular artifact.

Uniform sampling of neighbors means that the “neighbor-facing” term follows edge aliasing, while the center-based term generally does not. The result when you combine this aliased sample with the less-aliased center sample is a beat or interference pattern—an interesting effect in and of itself. If you’ve never seen it, go into Photoshop and take a hard-edged black-and-white sketch and blur it heavily (resize it to about 12.5 percent for instance), then superimpose the blurred version over the original with a subtractive or multiplicative filter. You’ll find that the interference between the blur and original is inconsistent and has a knack for picking out the “shadowed” areas of the original image. This effect is actually the core of the 2D AO algorithm in use by other products, but in ours it gave the proximity shadows an inconsistent and undesirable appearance. The problem is avoided if a non uniform neighbor sampling is used, though that of course has the previously mentioned side effects. It’s also possible to simply crank the range attenuation down to such a point that proximity shadows never appear.

One last difficulty is that, shy of sampling a very significant number of neighbor pixels, the results as produced by the basic algorithm are very minor and resolution-dependent. Especially at high resolutions, it will pick out only the line along which occlusion is greatest, as well as its few closest neighbors. To fix this, we apply a very heavy set of bloom passes. One blooms an especially large distance but reduces AO intensity overall, and the other blooms a more reasonable distance while amping the AO coefficients up. The two are then blurred together into our final AO buffer. The amount of blurring applied directly influences the appearance of the AO—it will appear “dreamier” as more blur is applied. You could also make the sample region significantly larger and avoid the blur, but the cost may or may not be significantly worse (and the results would then be less smooth and more accurate in appearance). Refer to Figures 3 and 4 for an example of how the AO values appear pre- and post-blur, and note that most of the detail seen in the pre-blur is purely from the normal map.

## RESULTS

Take a look at the example shots. Figures 5, 6, and 7 show an image rendered with ambient occlusion, the same camera angle without, and an inverted difference of the two images to make the difference more clear. Pay particular attention to the way in which the algorithm deepens the shadows around mostly obscured creases and the way in which it adds proximity shadowing. Subtle visual cues are now present that indicate object proximity and



FIGURE 5 The scene is rendered with ambient occlusion.



FIGURE 6 The same scene as Figure 5 is shown without ambient occlusion.

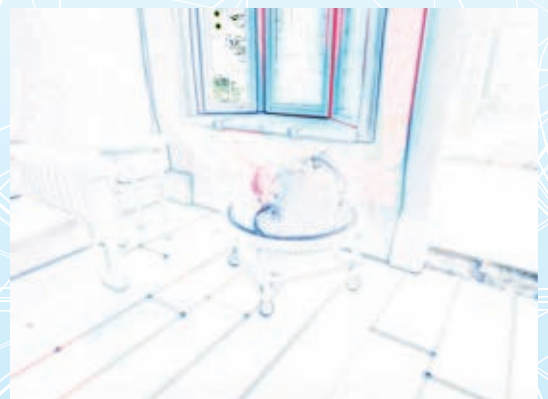


FIGURE 7 The difference between Figures 6 and 7 is shown.

general visual relationship. You might also notice how the AO tends to darken the scene overall, but this is largely a trick of the eye. The darkening is inconsistent, clustered about ambiently occluded regions, with the general darkening simply being the result of blurring the AO buffer. For instance, note how the algorithm shades the region between the globe and the hoop of its frame, and how wood and the scene in general take on a softer appearance. What appears to be a consistent dampening is actually surface-based noise that accentuates core material properties.



## LISTING 1 shader code

```
//-----  
/**  
  Shaders involved in crease shading  
  Uses: DiffMap1 (GBuffer 1)  
        DiffMap2 (GBuffer 2)  
        Color0 (AOCreaseValues - Range, Bias,  
Averager, Unused)  
*/  
  
float4 psCreaseShadeStippled11x11(const vsOutput  
psIn) : COLOR  
{  
    float2 UVLeft;  
    UVLeft.x = 1.0f / DisplayResolution.x;  
    UVLeft.y = 0.0f;  
    float2 UVDown;  
    UVDown.x = 0.0f;  
    UVDown.y = 1.0f / DisplayResolution.y;  
    float2 centeredUV = psIn.uv0 + (UVLeft /  
2.0f) + (UVDown / 2.0f);  
  
    float3 centerPos = tex2D(GBuffer1Sampler,  
centeredUV).xyz;  
    float3 centerNormal = tex2D(GBuffer2Sampler,  
centeredUV).xyz;  
  
    UpdateSamplesStippled11x11(Disp  
layResolution.x, DisplayResolution.y,  
SampleOffsetsWeightsStippled11x11);  
    float4 totalGI = 0.0f;  
    int i;  
    for (i = 0; i < 24; i++)  
    {  
        float2 sampleUV = centeredUV + SampleOff  
setsWeightsStippled11x11[i].xy;  
        float3 samplePos =  
tex2D(GBuffer1Sampler, sampleUV).xyz;  
  
        float3 toCenter = samplePos - centerPos;  
        float distance = length(toCenter);  
        toCenter /= distance;  
        float centerContrib =  
saturate((dot(toCenter, centerNormal) -  
AOMinimumCrease) * Color0.y);  
        float rangeAttenuation = 1.0f -  
saturate(distance / Color0.x);  
        totalGI.r += centerContrib *  
rangeAttenuation;  
    }  
    totalGI.r /= Color0.z;  
  
    return (totalGI);  
}
```

Listing 1 shows some of the shader code we used to create precisely those images. GBuffer1 contains per-pixel positions in its XYZ, and GBuffer2's XYZ contains the per-pixel normals. Range/Bias/Averager are stored in Color0 and customized on a scene-by-scene basis, and AOMinimumCrease must be present and adjusted to avoid artifacting as a result of accuracy. If AOMinimumCrease is too small, it will cause radial banding screen-wide, most visible on flat-on surfaces.

## OCCUSION CONCLUSION

Using the methods explained in this article, you should now be more than capable of duplicating precisely the results seen in the included example shots. There is a frame rate hit, and it would be tricky to usefully include this in anything below PS3.0, but IDYLLON (our product) achieves excellent frame rates and the algorithm operates beautifully in the real world. We've found it to run incredibly well on an nVidia 8800GTX, passably on a 7600GT, and similarly on the ATI equivalents. With any luck, you'll find ambient occlusive crease shading an approachable and proven method of giving your scenes the increased depth and warmth rapidly coming to define "next-gen"—or at least an interesting example of the way in which approaches in computer graphics are gradually becoming illustrative, rather than simulative. ❖



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# CALL OF DUTY 4

## MODERN WARFARE™

CALL OF DUTY 4 WAS INFINITY WARD'S THIRD CALL OF DUTY GAME, and as such we approached it knowing we needed to do something fresh. We don't want to pigeonhole ourselves any more than we have to, and many members of the team came off CALL OF DUTY 2 promising never to work on another WWII game. We tried several different directions, many of which were failures, but the ultimate result was the best game any of us have ever worked on. As a game development experience, it seemed to go so smoothly that it was difficult to come up with five things that went wrong.

---

*ZIED RIEKE was lead designer on CALL OF DUTY 4 and MICHAEL BOON was technical art director. They have been working together for 10 years, having been founding members of MEDAL OF HONOR ALLIED ASSAULT developer 2015. Together they have worked on WAGES OF SIN, ALLIED ASSAULT, CALL OF DUTY 1, 2 and 4, plus two budget titles they don't mention. Send comments about this article to [editors@gdmag.com](mailto:editors@gdmag.com).*



## GAME DATA

### WHAT WENT RIGHT

**1 MODERN SETTING.** Coming off CALL OF DUTY 2, we knew we wanted to do something different for our next game. We don't agree with some critics who say that WWII as a genre is dead, but we couldn't muster the same passion for the subject that we had in our first three WWII games (CALL OF DUTY 1 and 2 and MEDAL OF HONOR: ALLIED ASSAULT). We had a few ideas that we wanted to do and eventually settled on two. One was MODERN WARFARE, and the other was a new project.

Modern-day warfare is very emotional for people, which is both good and bad. We really wanted to avoid referencing any current, real wars, and one aspect of the gameplay that we really didn't want to change from previous titles was the idea of two large opposing forces with similar numbers and technology. To facilitate that, we invented a war with several fronts, primarily involving a group splintered from the Russian army, with a secondary front in the Middle East.

The modern setting inspires an enormous amount of gameplay variety. Modern warfare is very different from more traditional warfare in that direct confrontations between huge armies are relatively rare. Instead, you have a huge variety of different types of low-intensity conflicts and special forces missions. Because we already had a very

sophisticated scripting language in our engine, we were able to implement and iterate on that variety quickly, and take advantage of the modern setting to shake up the gameplay, but still deliver a polished result.

Modern weapons and tech are something that people like to see and play with. Kids the world over grow up fantasizing about being a soldier, and we aimed to let adults live out their childhood fantasies (CALL OF DUTY 4 is rated M). But we also knew we wanted to keep that signature CALL OF DUTY grittiness and avoid making the game feel too techy. One thing that helped us there was focusing the U.S. part of the game on Marines, who get a lot of their equipment second-hand from the Army.

By moving away from history and into the current day, we were able to do much more useful reference gathering. For example, the effect that happens when you are near an Abrams tank when it fires was inspired by our designers, artists, and sound designers experiences at a live-fire exercise at 29 Palms, which is a Marine training facility in the California desert. We were able to talk to real marines only weeks out of combat to get a feel for the background, emotions and attitude of soldiers in combat, and we had vets supervising our mocap and AI design to make sure our tactics were sound.

CONTINUED ON PG 26



**DEVELOPER**  
Infinity Ward

**PUBLISHER**  
Activision

#### IN-HOUSE TEAM BREAKDOWN

Engineers: 13  
Designers: 17  
Artists: 18  
Animators: 9  
Audio: 4  
Producers: 3  
Testers: 28  
Other important people with various roles: 11

**TOTAL TEAM SIZE AT INFINITY WARD AND ACTIVISION**  
100+

**LENGTH OF DEVELOPMENT**  
2 YEARS

**RELEASE DATE**  
November 6, 2007



CONTINUED FROM PG 25

**2 CLEAR GOALS.** At the beginning of CALL OF DUTY 4, looking at what we had done with CALL OF DUTY 2, we saw two main areas we needed to focus on improving. First, by dedicating more development time to multiplayer, we felt we could make some really big improvements. Second, we knew we needed to tell a story.

CALL OF DUTY 4 is our first game where we had a team working on multiplayer for the entire project. The quality bar for single-player first person shooters is really high right now, but there were and still are a lot of things that no one has really tried to do with multiplayer, and based on the success of the multiplayer in our previous games, we thought we could really impress.

With a seasoned lead and some dedicated designers and programmers, MODERN WARFARE multiplayer was much more ambitious, much more polished, and generally much better than ever before.

Story is something we've always put a little effort into, but by and large we've prioritized it below other aspects of our games. Moving away from WWII and into a fictional war removed that option. We spent hours brainstorming with military advisors, trying to come up with a credible scenario that would involve a large-scale war, and then weeks interviewing writers trying to find someone who could help us craft a narrative that would draw the player in. The result, while not Shakespearean, has drawn almost universal praise. We feel like we have a new skill, and we intend to build on it in our future projects.

**3 ALMOST NO TURN OVER.** Low turnover is Infinity Ward's secret weapon. You can throw all the money, top talent, outsourcing, mocap, and high-end middleware you want at a project, but without a team that knows how to work together, you'll only end up with delays and a fragmented product. We still have 20 of the 27 or so developers who worked on ALLIED ASSAULT six years ago, so our team has a remarkably stable base.

Before we started on CALL OF DUTY 4, we spent two years developing and using our new engine on PC and Xbox 360, and two years before those using parts of it (notably the scripting system and the level editor) on CALL OF DUTY 1 on PC. By retaining almost all of our people, we retained almost all of that experience. We were able to leap right into development on MODERN WARFARE, improving the engine, creating art assets and building levels immediately. Our leads were able to work directly on game content rather than spend all their time wrangling a team of new people.

**4 EXPERIENCE WITH THE HARDWARE.** We were very lucky (or smart, depending on who you ask) to have a team that had built a game on this generation of hardware before. Our engine already worked on the 360 and PC, and we already had 360 dev kits and tools that worked on them. We knew what performance to expect and had a good idea of how to optimize our assets for the hardware.

The PlayStation 3 and Xbox 360 have similar graphical capabilities, which meant that almost all the experience our artists had on the 360 on the last project was directly applicable to both consoles this project. While PCs are always changing, they didn't change so much in the two years since CALL OF DUTY 2 that we had to relearn anything—we just made improvements to our technique.

Relating to the previous point, we didn't need to hire many new people. We had staffed up dramatically for our first "next gen" game, but starting CALL OF DUTY 4 we already had the team in place, and they already knew how to use our engine and tools.

By building on what we already had, we were able to reach higher in two years than if we'd been forced to start from scratch. This goes not only for engine features, but also for tools and content too. By the end of the project we had replaced almost all the content carried over from CALL OF DUTY 2, but having it available during development removed bottlenecks and allowed us to work faster.



**5 SIMULTANEOUS MULTI-PLATFORM DEVELOPMENT.** From the point of view of our artists and designers, the PlayStation 3 and Xbox 360 have very similar abilities, so we could share assets between them. PC is a broad target, and at this



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stage in the console lifecycle, the consoles still have similar performance to mid-high end PCs, so we could share assets there, too. Of the thousands of assets in the game, only a few dozen are platform specific.

Working with an engine that already runs on all the target platforms—and keeping it running on all those platforms during development—is far easier than trying to port it near the end. While the end result on the two consoles is almost identical, the innards are dramatically different in many cases. On the PC, the differences are obvious. Depending on the specs of the PC or the user's choice, the game can run at one of dozens of different resolutions, with different texture and model detail settings, different control schemes, and different graphics hardware and drivers. Adding the functionality to allow the user to choose between those settings at the end of the project, while simultaneously trying to finalize the game on other platforms, would have been impossible.

### WHAT WENT WRONG

**1 TOO MUCH DESERT.** Naturally enough, early in the development of CALL OF DUTY 4 we were trying to take what worked for World War II and move it into the modern era. So we were trying to adapt popular movies and well-known battles from the modern time period and turn those into missions. We didn't have any Russian missions for the first year of our two year development. Our enemies were, like you see on TV, poorly trained and equipped Middle Eastern soldiers and militias.

In fairness, looking to real life for direct inspiration worked at first and produced some great missions. The missions that survived this period of the game design include the AC-130 mission, Aftermath, Charlie Don't Surf, and The Bog. Almost all the

desert environment multiplayer levels also came from this period.

The problem with the adaptation approach was that modern battles tend to be very lopsided and everything we saw was in desert environments. We needed battles where the opposing forces were well-trained and equipped, and we needed more settings. Eventually we decided to go back to the drawing board and change the high concept for the game.

It's worth mentioning that at this point in time our full team had been moved back onto CALL OF DUTY 4 [see "Distracted by Second Project" below] and we had also found a writer who we felt we could collaborate with successfully. We finally had the focus and the skills to build a fictional scenario that would enable us to take the game anywhere we wanted.

We decided to add the British SAS characters and a second plot line about a Russian civil war. We stopped all level building and scripting, cut a bunch of levels, and started designing missions again.

This design "reboot" is where we came up with the ghillie suit missions, the stealth missions, and all the rest of the missions set in Russia.

Ultimately, this reboot was a good thing for the game, but being so late into development it did slow us down for a while.

**2 NOT ENOUGH BETA TIME.** Early in alpha we learned that we would have to finalize the console versions early because it takes longer than we expected to make Blu-ray disks. This meant that our time for beta testing was shorter than planned. This also meant that some missions didn't get as much balance



testing as they needed and ended up being more difficult than they were supposed to be, which is one of the most common complaints we've received about the game.

CONTINUED ON PG 30



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CONTINUED FROM PG 28

**3 SINGLE PLAYER PC DEMO.** Our pre-release buzz was stronger than it had ever been for any of our previous games; we were getting tons of press despite it being a very crowded holiday season for games; our trailers and other videos on the internet were getting amazing numbers of viewers. Despite all this, we did as we had done with all our previous games—about a month before release we put out a single player demo on PC consisting of one of our missions.

The reaction to the demo completely blindsided us. Our fans were disappointed. The demo was “more of the same,” or even worse, just “meh”—not even worth talking about. After a couple of days we realized what went wrong. Anticipation was so high that we couldn’t possibly live up to expectations.

Also a huge part of the appeal of our single player game is the gameplay variety. Playing CALL OF DUTY 4, you almost never do the same thing twice. That makes it impossible to select just one mission to represent the entire game. Instead we had to choose what part of the game to represent with the demo. If we had chosen one of our radically different missions we would

**4 DISTRACTED BY SECOND PROJECT EARLY ON.** At the start of development on CALL OF DUTY 4 we tried to branch into two teams. We started a second project with a small prototype team, intending on shipping it a year after CALL OF DUTY 4. Our intentions were to create a new risky IP, which would allow us to stretch our creative muscles. We are determined not to stagnate creatively and just make clones of our previous games indefinitely. Growing a second team was one idea for how to do achieve this.

Almost immediately, the two projects began to compete with each other for ideas and people. We hired extra people, including some seasoned leads, so that neither project would be understaffed. As time went by, we were aware of the difficulties, but we initially focused on how hard it was for the team on the new game, failing to notice the damage that the second project was doing to CALL OF DUTY 4.

The area hit hardest was the game design. Our design leadership was distracted by the second project and put a lot of their creative energy into it. This meant that problems like “too much desert” were allowed to linger for longer than they should have.

Our second project was abandoned at the end of May 2006, allowing the entire team to focus on CALL OF DUTY 4. Naturally there were a lot of different reasons, but ultimately it came down to the realization that what made our previous games so strong was the chemistry of our team. Splitting the team into two parts broke that chemistry and both projects suffered because of it.

**5 SCARY SCHEDULE.** Our design workflow is very iterative. When members of the press visit us to see early versions of our games, they are always surprised to find that our games are fully playable, with what appear to be levels that are ready to ship, up to a year before the game is scheduled to be released. This is necessary for us to be able to iterate and throw out as much work as we do and still ship our games on time. This level of iteration applies not just to the gameplay and look of our levels, but also to the story and dialog. In this game, that led to some

big things not getting done until the last minute.

We knew we wanted high-tech looking movies between our levels to cover our load times and help tell our story. We didn’t know who to get to create them or if we should try to make them ourselves. We didn’t finish writing the game’s story until very late, so it wasn’t until well into alpha before we knew with confidence what we wanted these movies to be.

At the last minute, we contacted the producers of Discovery Channel’s *Future Weapons*, and signed a contract with Spov, which did the title animation for that TV show. Spov was able to deliver the movies in a very short time—something like two months from agreement on terms to final delivery.

The movies turned out really good and everyone on the team is really happy with them, but the late schedule meant that these movies were some of the absolutely last things to go into the game. Had they not been good, there wouldn’t have been any time to fix them.

Another scary schedule issue was with Captain Price’s dialog.



have alienated fans of the previous games, so we chose a level that we felt represented our “core gameplay,” which is fairly similar to the core gameplay of CALL OF DUTY 2.

Lastly we had to worry about story spoilers, as most of our favorite missions also advance the story. Giving away one of those as a demo mission was out of the question, as we didn’t want to wreck the game for players.

Given all these constraints, looking at the examples of other games which managed to build tons of pre-release buzz like GEARS OF WAR and HALO 2 and 3 without doing pre-release demos, we should have realized that a pre-release demo would be likely to hurt us rather than help us.

In hindsight, the PC demo was a distinctly different case from the Xbox 360 multiplayer beta. The beta was released earlier and was responsible for much of our buzz, it was much more novel on the Xbox, where gamers are not as used to free content, and it showcased a large amount of what was new in CALL OF DUTY 4. The beta also played a vital role in helping us ship a polished game.

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(Captain Price is easily the most important character in the game, with more mission-critical dialog than anyone else.) We always record dialog very late to prevent having to redo it all when we change the story and missions. After finishing most of the dialog recording for the game, we decided that we needed a different voice actor for Price. So, like the movies, Captain Price's dialog was some of the absolutely last assets to go into the game. His dialog turned out great, but had it not, there would have been no time to fix it. Unfortunately, Price's facial animation suffered as a result of his dialog being completed so late.

Because of our process, outsourcing is hard for us. We did outsource a small amount of art for CALL OF DUTY 4, but because of our design iteration, a large amount of it was not useful by the time we received it. We delayed work on outsourcing in order to be more confident in the assets we were requesting, which meant that we received final versions of many assets right around alpha. The last assets we received were too late to use because we had locked the game tree. Even some of the earlier assets were too late to actually use

because most of the missions had already maxed out their memory budgets. Other assets were requested for parts of the game that we cut while the assets were being built.

#### MAKING A NAME FOR OURSELVES

CALL OF DUTY 4 feels like a watershed moment in the history of Infinity Ward. We are all tremendously passionate about our games—all the choices we make in our design, even the ones that people complain about, we make because we feel they make the games more fun. Up until now we've always felt like we were underdogs, with each game fighting for recognition as one of the best in the genre. This may sound conceited, or stupidly modest, depending on your outlook, but that was the vibe around our office. With CALL OF DUTY 4, we suddenly feel like we've done it—we've produced a game that everyone loves. Coming out in a year with so many other great games, and still being counted among the best, is an amazing experience—one we will have to work very hard to surpass next time around. ❄️





## MaPZone 2.5

Jay Koottarappalli

### MAPZONE

★★★★★

#### STATS

Allegorithmic SAS  
31 rue Gonod  
63000 Clermont-  
Ferrand  
France

[www.mapzoneeditor.com](http://www.mapzoneeditor.com)

#### PRICE

Free

#### SYSTEM

##### REQUIREMENTS:

Pentium III or equivalent. 256 MB RAM (512 MB recommended). Windows XP or Vista.

Allegorithmic also recommends using a graphics card that supports Shader Model 2.0 in order to preview textures on 3D objects within the program's "3D View" pane.

#### PROS:

1. Incredibly flexible editing paradigm.
2. Combined with ProFX, you can't beat the disk space savings. An amazing solution for downloadable titles.
3. Free.

#### CONS:

1. Steep learning curve.
2. Even simple textures end up with messy node graphs. Complex textures are extremely difficult to traverse.
3. Easily cluttered interface.

#### ALLEGORITHMIC'S MAPZONE IS A

texture-generation tool built entirely on procedurals, which provides very powerful controls, enabling you to assign rules to the procedurals and directly affect the elements of the procedural on a very low level. This results in textures that don't look procedural at all.

Supplementing MaPZone, Allegorithmic also created ProFX: a middleware solution for rendering the procedural algorithms from MaPZone into bitmaps at run time, allowing you to store the algorithms themselves on disk as opposed to the actual image file, which saves space. While this is not always a huge concern for retail products, downloadable games see massive benefits from this (Figure 1).

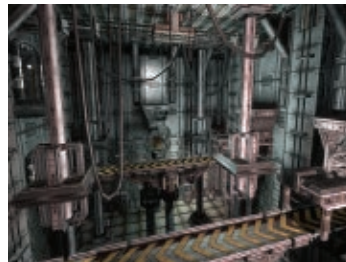
#### BUILDING TEXTURES

When beginning with MaPZone, it's important to remember that while the way you edit the texture has changed, you still develop the texture using the same concepts as traditional texture painting. Starting with your base layer, you add layers of detail, adjusting each layer as you progress. However, with MaPZone you are no longer using a brush, but rather a series of very powerful procedural tools to author each layer and the image as a whole.

Allegorithmic has parameterized the procedural (FX Maps) and exposed the variables to users, allowing them to affect how the procedural is generated, through a series of controls. MaPZone's editor can be daunting to non-technical artists, and it takes a fair bit of play to grasp exactly what is being done on each parameter. But once you understand the controls, the possibilities of MaPZone really make themselves apparent.

The workflow is broken down into a few simple tasks, each of which have a lot of options. The first task is to determine how much detail you will need for a particular piece. You then decide on a pattern to use—the image is algorithmically generated and gets patterned based on the parameters set in the editor.

Next comes the layout of the whole pattern. Through the same controls as pattern-image editing, you have the power to change everything from brightness, to opacity, to the random



**FIGURE 1** Naked Sky's *RoboBlitz* utilized MaPZone and ProFX to help bring the game down to a 50MB download. 80 percent of the textures were done procedurally and as a result the game saw a 300:1 texture "compression" ratio.

placement of the images in the pattern. If you still want more control over the actual placement, you can go in and modify the detail element itself (Figure 2).

Furthermore, at each detail level, you can actually have completely different values for the pattern image and the pattern itself through the use of parameter sets, which allows for some very complex shapes that you would not immediately attribute to procedural art. The ability to edit your procedural at such a low level is the answer to just about every excuse that anyone could ever come up with for not believing in procedural textures.

Once you have a good FX Map, the image editing begins. Editing happens on a node graph by wiring different FX Filter nodes together and seeing the results in the view window and a 3D

viewport where you can bring in your own shaders (Figure 3). Through the use of FX Filters, it's possible to modify RGBA values, warp and blur the result, among other operations, but most of the work is still in wiring together different procedural FX Maps. Because nodes can output to multiple inputs, it's also possible to have parameters of nodes drive other aspects of texturing, such as normal, specular, height, and practically any other color values you can think of (Figure 4).

Once you've created a material, creating texture variants is really down to clicking a few buttons on various nodes and some minor tweaking. The power of being able to create a set of 20 different ground tiles complete with multipass maps for an environment within about 20 minutes is invaluable.

#### WITH POWER COMES COMPLEXITY

In the end, however, there are a few drawbacks. One is that the FX Map editing is not readily mastered. It takes time to grasp the numerous settings and how you need to tweak them in order to get the image you need. The next issue is that your main window will turn into a mess of nodes. While a Clean function will remove unused nodes from the scene, the number of nodes you need for simple operations will soon clutter the interface. Because you can't create any logical groupings of nodes and expose parameters (as you can in Mental Mill or Virtools) it is difficult to read a graph and immediately tell what a node is doing. This can make it hard to hand off a material to another artist and have them quickly begin working. [Although not snap-to-grid functionality, version 2.6 of



**FIGURE 2** Adding detail to the procedural. Image 5 from the left features random placement and auto color leveling applied. Image 6 from the left represents elements moved by hand.



## product news

### AudioTools AWE Plugin Bundle

#### Minnetonka Audio

Minnetonka Audio announced the release of Master Bundle for AudioTools Audio Workflow Engine (AWE) version 1.3. The Master Bundle is a suite of plug-ins specifically designed and integrated for use in AWE. The plug-ins include Minnetonka Audio's TimeStretch and PitchShift which is powered by iZotope Radius, as well as iZotope's Mastering EQ, Mastering Limiter, Mastering Reverb, and Multi-Band Compressor.

AudioTools AWE is an automated audio workflow engine for editing, format conversion, encoding, plug-in processing, and processing through external I/O devices. It has the ability to process thousands of files in a single job and processing chains can be auditioned and saved as templates. Advanced job management features include Hot Folders, a Job Queue that manages any number of sequential jobs, robust failure recovery, and job logs.

[www.minnetonkaaudio.com](http://www.minnetonkaaudio.com)

### DAZ Studio 3D Bridge for Photoshop

#### DAZ Productions

A beta version of DAZ Studio 3D Bridge for Photoshop plug-in has been released. The new plug-in allows DAZ Studio users to automatically apply 3D imagery and artwork to any Photoshop project. Users can view 3D scenes as Photoshop layers, change objects and figures

simultaneously, render directly into Photoshop, import, export and modify image maps and textures onto 3D models, and composite 2D and 3D content.

The plug-in is available for both PC and Mac formats and is compatible with Photoshop 7, CS, CS2 and CS3. The 1.0 version will be available for purchase in spring 2008. DAZ Studio is free of charge and is available on Windows 98 SE or higher and Mac OSX 10.3 or higher.

[www.daz3d.com](http://www.daz3d.com)

### Houdini 9.1 with FBX Support Released

#### Side Effects Software

Houdini 9.1 now includes an importer that allows access to the Autodesk FBX 3D file format. The importer remains in development and will see a variety of enhancements over the coming months. For now, it supports geometry, attributes, lights, cameras, node and joint hierarchies, and animation and geometry caches. Support for FBX export is planned and will be released in Q2 of this year.

The Houdini 9.1 release includes a variety of enhancements and optimizations to fluids, cloth, character rigging, animation, lighting, and UI. The user interface now ships with an alternative dark color scheme and the ability to download a variety of user-defined color schemes from the net.

The Network view and Channel editor have been optimized, and the timeline interaction has been streamlined

to make it faster and more intuitive.

Animators can now work more easily by using the Channel List to select objects in the 3D view.

New Fluid emitter tools have been added and the surfacing of particle fluids are up to 60 times faster than before. Cloth simulations are also faster and more reliable especially when interacting with dynamic volumes.

[www.sidefx.com](http://www.sidefx.com)

### Virtools Wii Solutions 1.1

#### Dassault Systèmes

Dassault Systèmes released its Virtools package of prototyping and full game production tools for the Nintendo Wii. The package gives developers for the console access to the Behavior Engine and the VSL compilation, as well as new Wii-dedicated functionalities.

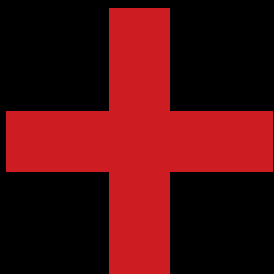
The Wii Solutions package also provides add-on libraries of building blocks specifically dedicated to Wii game prototyping and game development. Game developers will be able to test on the console anytime during the development, using Virtools 4 and accessing the Wii Remote information from a Virtools application running directly on a PC.

[www.virttools.com](http://www.virttools.com)

### 3D-Brush Version 2.04

#### Pilgway

Pilgway announced the 3D-Brush Version 2.04 release of its proprietary



Launching an MMO is a complex process. It requires skill and great fortitude, sprinkled with optimism. Each decision is dependent on the next. Before your MMO hits the crowd, the work begins to make sure your big idea is both well designed and well coded. It also has to be technically capable of coping with several thousands of concurrent players – if not, something that appears to be a minor technical issue in the beginning, can lead to a catastrophe once your game is launched.

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3D-Brush tool, adding a number of new texture-baking, normal mapping and redo features. The latest release adds a texture-baking tool, which allows users to project a current mesh onto a new one with completely different topology and get normal, color and specular textures.

Additionally, 3D-Brush has added a normal map importing update that does not displace geometry, but creates a new layer with corresponding blending, also allowing users to add details on an already existing normal map.

[www.3d-brush.com](http://www.3d-brush.com)

#### Lightsprint Lighting Middleware SDK

##### Lightsprint

Lightsprint updated its Lighting Middleware SDK to integrate offline and global illumination engines and improve lighting quality. New features in the Lightsprint SDK 2008 include unified API, both realtime and offline lighting, physical light simulation with infinite bounces, color bleeding, unlimited number of static and dynamic light sources, and 400 fps performance. The SDK also fully supports both precomputed lightmaps and realtime computed global illumination.

<http://lightsprint.com>

#### EMotion FX Character Animation Package

##### MysticGD

The latest release of EMotion FX Character Animation Package introduces a level of

detail (LOD) system that allows users to tune model skeletons to optimize runtime performance. It also provides a workflow pipeline aimed at speeding setup of complete in-game characters.

Additionally, a new Geometry LOD system allows artists to either specify LOD levels for given meshes manually, or let them be generated automatically. The SDK's documentation has been rewritten, adding a sample browser to navigate the 44 different API examples.

The latest release also enhances memory management with the aim of improving EMotion FX efficiency on consoles.

[www.mysticgd.com](http://www.mysticgd.com)

#### PathEngine SDK Release 5.14

##### PathEngine

The new release of PathEngine includes several important bug fixes and boasts significant performance improvements across the board, including a 20 percent speedup in pathfinding preprocess generation and a 15 percent speedup in collision preprocess generation and runtime pathfinding queries.

The update has speedups in pathfinding around dynamic obstacles as well as improved scaling when loading meshes without a mapping to 2D. It also speeds up 3D processing, with improved scaling of content processing times with respect to scene complexity.

[www.pathengine.com](http://www.pathengine.com)

#### Half Price On PSP Development Tools

##### SN Systems

SN Systems announced a 50 percent price reduction for all its development tools for PlayStation Portable. The price reduction applies to all SN Systems PSP development tools including full and rental ProDG for PSP, Tuner, Build Tools and ProView licenses ordered through the UK-based SN Systems office. Support fees will also benefit from the same 50 percent reduction in price. The reduction in support fees will also apply to developers seeking to renew their annual support on existing PSP products.

[www.snsys.com](http://www.snsys.com)

#### Torque Game Builder 1.7 Released

##### GarageGames

Torque Game Builder 1.7 adds improved link point and collision polygon editors and a number of other usability improvements including new methods for dealing with scene objects and a new editor for creating vector objects.

Built on the 3D Torque Game Engine, Torque Game Builder features animated sprites, flexible tiles, a special effects system, collision, real world physics, and hardware-accelerated 2D rendering. Torque Game Builder is a 2D engine that incorporates 3D objects and features such as parallax scrolling, enabling designers to create pseudo-3D games and environments.

[www.garagegames.com](http://www.garagegames.com)

**A minor issue can turn into a serious nightmare in the end.**

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MICK WEST

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# EXPONENTIAL OPTIMIZING

### MANY TASKS IN GAME PROGRAMMING

involve dealing with a large set of objects, where any object in that set can theoretically be affected by the state of any other object in that set. A good example is any type of physics object, such as bricks that need to potentially collide with all other bricks. A linear increase in the number of objects will result in an exponential increase in the potential number of interactions that need to be considered.

Solutions to this problem usually involve some kind of partitioning, so that the entire set of objects does not need to be considered at once. A brick need only check for collisions with other bricks that it knows are nearby. The ways in which the exponential increase in complexity can be addressed by partitioning the data are theoretically reasonably well understood. However, the practical realities of target hardware limitations and of the types of events and situations we have to handle in computer games make for some interesting complications. I'll explore a couple of simple examples of this partitioning, and discuss potential complications.

### SORTING

Sorting is not usually considered an interesting problem in computer science. The basic algorithms were all discovered many decades ago, and they are very well understood. However, the specifics of computer games and

computer game hardware (consoles in particular) make an investigation of sorting quite interesting. While the theoretical performance of algorithms is straightforward, your actual results are affected by several complex factors.

Before you dive head first into optimizing your sorting functions, you might want to consider whether you're optimizing prematurely. If you hardly ever do sorting on a per-frame basis, and it's only for small lists of a few tens of items, then it's unlikely you need to optimize. If, on the other hand, you have a list of 5,000 particles that you need to sort for a transparency draw order every frame, then it's a pretty safe bet that the sort time is going to be an issue. Because a change in a sort algorithm can result in a significant increase in memory usage and potential new bugs, it partially qualifies as a mature optimization in that it is best done early in the project, before you know if you actually need it. [See "Mature Optimization," January 2006.]

The most common trivial sort algorithm I use is the selection sort, where you simply scan the list, find the lowest item, put it at the start of the list, then repeat for the rest of the list. It's pretty easy to implement, and for short lists it's reasonably efficient, as it has no overhead and minimizes memory writes. Figure 1 shows what happens in the selection sort. For each pass, each item is compared to the lowest value found so far (faint arcs), and the smallest is moved to the start of the list (bold arcs). Note: In these examples, I'm just sorting an array of numbers into ascending order; more typically you'd be sorting larger items based on some value or key.

It's easy to see the run time of this algorithm is going to be exponentially proportional to the length of the list. It requires a fixed  $n*(n-1)/2$  comparison: it is essentially  $O(n^2)$ . This makes it impractical for large lists.

### QUICKER SORTING

All good programmers know that there are  $O(n^2)$  and  $O(n \log n)$  sort algorithms, so your next step is going to be to implement something like the quicksort algorithm. Quicksort is slightly more complex than selection sort, but not excessively so. It's well documented, and there are many implementations. You basically choose one element in the list and create lists of higher and lower elements, and then recursively do the same to those lists until all the lists are one item long, at which point you join all the lists together, and they will be sorted.

CONTINUED ON PG 38

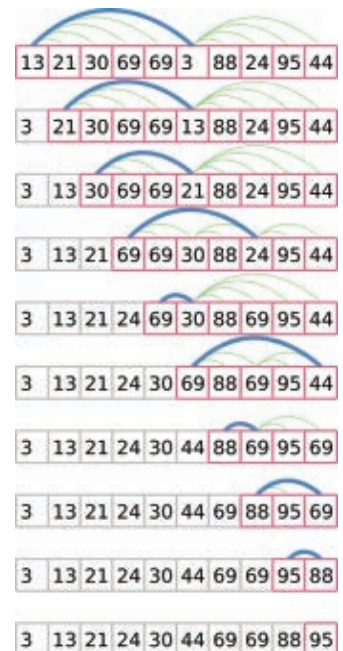


FIGURE 1 Selection sort: All items in the list are tested by comparing them to the lowest value found so far (faint arcs), and the smallest is moved to the start of the list (bold arcs). This is repeated until the whole list is sorted.

MICK WEST was a co-founder of Neversoft Entertainment. He's been in the game industry for 19 years and currently works as a technical consultant. Email him at [mwest@gdmag.com](mailto:mwest@gdmag.com).

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CONTINUED FROM PG 36

You can do this in place, so you won't need any additional storage.

Why would you not use quicksort? For very small lists, typically fewer than 15 items, it's actually slower than the selection sort. This is due to the additional overhead and the increased number of memory writes. The last four lines of Table 1 show the typical number of memory reads and writes for simple implementations of quicksort (QS) and selection sort (SS) for 10, 20, 40, 80, etc., items. Note that for 10 items, the selection sort uses fewer reads and writes, and for 20 items or more it always uses fewer writes.

The analysis of memory reads and writes is important if you want to understand why an algorithm performs as it does in terms of execution time. On some architectures, memory writes are slower than memory reads, so the total time is not simply a sum of memory accesses. Cache obviously plays a big part, and as such the patterns with which memory are accessed can play a role.

Theoretically, a bubble sort could be fastest in certain situations.

The quicksort scales very well for larger numbers. With more than 20 items, the quicksort is a clear winner over selection sort, which quickly explodes into an exponential number of memory reads (818,000 for selection sort, versus 18,260 for quicksort).

QUICKEST SORT

The biggest reason not to use quicksort is that it's not actually the quickest sort algorithm for list of the size that you typically find in video games. Now we enter the realm of partitioning, and hence to bin sort, also known as the bucket sort.

In this algorithm [see Figure 2], you simply divide up the key space into a number of bins and place each item into the corresponding bin. The bins are then sorted (which is often done as an insertion sort when adding the item), and then concatenated to give the sorted list.

Theoretically, this method can give us a run time of  $O(n)$ . But the actual time is greatly affected by the number of bins used. Too few bins and your time devolves back to the time taken to sort a bin; too many bins and there is excessive overhead in maintaining them. Table 1 shows the number of reads

(usually about the same as the number of writes) for a bin sort with various length lists, sorted using various bin sizes. You can see that with 10 bins, the performance is roughly comparable to a quicksort for low numbers, but begins to exponentially increase at a certain value. As we increase the number of bins, the performance increases for the longer lists. However, if the number of bins is increased too far, the performance can actually decrease. This is illustrated by the area of the table shaded in orange where the overhead of the large number of bins outweighs the performance gain.

It's interesting to compare the performance of the three algorithms. Selection sort is the fastest and simplest for a low number of elements (15 or fewer). Quicksort scales very well for large numbers. Bin sort can always outperform quicksort for a regular distribution, although you need to be careful in choosing the number of bins. Too few bins, and you'd be far better off using a quicksort. Having too many bins is better than having too few, but there's a sweet spot to which you would need to tune your algorithm. This depends on various factors of your implementation.

Another downside of the bin sort is that it requires quite a lot of additional memory. This is temporary memory, so you could perhaps use something that will be re-used later like a vertex

TABLE 1 Bin sort, quicksort, and selection sort.

Bins	Number of Elements to be Sorted									
	10	20	40	80	160	320	640	1280	2560	5120
10	42	88	193	459	1200	3803	12701	47148	174332	681551
20	52	87	170	389	945	2385	7620	25607	93950	351134
30	61	98	179	349	798	2099	5741	18721	65961	237101
40	71	105	177	343	770	1792	5079	14978	51437	187979
50	80	115	183	350	723	1712	4499	13061	42937	149393
60	91	122	196	343	734	1638	4146	11534	37584	129619
70	100	133	196	366	702	1576	3946	10821	33002	114995
80	111	143	211	350	694	1520	3747	10095	30694	102148
90	121	152	220	370	686	1485	3618	9431	28077	92399
100	130	164	232	367	696	1453	3496	9157	25976	86473
110	140	172	237	374	699	1425	3333	8613	24524	80850
120	150	182	248	379	680	1411	3262	8220	23794	74732
130	161	192	255	389	703	1400	3210	7875	22183	71207
140	170	201	262	396	715	1394	3157	7856	21625	67138
150	181	210	273	408	709	1379	3117	7493	20609	63250
160	190	222	285	420	712	1375	3034	7368	20332	59975
170	200	231	294	429	724	1381	2994	7241	19407	58497
180	211	241	304	437	730	1379	2998	7181	18905	56918
190	221	251	315	444	726	1396	2937	6952	18619	54967
200	230	260	325	456	736	1389	2952	6980	18091	52645
QS-read	48	110	279	728	1612	3668	8100	18260	42480	90478
QS-write	20	46	108	251	572	1296	2926	6365	13894	30424
SS-read	45	190	780	3160	12720	51040	204480	818560	3275520	13104640
SS-write	14	34	72	154	306	630	1260	2554	5094	10220

The table shows a comparison of the number of reads required to sort variously sized lists using bin sort, quicksort, and selection sort.

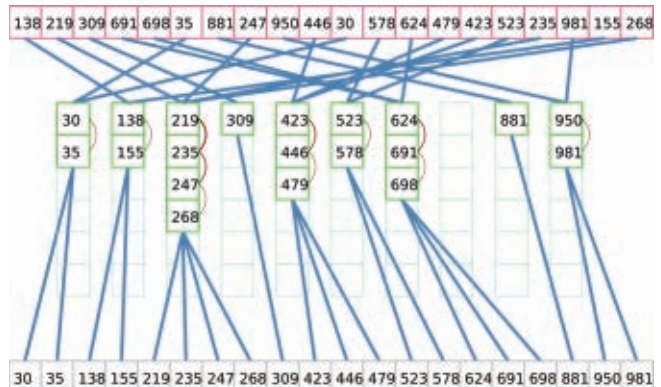


FIGURE 2 Bin sort: Items are placed in sorted buckets and are then concatenated. This method is more complex and memory-hungry, but generally works best for longer lists.

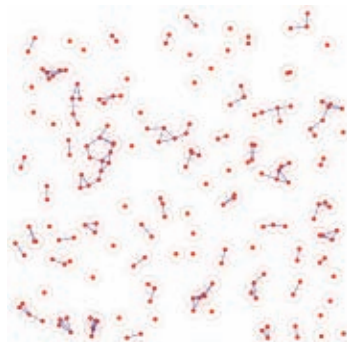
buffer. But this extra memory can still be a problem. Bin sort is also vulnerable to items being bunched up. If a large number of items goes into the same slot, then the performance will massively degrade, unlike quicksort. It's important to consider these cases when choosing an algorithm.

### OBJECT INTERACTIONS

Another common task with  $O(n^2)$  complexity is object interactions, particularly object collisions. Every object in the world can theoretically collide with every other object, but obviously they are limited to objects that are close enough. You need not consider objects that are half a mile away, and obvious optimizations arise where you can group objects that are close to each other.

Figure 3 shows a scattering of 200 objects in a world. Each object is a red dot, and the circles represent the distances at which the objects need to test each other for collisions. If two circles overlap, then tests must be performed. By only testing the overlapping objects, the number of tests is reduced from a theoretical 40,000 to a more manageable 265.

How do we know which circles overlap? The most common technique to use here is to have a grid that overlays the world. The grid is an array of lists of objects.



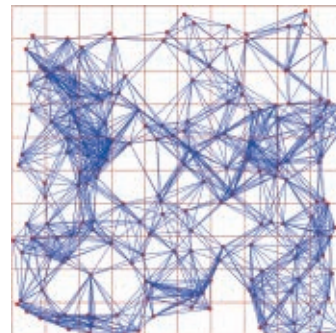
**FIGURE 3** The red dots represent 200 objects in a world, and the circles show the distance at which the objects need to be tested for collision. Objects need a collision test if their circles overlap, but this requires  $n^2$  tests.

Whenever an object moves, it tells the grid which cell it is in, and the grid updates the list of objects in that grid cell. This requires very little time to update.

Then, when wanting to find which objects are nearby, we only need to check the lists of objects that are in nearby cells. Figure 4 shows a grid of 10x10 cells. By checking only the objects in the same or adjacent cells, the number of checks is reduced from 40,000 to 1,614. This is still significantly more than the theoretical minimum of 265, but a vast improvement nonetheless.

As with the bin sort method, we can increase performance by increasing the resolution of our partitioning. Figure 5 shows a 20x20 grid, and the number of checks is now down to 536.

This grid method is similar to bin sort in that it uses simple criteria to place objects in slots. The simple  $O(n^2)$  comparisons of every object against every other object is analogous to the selection sort. As with the selection sort, the simple method of checking all objects can actually be the fastest method when there are only a few objects. It's very simple, and generally requires few computations. The grid method, on the other hand, suffers from the same problems as the bin sort method—it uses up extra memory. Too fine a grid can actually slow things down, and if objects bunch together, their performance can degrade massively.

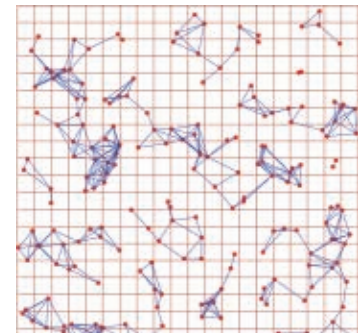


**FIGURE 4** By partitioning the world, we only test those object in nearby cells.

### TRADEOFFS

Optimization is about trade-offs. The examples in this article are quite simple, but are illustrative of the problems that can arise in typical game development. Here we've seen four primary trade-offs:

1. Faster algorithms are generally more complex. This increases your development time, but also increases the possibility of new bugs.
2. Speed can often only be bought at the expense of additional memory usage. This is a classic trade-off.
3. Faster algorithms have less predictable behavior. Quicksort is generally  $O(n \log n)$ , but can devolve to  $O(n^2)$ . Bin sort has an even wider range of possibilities, ranging from  $O(n)$  to  $O(n^2)$ . The worst-case behavior may render pointless any optimization you got in other cases, and it might be best to go with a slow and reliable method.
4. Partitioning algorithms such as bin sort or grid-based proximity detection algorithms vary greatly in their results based on the number of elements, the resolution of the grid (or bins), and the spatial distribution of the elements. The ideal configuration is difficult to discern, and may require careful tuning. ❌



**FIGURE 5** Using a higher resolution means fewer tests, but increases memory usage.



STEVE THEODORE

## PIXEL PUSHER

# FACE TO FACE TO FACE

## Some Hints For Your Head Pipeline

### THE HUMAN FACE IS THE MOST

technically challenging subject in art. Capturing its complex forms is tough enough—but what really complicates matters is the audience.

Our brains have the equivalent of specialized facial-recognition hardware (called the “fusiform gyrus,” if you want to impress your friends) that helps us recognize individuals and read facial expressions. People can remember hundreds of faces effortlessly, penetrate all sorts of disguises (see Figure 1), even recognize well-known faces in images as small as 16 pixels across (see Figure 2). All this, of course, is bad news for us poor artists. It’s tougher to pull a fast one when the audience is so well informed.

At least technology is offering a little help these days. The rise of sculpting programs like ZBrush and Mudbox has revolutionized digital portraiture. The combination of gestural modeling, symmetry tools, and the ability to hop back and forth between macro and micro details has been a godsend. Nowadays, artists like Steven Stahlberg or Francisco Cortina can satisfy even the most demanding fusiform gyrus with subtly molded forms and lush surface details. Rifling through the pages of the latest glossy Ballistic Publishing tome can’t fail to amaze, awe, and humble even jaded old poly pushers—emphasis on “humble.”

For game artists, the first reaction when flipping through those lush, detailed images may be admiration, but

the second is usually defensiveness. “I bet I could do that too, if I had eight weeks to work on one head,” or “Sure, it looks great with a 10-hour mental ray render but how good would it be in real time with a 512 texture?” The relentless



**FIGURE 1** How good are people at reading faces? Good enough that it only takes a small hint for them to realize that all eight of these people are actually Obi-Wan Kenobi, AKA Sir Alec Guinness in *Kind Hearts and Coronets*, 1949.



**FIGURE 2** Our built-in ability to recognize human faces is good enough that we can spot a familiar person in an image as small as 16 pixels across.

pressures of time and budget are never far from the game artist’s mind, and they can be a depressing drag on what’s achievable.

But the boundaries of “achievable” have stretched an awful lot lately. Real-time characters from games like *HEAVENLY SWORD* and *ASSASSIN’S CREED* prove that the days of stiff and bland mannequins are gone. The stakes are very high these days.

### HEADS UP

The question for us mortals is how to hit that kind of quality bar in the tiny little window of time that our gracious overlords see fit to allow us.

Underneath it all, people are basically the same—a heartwarming moral for an after-school special, but also a handy fact for a modeler cranking through a stack of character concepts before the next milestone. Using that similarity to your advantage is the most important way you can improve your facial modeling workflow.

Most veteran modelers have a few heads stashed away for emergencies. (After all these years, it’s still satisfying to be able to write that sort of thing with a straight face!) However, leveraging these source models is a lot easier if you think ahead a little. There are three big areas where it helps to think ahead: budgets, texture layouts, and morphing the generic library head into shape.

### BUDGETS

Naturally, the first big question is the budget. It’s no good building a library of reusable heads that you can’t reuse because they’re too big. Unfortunately, there’s an inescapable trade off between tight poly budgets and workflow efficiency.

To get the most out of your sculpting program, you have to have a nice quadded mesh, with good edge loops, well hidden pole-points or N-gons (if the terminology is unfamiliar, see “Subdivide and Conquer,” January 2004). Alas, this will never be as lean as a hand-built triangle mesh. A proper layout can easily add 10 to 20 percent or more to the polycount for visually similar results.

Why take that hit? Think of it as a time-saving tax. If your base mesh isn’t laid out properly, you’ll end up having to edit it into a subdivisible form every time you head to ZBrush, Mudbox, or the like. With a subdivision-friendly mesh, on the other hand, you can even do your normal casting right inside your sculpting package, which spares you the agony of shoehorning multimillion-poly high resolution heads into 3ds Max or Maya for casting.

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**FIGURE 3** Good edge loops are essential to building up a good head-modeling workflow. This model shows a minimal set of edge loops for good facial subdivisions: the jaw line (cyan), the orbital ridges (orange), the eye sockets (red), the labio-nasal fold (blue), and the mouth (green).

The other big benefit of really nailing the edge loop layout is that you can be done with it. This layout step is the worst kind of annoying, computer techy workaround. Every time you think you've hunted down the last five-way vertex or rogue triangle, another one pops up to ruin your afternoon. Doing it more than once is sheer masochism. So sit down, take the time to lay down the edge loops correctly once, and then clone, clone, clone. Doing the job right once means you can get to the fun part right away for all subsequent heads.

Grab a copy of Ballistic's *The Face*, or troll the web for good articles on facial edge loops, and do it right ... once! (See Figure 3.)

**TEXTURE LAYOUT**

In much the same vein, it's important to get a good set of UVs on your base head model before you go charging off to the sculpting phase. If you put in the time early and lay out a good map, you'll have a much easier time later when you're ready to slap on your textures. Sharing a single UV layout allows you to share secondary maps for things like subsurface scattering or pores, which

are important for skin shaders, but expensive to keep in memory.

You might fear that the mesh changes you introduce during sculpting will distort your UVs. It's true that some stretching will creep in as you morph the head toward a final form, but unless you have very low-resolution textures, the generic similarity of most heads means any stretches you create are generally tolerable (and remember, the alternative is building and UVing lots of similar meshes one at a time).

In any case, one of the great advantages of a subdivision-sculpting workflow is that it makes it easier to paint your textures directly onto the model, whether with ZBrush's projection paint, Maya's 3D paint tool, or a 3D painting application like BodyPaint. Projection painting tends to minimize distortions in the underlying UVs, which is a nice side benefit on top of the precision you get from direct 3D painting.

One important thing to think about before committing to a final layout is the trade off between output resolution, seams, and stretches. If you've got a tight texture budget, you may need to accept a few more seams than you'd otherwise want.

**MORPHING**

Once you have a good idea about the right layout, you'll still have just one head, and you'll need to have a strategy for morphing into roughly the proportions of any individual character. A program called FaceGen (from Singular Inversions, [www.faceGen.com](http://www.faceGen.com)) provides a nifty way to simplify and speed up this process (see Figure 4).

FaceGen is a procedural face-modeling program. It lets you manipulate faces by adjusting things like the width of the mouth, the depth of the eye sockets, and so forth. What makes it such a good tool for building a library of heads is an add-on product called Customizer, which allows you to apply these procedural tweaks to a mesh layout and UVs you create yourself.

FaceGen actually runs on top of a database of about 300 scanned faces. When you twiddle a FaceGen slider,

you're not directly pushing verts as you would in a typical model-by-sliders tool like Poser. What you're really doing is saying, "Add in more of a head that has eyes like this," and FaceGen is applying a blendshape morph based on the closest samples in the database. Since the results are based ultimately on scanned data, they usually have the kind of coherence and holistic quality that Poser-style slider tweaks never manage. As an added benefit, the database allows for surprisingly good photo fitting. If you pass FaceGen front and side photographs, you get back a pretty decent 3D model with pretty good proportions, even for hard-to-capture areas like cheekbones and the outer ridges of the eyes.

With all that said, there's no need to worry about FaceGen stealing your job. It's great for getting the rough proportions and masses in a face, but



**FIGURE 4** FaceGen uses a statistical model of human features to deform your base mesh into a wide range of plausible characters. It's not next-gen quality out of the box, but it's a great starting point for crafting your own models.



**FIGURE 5** These heads share identical mesh topology and UV layout—both were roughed out in FaceGen and finished in Zbrush. Despite technical similarities they are very distinct characters.

it doesn't produce next-gen quality characters on its own. For one thing, it doesn't know anything about complex shaders—though it does generate diffuse color maps, which can be a helpful guide to painting your own textures. However, they aren't really triple-A quality on their own.

Most importantly, though, the statistical morphing process has a tendency to render all the output models just a bit, well, boring. The little details that give a face individuality and character tend to wash away as little bits of different people are blended together to create the final model. Luckily, that's precisely the kind of thing you want to do for yourself anyway. Once FaceGen has gotten you halfway there, you can hop over to Mudbox or ZBrush and start refining the critical details (see Figure 5).

You'll probably have to sharpen up some key areas like the wings of the nose, the ears, and the curve of the eyelids. Then you can really go to town on the wrinkles, creases, and folds of fat that make digital sculpting so much more fun than traditional vertex munging.

### FACE FACTS

All of this might sound like a lot of steps in between the initial concept and the final model. Alas, that's true. At least you can console yourself that building every head from scratch each time is even more work—work that mostly consists of dreary chores like optimizing subdivision meshes or packing UVs. Preplanning mesh layouts and texture packing stuff is like spinach: It's important, it's good for you, but you don't have to pretend to like

it. If you need motivation to undertake a thorough review of your head pipeline, remember that moving to a library-oriented workflow with a well done base head is like gulping down all your spinach in January and having the rest of the year left for pizza and Hägen Dazs.

While we may take a certain grim pride in the neatness of our texture packing or the elegance of our edge loops, nobody gets into this business because they can't wait to start eliminating N-gons. We're really pretty lucky these days, though. The rise of sculpting tools is the single most fun and liberating thing that's happened to our art form in years. It's exciting to be around now that games are catching up with what those tools can do. Just gulp down that spinach so you can come out to play. ❄️

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NOAH FALSTEIN

## GAME SHUI

# COMING OF AGE

**LAST YEAR WAS A GREAT YEAR FOR** games. I occasionally judge various “best of the year” awards, and some years it has been difficult to find more than one or two standouts, but 2007 saw many great games released. There was even a surprising and welcome variety among the year’s best games, with original and fresh titles breaking new ground as well as some very beautifully-executed improvements and iterations on old favorites.

I expect the next-gen console excitement was behind some of the quality we saw, but not all of it. Another factor was simply a growing maturity of the games industry and of game players themselves.

It’s been 21 years since the first Game Developers Conference, and the average age of game players has been steadily climbing all that time. We’ve had our game-world equivalent of art films for years, a handful of titles that go beyond the standard orcs and elves or blasters and starships conventions. There has been a rich culture of experimentation in small-scale indie games for quite a while, and better software tools and online connectivity continues to encourage that movement. But this year we actually saw mainstream hits exploring some really multifaceted and mature topics and settings.

### BIOSHOCK THERAPY

One game in particular impressed me this way: *BIOSHOCK* from 2K Boston/Australia. While the game does base

its core interactivity on tried-and-true shooter gameplay elements and is a self-proclaimed successor to *SYSTEM SHOCK 2*, it seamlessly integrates these familiar factors with several very unusual and adult themes.

The game’s setting of the hidden city of Rapture employs art deco design features, which are by themselves unusual, and it also portrays the city as decaying and nearing death. Its undersea setting and omnipresent dark waters add an ominous foreboding, elegantly keeping with the game’s themes. Not content to stop with a striking physical setting, the core storyline is heavily influenced by Ayn Rand’s objectivist philosophy. Although her 1957 novel



**Art Deco, Objectivism, and Genetic Manipulation—*BIOSHOCK* isn’t kiddy fare.**

*Atlas Shrugged* has sold more than 5 million copies, these days her utopian concepts of capitalism and individuality above all have largely fallen into disfavor and obscurity, and so are a daring choice for a game theme—and are marvelously integrated into the underlying assumptions of the game.

On top of that, *BIOSHOCK*’s story centers on some very disturbing and mature concepts regarding the ethics of genetic manipulation, questioning what it means to be human. Despite these grim, adult themes [or perhaps because of them], it managed to be one of the big hits of 2007. I confess, I have personal reasons to admire *BIOSHOCK*, too. I was approached years ago by someone who had the rights to do a game based on

*Atlas Shrugged*, and I spent a lot of time considering how it might be undertaken [concluding that it was a tough and risky venture]. I also contributed to the LucasArts title *PIPE DREAM*, clearly an inspiration for the hacking sub-game in *BIOSHOCK*. Those experiences give me an added appreciation for what lead designer Ken Levine has done, as well as a sense of how far games have come in these last two decades.

### BREAKING TABOOS

There were other mature themes in evidence among the hit titles last year. *ASSASSIN’S CREED* experimented with a commercially risky real-world historical setting and some sophisticated and controversial religious themes. *MASS EFFECT* even features the possibility of a [tasteful] human and alien lesbian sex scene. This is the kind of thing I’m used to seeing on cable TV or at the movies—it’s impressive to find it in games as well.

I feel it’s only fair to contrast these mature themes with one long-time holdout against them: Nintendo. We all enjoyed Nintendo’s great hit title released last year that took a familiar hero and started with his unrequited lady love, a princess, being yet again stolen away, requiring him to go off and [yet again] rescue her.

I’m speaking of course of *LEGEND OF ZELDA: PHANTOM HOURGLASS*. Or was that *SUPER MARIO GALAXY*? Sure, they have some great game mechanics and wonderful design details, but even Disney introduces new characters and sometimes [gasp!] has princesses who don’t need rescuing. For a company willing to take such interesting risks with game controls and level construction, Nintendo’s characters and situations seem linked—no, chained—to the past. After all, both the *MARIO* and *ZELDA* games go back more than 21 years now. Isn’t it time they came of age, too? ❖

**NOAH FALSTEIN** has been a professional game developer since 1980. His web site, [www.theinspiracy.com](http://www.theinspiracy.com), has a description of *The 400 Project*, the basis for these columns. Also at that site is a list of the game design rules collected so far and tips on how to use them. Email him at [nfalstein@gdmag.com](mailto:nfalstein@gdmag.com).

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JESSE HARLIN

## » AURAL FIXATION

# THE ART OF DESIGNING ART

**BECAUSE OF AUDIO'S INTANGIBLE NATURE,** we tend to speak about sound with the borrowed language of painting. We talk about our canvas. We talk about sketches, palettes, and colors. But in a practical sense, game audio much more closely resembles photography insofar as we frequently strive to authentically impart real-life detail into our titles. If it revs, jumps, or shoots, we ensure that each instance is faithfully, predictably, and realistically scored. The technological ability to create these richly nuanced worlds is relatively new to our industry, roughly a decade or less, but we're there now. We've proven that we can build the believable. As audio designers, we're ready to move onto the next step—infusing art back into our technical accomplishments.

### LIMIT THE LITERAL

Compared to audio design in both television and film, game audio is extremely literal. Everything in the game world is constantly emitting sound to the perpetual accompaniment of dialogue and music. The more music there is in a scene, the more a scene strays from the edges of realism toward hyperrealism as the game's score helps to telegraph emotion, pacing, and setting to the player.

But listen to the audio for a movie like *I Am Legend* or *The Graduate*. Watch an episode of anything from *ER* to *Buffy The Vampire Slayer* to *The Real World*. With exceptional frequency, film and television both play with massively exaggerated hyper reality in ways that games rarely approach. The end of Terry Gilliam's *12 Monkeys* is shot entirely as

a slow-motion action sequence. Most of the sound for the world has drained away. What remains resonates in a massive wash of reverb. At a pivotal point in the scene, all remaining sound finally fades away leaving only music to carry the emotion of the finale. By selectively isolating specific elements of the film's soundtrack, the movie moves away from a simple documentary of events and becomes impressionistic art.

If we are doing this in games, we're almost exclusively relegating this kind of audio treatment to the realm of cinematics, with few notable experiments such as *XIII* and *MAX PAYNE 2*. There is really no reason why this kind of audio mixing can't be done in real-time during interactive gameplay. Most audio engines contain separate busses for sound effects, music, and voice. Most times, a general mix of these busses is set and then the volumes of individual files and specific sound banks are tweaked as needed to refine and finalize the mix. However, nothing in the compliance guidelines for Sony, Microsoft, or Nintendo prohibits audio designers from dynamically interacting with these busses for dramatic purposes during gameplay. By combining dynamic control over these master mix busses with real-time digital signal processing (DSP) effects such as filtering and reverb, game audio engines have the exact same ability to achieve impressionistic hyper-reality within the art of audio design.

### LIMIT THE LINEAR

For all our bluster as an industry about the promises of interactive storytelling over the traditional medium of film, games almost always adhere to a rigidly linear narrative structure. The visual language of film and television, however, is frequently more sophisticated and uses flashbacks, montages, and other departures from strict linearity to help tell their stories. As clichéd as an arpeggiated whole-tone harp scale may be to mark the beginning of a dream sequence, this example scores the vast

importance audio has in helping to sell shifts in time and setting. Watch the film *Atonement* or any episode of *Lost* and you'll find that hyper real sound and music effects always precede jumps in time and place as a means of preparing the audience for a shift in setting.

Again, if we use flashbacks or montages in games, they rarely come in any form other than cinematics. Rarities like *SHADOW OF DESTINY*, *FINAL FANTASY VIII*, and, again, *XIII* have experimented with non linear time during gameplay. While it's essentially disjointed nonsense and devoid of actual story, the *WARIOWARE* series is basically micro-game montages frequently tied together only by their audio content.

The potential for non linear gameplay as part of a game's narrative structure is endless with just as many creative opportunities as those available to film and television. Again, it's going to be up to audio to help sell the distinction between real and hyper real. By decoupling audio from the game's cutscene movie player and ensuring that audio has the necessary available streams for crossfades, cinematics can occur as bookends to gameplay and yet allow audio to continue seamlessly from gameplay to movie and back to gameplay. By ensuring that audio engines utilize banks of sounds that can be dynamically loaded, separate sets of assets can be created and DSP effects established to differentiate between past and present, realistic snapshot and impressionistic hyper reality.

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**JESSE HARLIN** has been composing music for games since 1999. He is currently the staff composer for LucasArts. You can email him at [jharlin@gdmag.com](mailto:jharlin@gdmag.com).

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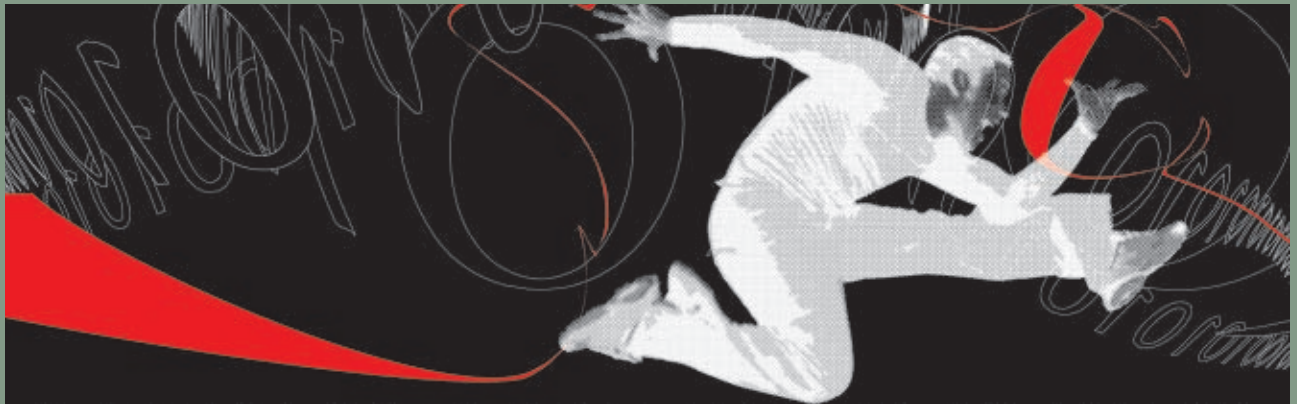
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## ARRESTED DEVELOPMENT

# PRINT IS DEAD

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### GAME PROGRAMMING TURDS, VOL. V

Here's a great example of a system that checks an entered player name against a database to make sure it isn't taken already.

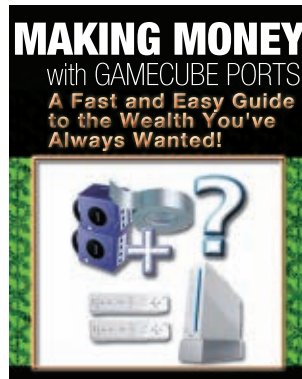
```

void GUIUserManager::OnKeyPress(const
GUIKeyEvent& e)
{
    mUsername.append(e.key);
    mThreadMan->StartNewThread
(ValidateUserThread, &mUsername,
UpdateValidUserGUI);
}

void GUIUserManager::
ValidateUserThread(void* userdata,
ThreadManager::Callback_T callback)
{
    NetDBConnection dbconn; // Open
a new connection to the remote DB
    callback->CallWithBool(!dbconn-
>UserExists((std::string*)userdata));
}

```

**MATTHEW WASTELAND** is a pseudonymous game developer who has a fairly common first name. Email him at [mwasteland@gdmag.com](mailto:mwasteland@gdmag.com).

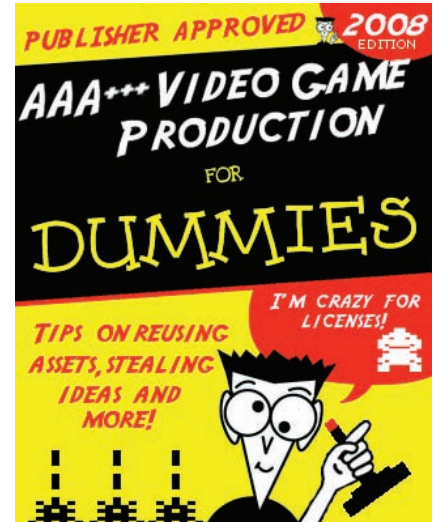


### MAKING MONEY WITH GAMECUBE PORTS: A FAST AND EASY GUIDE TO THE WEALTH YOU'VE ALWAYS WANTED!

First of all, you'll need to get yourself one or more "Dolphin" developer kits, which is the device that is used to create GameCube games. I've had some success finding these in local landfills, but your luck may vary depending on location (I live in San Rafael, California). Sometimes you see them for sale on Craigslist by a developer's divorced wife or estranged parent, who doesn't know what it is, and you can nab it for cheap. Ask to see it first, of course; you'll know it's a real Dolphin because it has a picture of a dolphin, along with an emergency-eject lever on the front. Hopefully you will never have to pull that!

Once you've secured yourself one of these boxes, you can start the porting process. Even if you've never programmed so much as your VCR before, you shouldn't be frightened at the prospect of doing a port to GameCube. The unique the architecture makes it easy! Non-unified RAM keeps things simple, because you won't have to worry about all of the memory at once. The small, 1.5GB discs mean there's a lot less data to load and process. If you're still afraid, consider this: A famous game industry technologist recently pointed out in reverse that GameCubes are essentially one-half of a Wii—which means that they are about twice as easy to program! And I don't know if you've played any Wii games lately, but come on. How hard could those have been?

At some point during the process, the publisher will call to see how things are going. Tell them everything is fine.



### AAA+++ VIDEO GAME PRODUCTION FOR DUMMIES

Think "AAA+++ " is a description for eBay sellers? Think again—it's a type of video game! And if you didn't know that, this book is for you: the ultimate one-stop, no-nonsense guide to developing and shipping blockbuster titles. Inside, we'll comprehensively cover all the aspects of modern development—from the exciting initial brainstorming sessions to the embarrassing cab ride home from the launch party.

As a simplified and easy-to-read primer, this book is ideally suited to managers and executives. Common production questions such as "What can we do to make our graphics competitive with those of other titles?," "How can a Visio diagram enhance my credibility?," and "How much can we exploit contractors before they sue us, and do the rules change overseas?" are all discussed and addressed.

And if you're intimidated by the industry's formidable technical jargon, like "ambient occlusion," "procedural," "spherical harmonics," or "work-life balance," don't worry: special care has been taken to explain these difficult concepts in layman's terms.

But if you're a seasoned pro just looking to brush up on the latest tips and techniques, you'll find those here too—including a section, new to this edition, on how to tolerate casual game people.

Finally, if you've purchased this book because your own project is already on the skids, and are looking for immediate help, please feel free to skip the introductory material and go directly to Chapter 7: How to Turn Whatever You Initially Designed Into a Run-and-Gun Shooter. ❖

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