GDC 13

Igniting the Spark: Building Online Services for *Borderlands 2*

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A Word About Me

- I’ve been programming for 20+ years, 15 professionally
- Making games since 1995; at Gearbox for over 10 years
- Network Programming on multiple titles
  - Halo: Combat Evolved (2003: PC)
  - Brothers in Arms: Road to Hill 30 (2005: PC/Xbox)
  - Brothers in Arms: Hell’s Highway (2008: PC/PS3/Xbox 360)
  - Borderlands (2009: PC/PS3/Xbox 360)
  - Borderlands 2 (2012: PC/PS3/Xbox 360)

A Word about Borderlands

- Introduced in 2009, sold over 6 million
- Coop Shooter Looter:
  - FPS Action, Action-RPG Mechanics
  - 4 player Cooperative, drop-in drop-out
- Borderlands 2 released in 2012, sold over 6 million
  - Refined Shooter Looter, enhanced coop play
  - Built SHiFT and Spark to connect to community
  - A new initiative, something we've never done before

What is Spark?

- **Spark**: Our backend platform
  - Internal name
- **SHiFT**: Our online service
  - Customer-facing

Spark Features for Borderlands 2

- **Archway**
  - SHiFT Account Signup, Platform account linking / authentication (Xbox LIVE, PSN, Steam)
  - Code Redemption & Rewards
- **Discovery**
  - Dynamic configuration, per-environment and per-user
  - Supports user populations for betas and testing
- **Micropatch**
  - Data-driven hotfixes for rich game content
  - Hard-coded or service-delivered (tied into **Discovery**)
- **Leviathan**
  - Telemetry for gameplay
  - Stats and Events with rich metadata

Why do this?

- Games are increasingly social, connected experiences
- AAA Games must go beyond the box
  - Embrace the web and mobile, companion experiences
  - Engage with players any time, anywhere
  - Build the brand
- Ultimately, all about the customer
  - Build the connection directly to the fans
  - Enable the community to forge connections
- These are pillars of the next generation of games

Archway: Accounts and Authentication

- Single Sign On via ticket verification
  - Xbox LIVE, PSN, and Steam supported
- Platform ID only comes from a valid ticket
  - This makes it difficult to impersonate a user

Spark: Single Sign-On Process

Spark: Reward Redemption

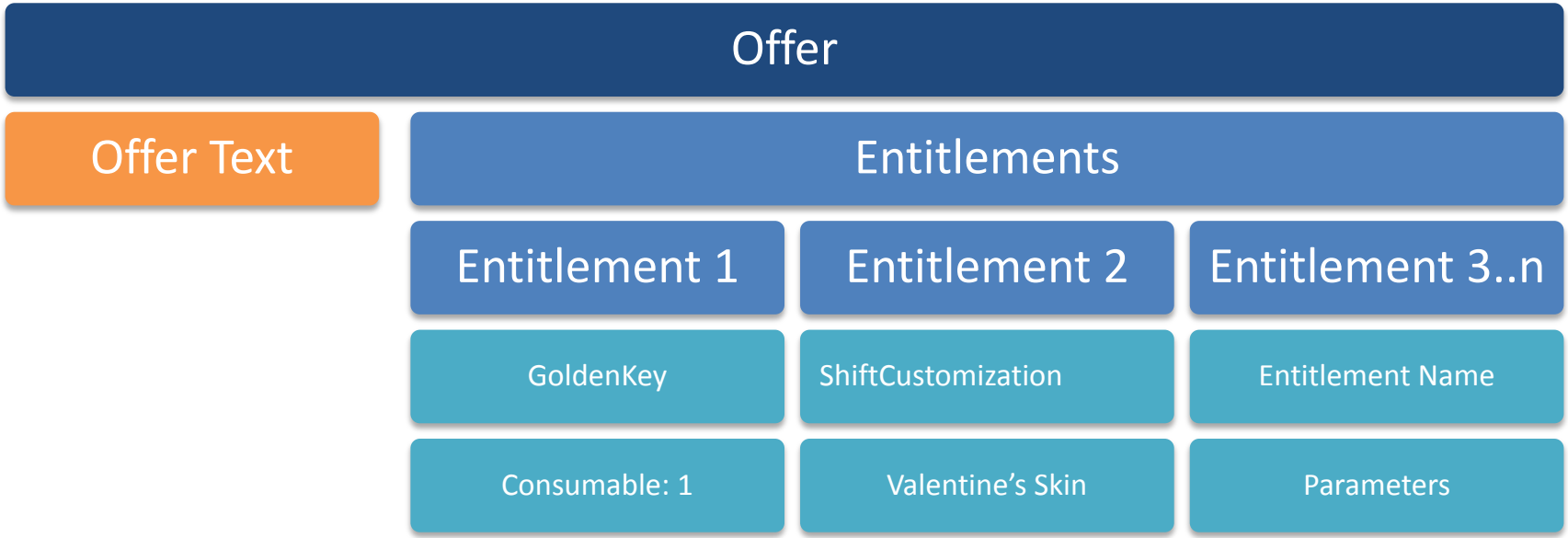
- Built a system of Offers and Entitlements into our account system
- Created a code generator for 5x5 codes

SHiFT Code Example

Xbox 360	CBKBJ-3TXBH-55S3X-W6TT3-9BSZ5
PlayStation 3	WBKTB-CB6TT-X6WCJ-9T5BB-W5CBT
Steam	WTCTB-HHX3C-39FJJ-JB333-FWWJZ

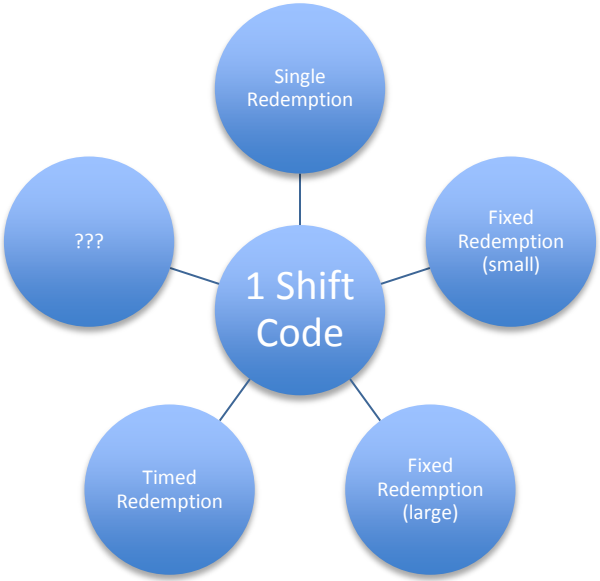
These are real-live codes, good for a Golden Key in Borderlands 2.
Redeem them when you get home ☺

SHiFT Code Reward Architecture



SHiFT Code Entitlement Architecture

SHiFT Code Redemption Patterns



Spark: Micropatching

- Borderlands 2 is a rich data-driven game
- So much of the game is actually implemented in data, how can that be updated on the fly?
- We built a system to package data updates into Micropatches, deliver them via Spark
- This allows us to do balance tweaks, bug fixes, live events by changing data implementation
- Authoring support in editor and backend tools

Spark: Telemetry

- How do players experience Borderlands 2?
- Drive Micropatches
- Provide business intelligence during launch
- Get visibility on exploits and cheats
- Feed into future development

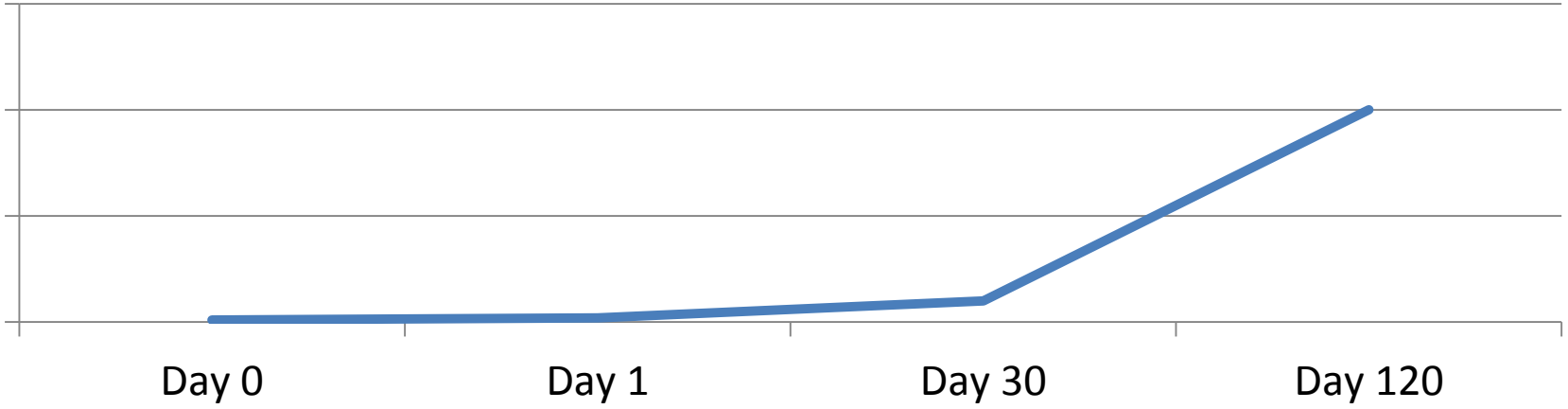
How do you do this?

- What does a backend service look like?
  - GDC talks
  - HighScalability.com
  - Amazon, Facebook, Microsoft, Google publications
  - Phone a Friend
- How do you choose technology for Blue Sky?
  - Know your priorities: What you like, Healthy ecosystem
  - Rapidly evolving space
  - Just choose and go – adaptability is key

The Challenge of AAA

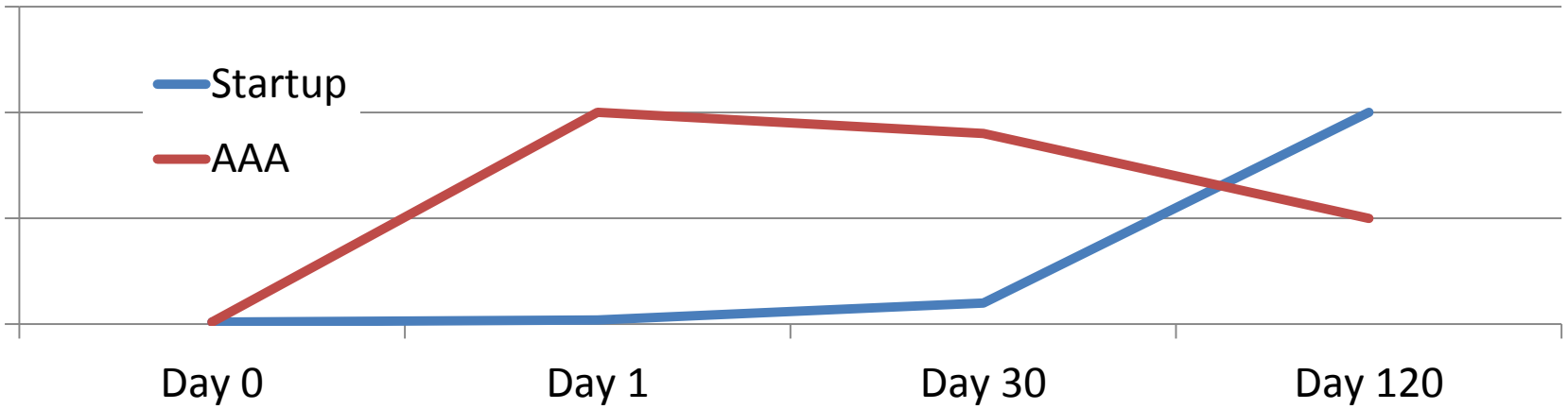
Startups & mobile teams reference soft launch, gradual run-up to inflection point

(John Mayer tweets about Words with Friends)



The Challenge of AAA

- AAA game launches are the opposite: Vertical, long tail and plateau



Building the Service

- Research
- Build a team
- Start coding
- Ship it 2-3 years later?
- …. This isn’t easy. Is there a better way?

Building a Beta!

- We shipped BTest for Borderlands on Steam
- Beta test of our toughest feature: Telemetry
- Early visibility into key decisions and questions for Authentication
- The focus of the first 10 months of Spark
- Shipped on 9/9/2011

BTest Postmortem: Test Everywhere

- We took our beta to different networks
  - 2k and Gearbox corporate
  - Home, with and without VPN
  - QuakeCon!
- QuakeCon used a transparent Squid proxy
  - Exposed a copy/paste bug in our HTTP code
  - Oops, sending POST data on a GET!

BTest Postmortem: Crash Bug!

- Clock synchronization problem on server
  - Game clients slowly drifted away from server
  - Some crash reports early
  - By Saturday morning, all clients crashing
  - Workaround server side, instantly fixed crashes!
- Lessons
  - Some test are vectors very difficult to predict
  - Server tunability is incredibly valuable
  - **Tuesdays are the Best Days!** (Not Friday!)

BTest Postmortem: Leaderboard

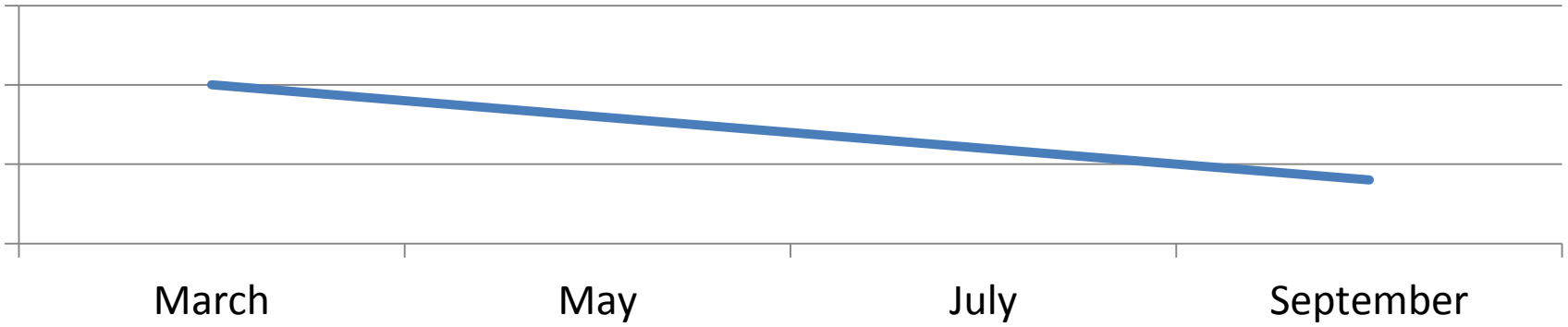
- We created a simple leaderboard to encourage players to try the update
  - It got slower and slower and slower, until updates were taking over 45 minutes. Refactored queries and got updates down to 20 seconds
  - Hacker submitted bogus data within hours of launch
- Lessons:
  - Test with full data set early
  - Try and break your assumptions
  - Malice is the Norm

BTest Postmortem: Database Schema

- We didn’t know exactly what we wanted to ask, so we built a very flexible, generic model
  - Very quickly got too slow to work with
  - How many enemies killed: 1 hr+ query times!
  - Database size out of control
  - Hard to plug in tools for visualization
- Lessons:
  - Knowing what you want to do w/ data is crucial
  - Data archival was very useful

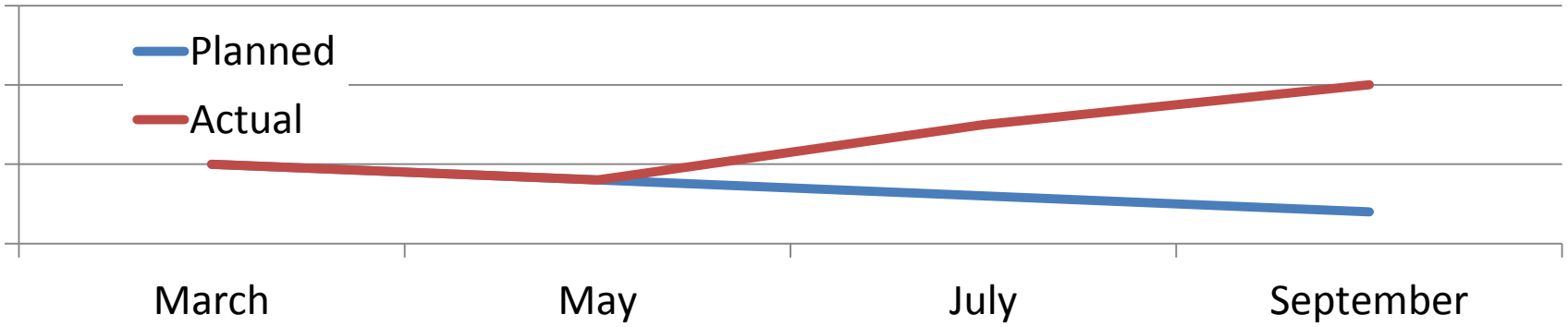
BTest Postmortem: Capacity Planning

- Looked at Steam data in March
- Predictable decline to July Launch



BTest Postmortem: Capacity Planning

- We shipped Btest in September…
- Steam Summer Sale!
- Borderlands 2 announced!



BTest Postmortem Capacity Planning

- Scrambled to handle dramatically higher load
  - Resized DBs, more servers, reconfiguration
- Lessons:
  - Pay close attention and adjust constantly
  - Be plugged in to PR and Business
  - Be agile

Building another Beta!

- BTest was so helpful, we shipped another beta!
- Launched December 13, 2011 (a **Tuesday**!)

Gearbox Moves into the Cloud

- BTest1 was hard to operate on shared hosting
  - Capacity hard to adjust, and we didn’t get it right
  - We knew we needed to design for more flexibility
- BTest2 Shipped on Amazon Web Services
  - EC2, RDS, ELB
  - Steep learning curve, but paid off…
  - Didn’t get everything right…

BTest2 Postmortem: Holiday Stability

- We launched and were mostly stable
- However, problem Christmas evening!
  - Our game was still selling, new people playing
  - Queues were backing up, not severe
  - A few days later, CPU is pegged!
  - The Cloud to the rescue! Deploy more bigger!
- Lessons:
  - Queue storage in cloud gave wiggle room
  - It was actually pretty easy to recover from CPU peg
  - Capacity planning still hard!

BTest2 Postmortem: Missed Opportunities

- New to AWS, Deployed regular EC2 instances
- Skipped VPC
  - This turned out to be a mistake
  - More difficult to secure some resources like we wanted
  - Had to build load balancing logic into app layer
- Lessons:
  - Embrace as much of the feature set as you can
  - Don’t be afraid to choose long term over short term
  - Especially for a Beta!

Going Wide

- After shipping two iterations, had some confidence in architecture
- Define the final feature set for the game
- Building an implementation plan is hard
  - Include all stakeholders
  - Navigate difficult policy waters
  - Finish building the team and finish the code!

Discovery: Design for Tunability

- Created **Discovery** service which is central store for service configuration
- If the client doesn't get service info, disable it
- Flexibility is key:
  - Simple key/value pairs, dirt-simple format
  - Different configs for environments, titles, and platforms

Discovery: Design for Testability

- Endpoint URLs and Versions from Server
  - Single point of entry hardcoded in code / platform config
- Client overrides for configuration via INI and command line
  - Allowed developers to work offline
  - Allowed QA to customize things for testing
  - Supported even in final builds
  - Enabled internal and external beta scenarios!

Design for Bad User Behaviors

- Be conscious of user behaviors which can harm the service
  - Signup / Signin
  - Code Redemption
- We implemented client side throttles
  - Prevent button mashing denial of service attacks
- Don’t create incentives for users to be bad
  - Signup/delete path not optimized for churn
  - Signup rewards once per platform ID, ever

Load Testing Difficulties

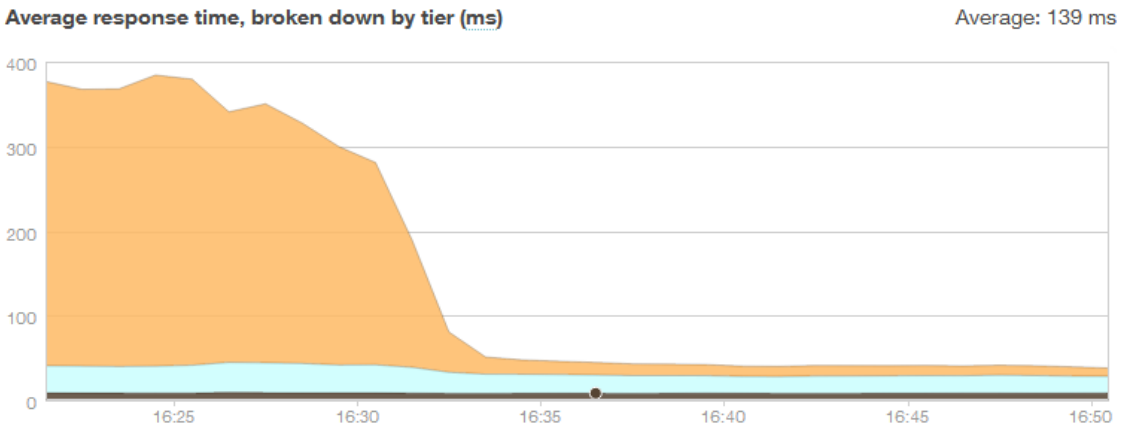
- We didn’t fully understand how ELB worked at first
  - Amazon’s documents are good, but easy to overlook
  - Turn off DNS caching
  - Prewarming critical
- JMeter limitations led us to write custom scripts
- Costs can get out of hand! Watch carefully!
  - Should have invested more in automation

Launching Borderlands 2

- Borderlands 2 launch: September 18, 2012
- The team was all set in the war room
- Night and day shift established for launch
- Latest capacity info from industry friends and experts projected we would survive
  - But still, wave of terror washed over me a T-6 hrs

So?, What Happened

- Nothing!
- Well, almost. At least at first.
  - Email queues backed up, deployed more workers
  - Slowing turning up the dials on telemetry
  - Watching the numbers, generally OK
  - Went to sleep happy!
- A few things did come up in the following days…



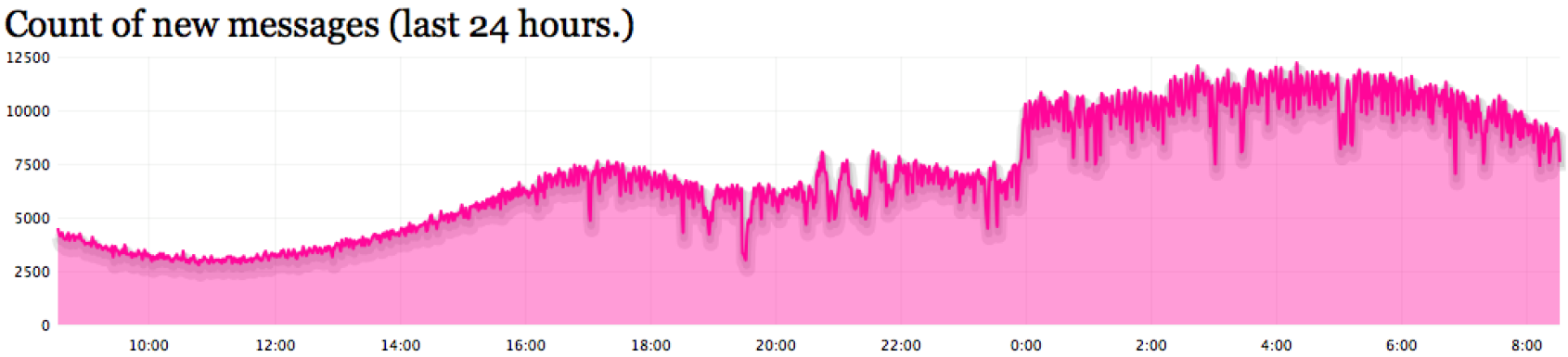
Day 1: Bad Query

Beware tolower() query on indexed columns
Our testing missed this because it only shows on a loaded database

Day 2: Keeping Telemetry Going

- Launch week capacity was tough to manage
- We wanted to keep costs in check, but had not implemented AWS Auto-Scaling Groups
- Manually add/remove instances at set times

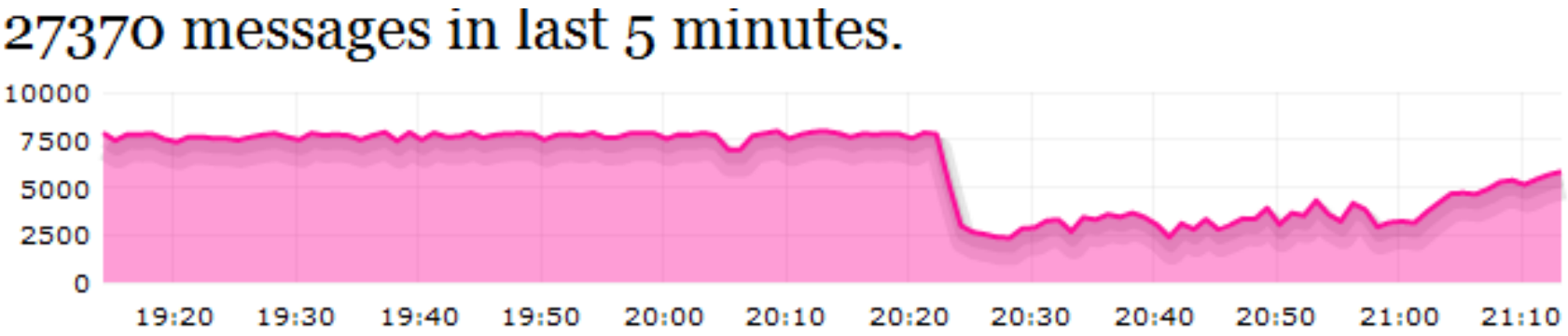
Day 2: Keeping Telemetry Going



Day 2: Operation Mistake Reveals Bug

- Made a mistake pushing change to Redis
  - Lots of users kicked off service accidentally
  - Many of them didn’t come back automatically!

Day 2: Telemetry Bug



Day 2: Telemetry Bug

- Actually found 5 different bugs
  - Reauthentication is a tricky process to test
  - Bugs in each layer involved in process
  - Hard to test all the interactions in the system
- Fixing it was also a challenge
  - Coordinate operations, dev, production, QA
  - More on that later…

Day 3: Bad Build

- An early Steam patch was released with bad configuration, pointing at test environment!
- Fortunately, just after patch release we took down test environment for maintenance.
- Deployed a workaround on server frontdoor
- Could not bring it back up until all users were patched

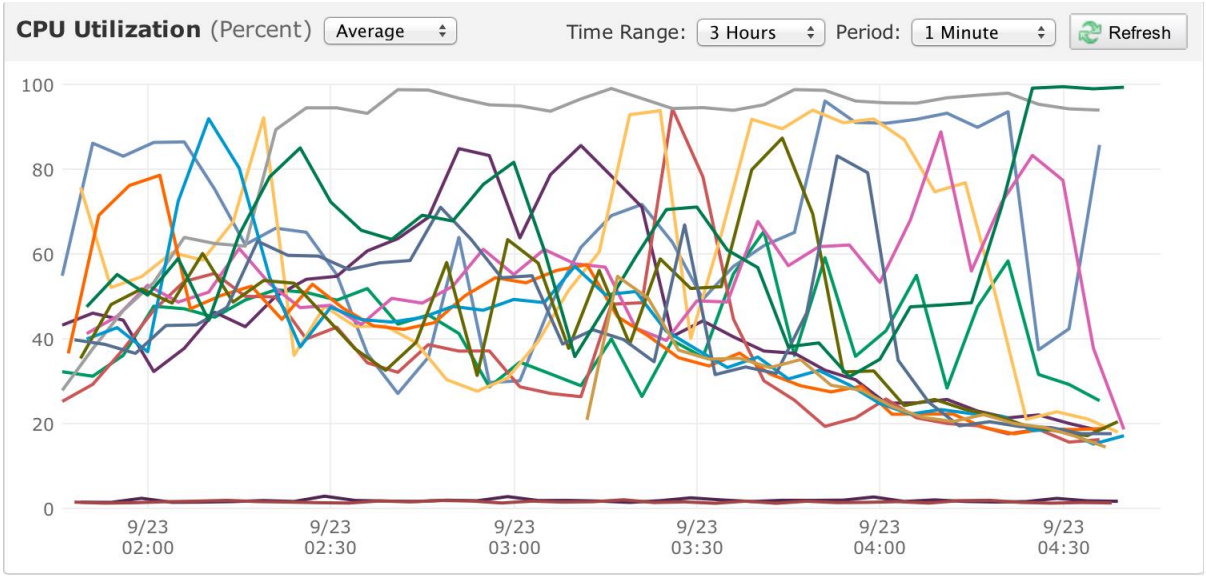
Day 3: Bad Build Continues!

- It wasn’t just our main SKU that had this problem
- We released that code to the Russian SKU as well, which had a delayed update plan
- It took almost 3 weeks to deploy that patch
- **Still** not out of the woods.
  - Unpatched users still out there
  - Pirated copies? Users that didn’t update?
- Lesson: be very careful with configuration!

SHiFT Codes!

- A few days into launch, we were stable enough to start using our SHiFT Codes
  - Randy Pitchford (@DuvalMagic) got things started with some quick tests
  - Engaged directly with devops team to measure results
  - Got a little TOO engaged…

SHiFT Codes: Chaos



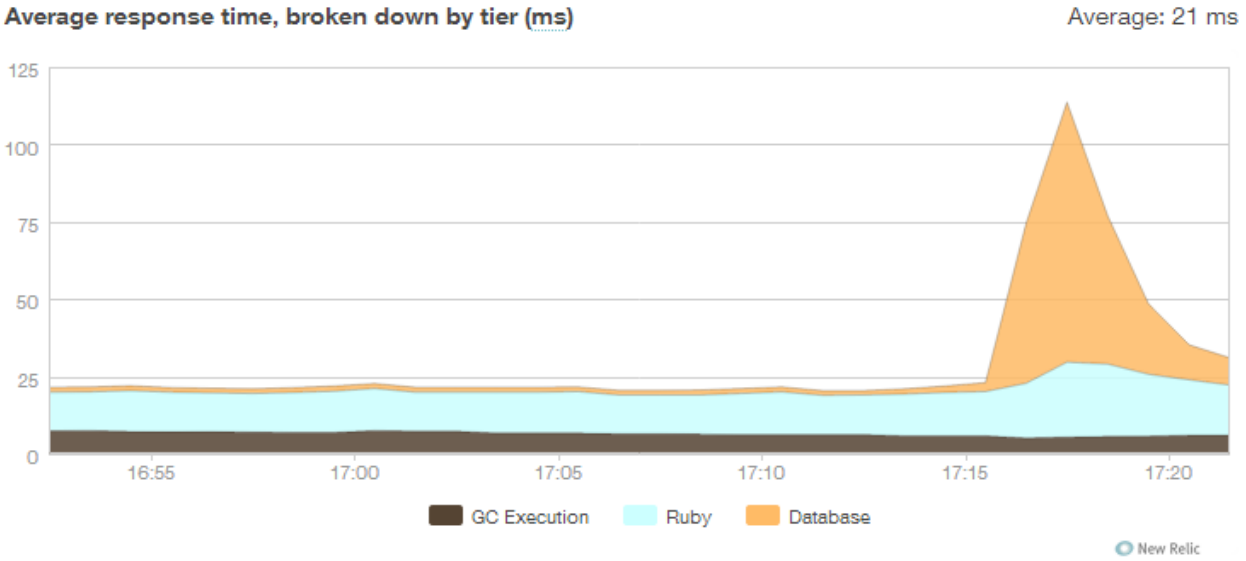
SHiFT Codes: Chaos

- While looking for real-time code redemption results, I issued a bad query that impacted some monitoring
- Took most of the afternoon and evening to recover
  - Redis failover scripts did not work as expected
  - Restart monitoring node, stabilize cluster
  - Move some monitoring functionality to new node
- Lessons:
  - Try not to intermingle monitoring for different components
  - Be extra careful querying 100MM record datasets!

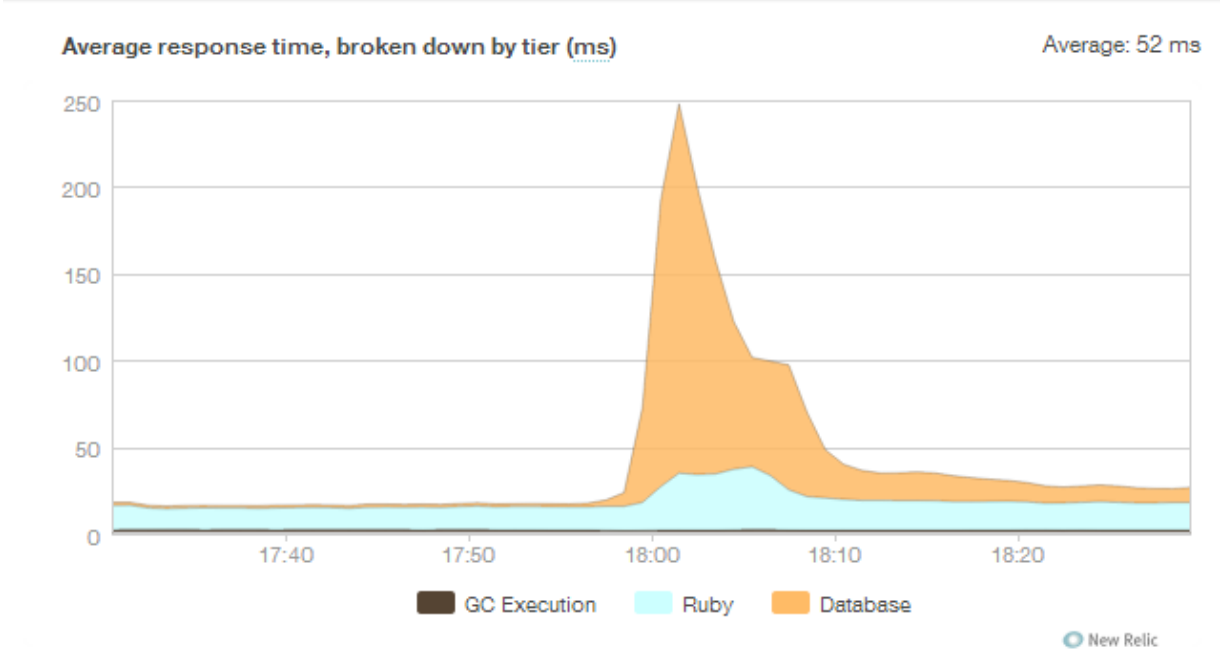
SHiFT Codes: Optimizations

- During week 2, we used a new type of code that was active for a period of time
- This allowed us to build a social engagement strategy around code redemption times
- Essentially created Flash Mobs for SHiFT

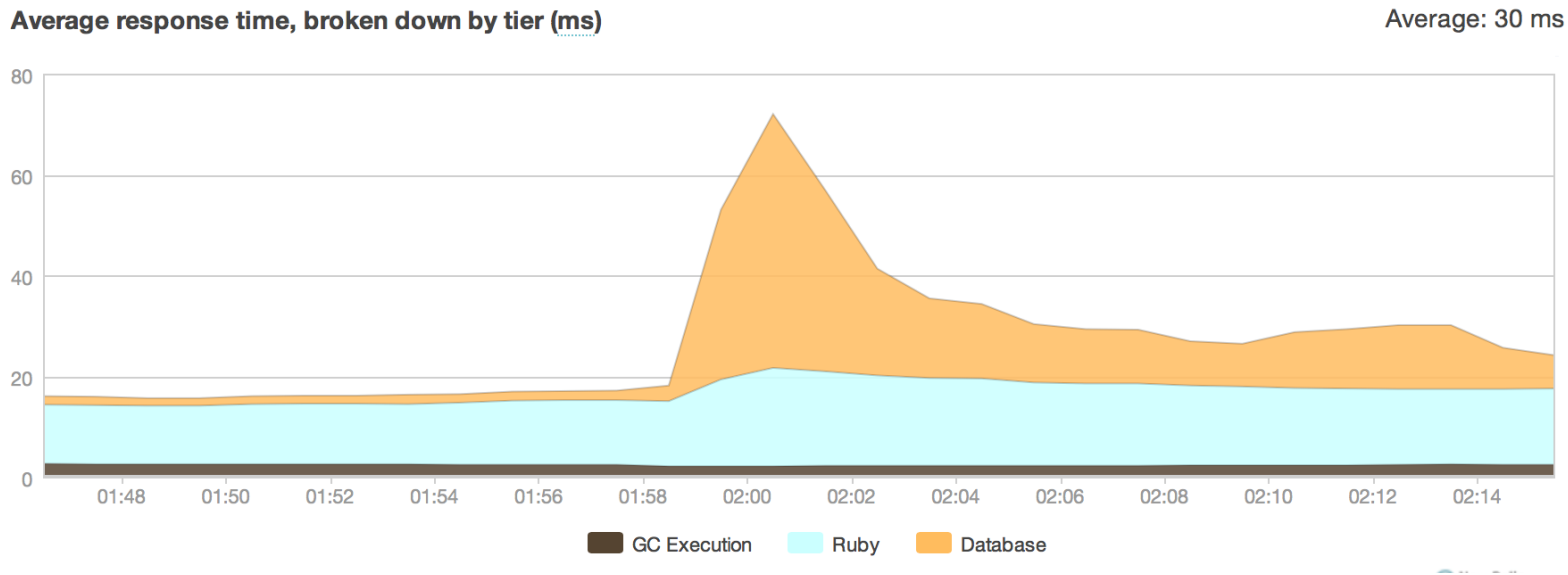
SHiFT Codes: Optimizations



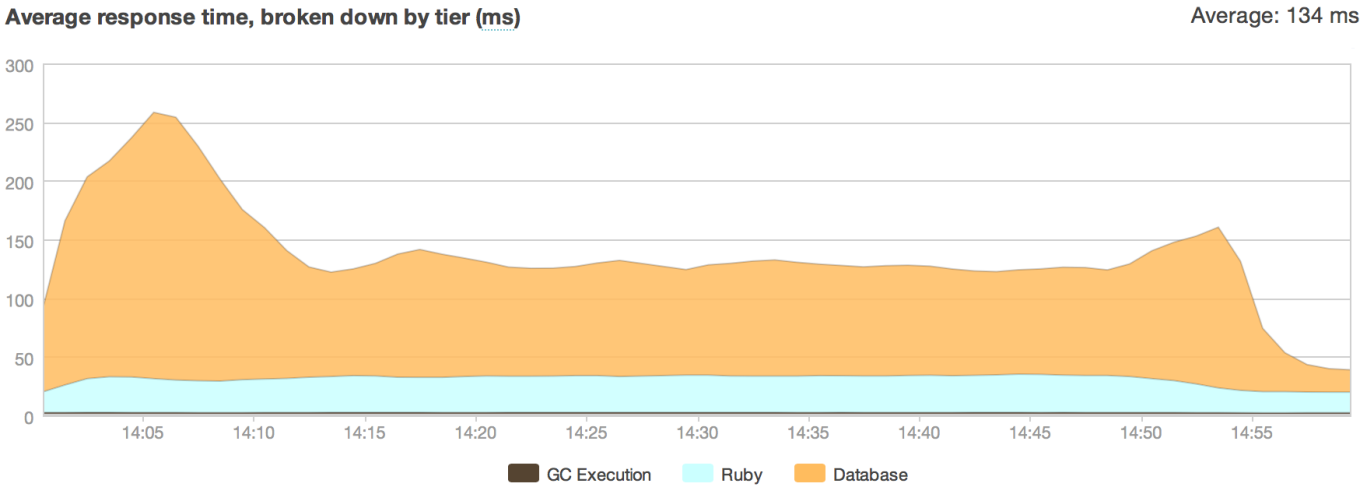
SHiFT Codes: Optimizations



SHiFT Codes: Optimizations

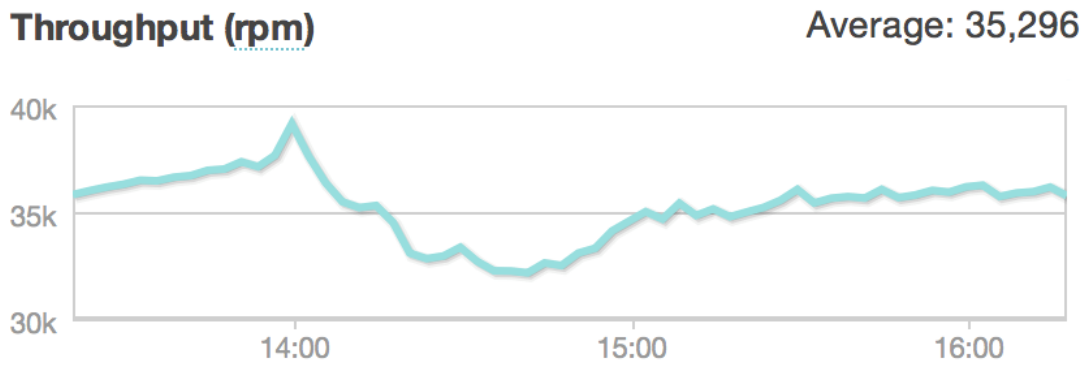


SHiFT Codes: Optimizations



SHiFT Codes: Optimizations

- Linear table growth as redemptions increase
  - By the second weekend, there were many many rows
  - Lookups on this table were missing an index
  - Didn’t catch this growth over time in testing
- Query for entitlement and offer info not cached
  - This data doesn’t change during a code drop
  - Missed this: requires large table **and** flash mob
  - Easy to cache in app layer to reduce DB pressure



SHiFT Codes: Unexpected Behavior

Telemetry traffic pattern changes when a code drops
Users Save & Exit game, wait to redeem in menu
Causes spike and lull in telemetry traffic

SHiFT Codes: Unexpected Behavior

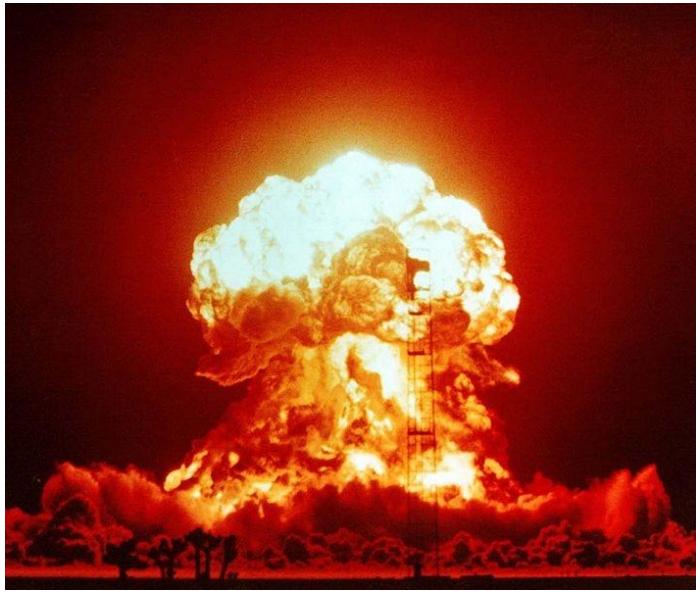
- We didn’t expect this behavior
  - Fortunately this didn’t cause a big problem
  - Had extra capacity on hand for launch window
- Lessons
  - Carefully think through interactions of systems
  - However, must recognize that not all user behaviors can be predicted
  - Be prepared for surprises

The Challenge of AAA: DLC

- Successful AAA games must have a DLC plan
- Borderlands 2 successfully launched 5 packs
  - Week 4: Gaige: Mechromancer character class
  - Week 5: Captain Scarlett & Her Pirate's Booty
  - Week 10: Mr Torgue's Campaign of Carnage
  - Week 17: Sir Hammerlock's Big Game Hunt
  - Week 18: Domination, Madness, and Supremacy

The Challenge of AAA: DLC

- This put a lot of pressure on live team
  - New Features, bug fixes, balance tweaks
  - Packaging and builds
- Meanwhile Spark team had challenges too
  - Improve service manageability, security patches, keep it running
  - Optimize server performance and costs
- Lesson: Very difficult to do things post-launch
  - Plan ahead for anything you need in the first 10 weeks
  - Lots of slack in schedule, communicate with dev

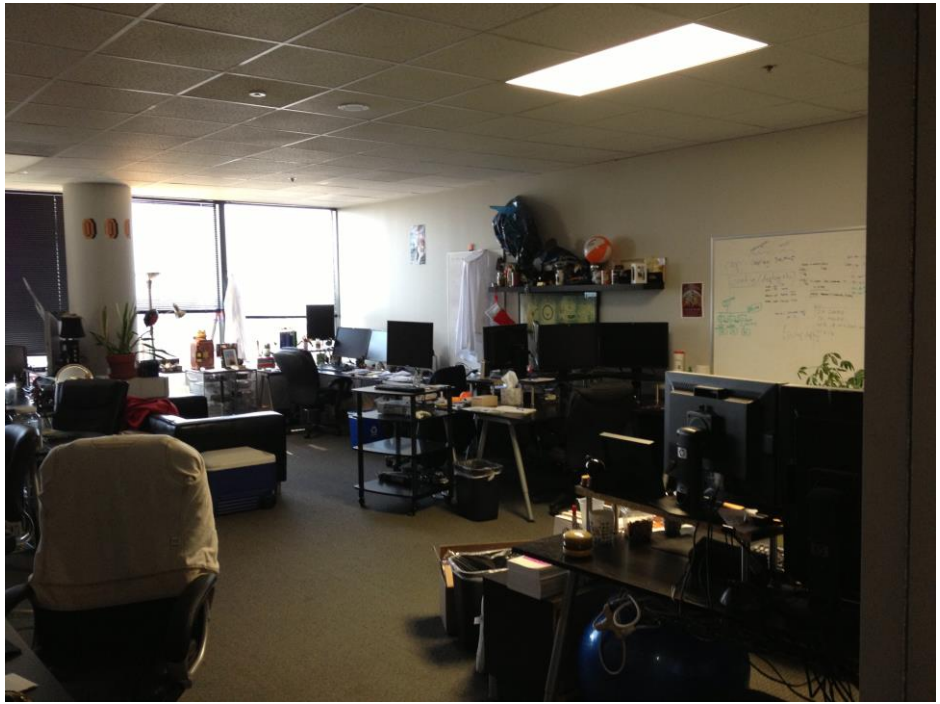


What Didn’t Happen?

What Didn’t Happen?

- Spark performed above expectations
  - No downtime in launch window
  - User-facing components didn’t buckle
  - Team wasn’t killed keeping it going

Team Wasn’t Killed Keeping it Going



Why Did We Succeed?

- Great team of smart, passionate, and committed people
- Spent adequate time testing user-facing (10 weeks from certification to launch)
- The cloud: over provision, then scale back
- We launched 2 betas

What's Next?

- We originally developed Spark for a single title, Borderlands 2
  - Felt that constraining scope was key to success
- SHiFT was so successful, we shipped it again!
  - Aliens: Colonial Marines launched February 2013
  - Integrated accounts, rewards, and built new rewards for SHiFT

Getting Spark to 1.0

- Finish integrating Amazon features: VPC & ASG
- Optimize costs around known traffic patterns
- Enhanced monitoring and deployment tools
- … And beyond!
  - Find new ways to use the platform!
  - Experiment with new ways to engage with fans

Final Thoughts

- This is really important for next-gen
- Capacity planning is very hard to do
  - Coped by being agile and relying on the cloud
- Ship early and often
  - Possible even for AAA Games!

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