Zero to Millions:

Building an XLSP for Gears of War 2

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About Me

- Working in online gaming for over 10 years
- At GameSpy from 1999-2008
  - “Powered by GameSpy” technology
- Joined Epic Games early in 2008
  - Part of the online team

About Epic Games

- Gears of War Franchise
- Unreal Franchise
- Unreal Engine
  - 100+ games

Gears of War

- Released November 2006
- Multiple Game of the Year awards
- #1 Xbox LIVE game of 2006
- #2 Xbox LIVE game of 2007

Gears of War 2

- Build a better game
- More visually stunning
- More fun

Gears of War 2

- Build a better game
- More visually stunning
- More fun
- “Bigger, better, and more badass”

Gears of War 2

- Great online community
- New online functionality
- Better for gamers
- Better for Epic
- Build our own online backend
- Add features not supported by Xbox LIVE

Gears of War 2
Online Backend

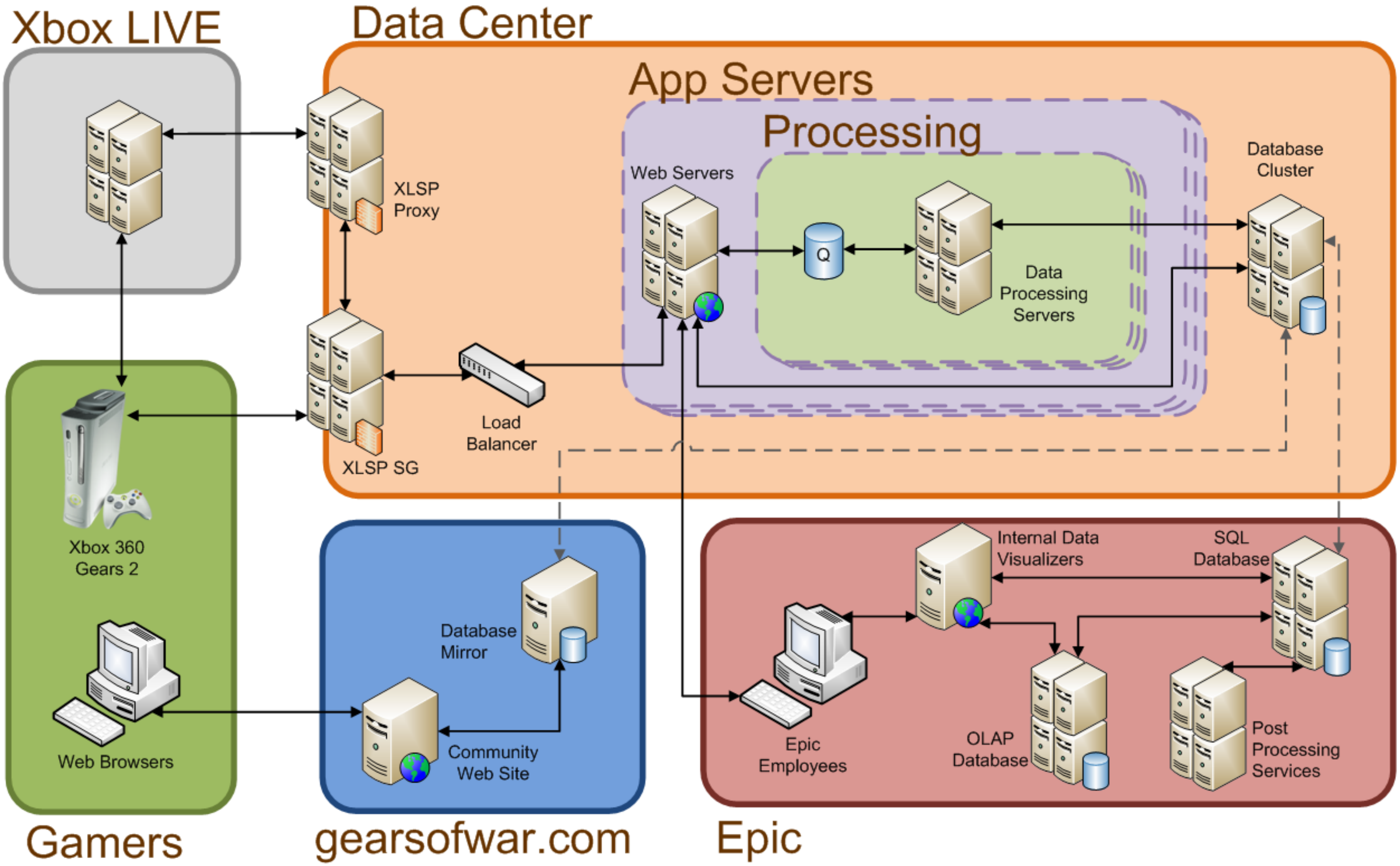
- What features?
- How will it work?
- How will we build it?
- What technologies will we use?

Gears of War 2
Online Backend

- Starting from scratch
- Small team
  - 3-4 programmers
  - Also doing client-side work
  - Little backend experience
    - (aside from me)
- Lots of data to handle
- Less than a year
- Team at Microsoft working on backup

Unreal MCP

Unreal MCP


Xbox LIVE
Data Center
App Servers
Processing
XLSP Proxy
Web Servers
Q
Data Processing Servers
Database Cluster
XLSP SG
Load Balancer
Xbox 360 Gears 2
Web Browsers
Gamers
Database Mirror
Community Web Site
gearsofwar.com
Internal Data Visualizers
SQL Database
Epic Employees
OLAP Database
Post Processing Services
Epic

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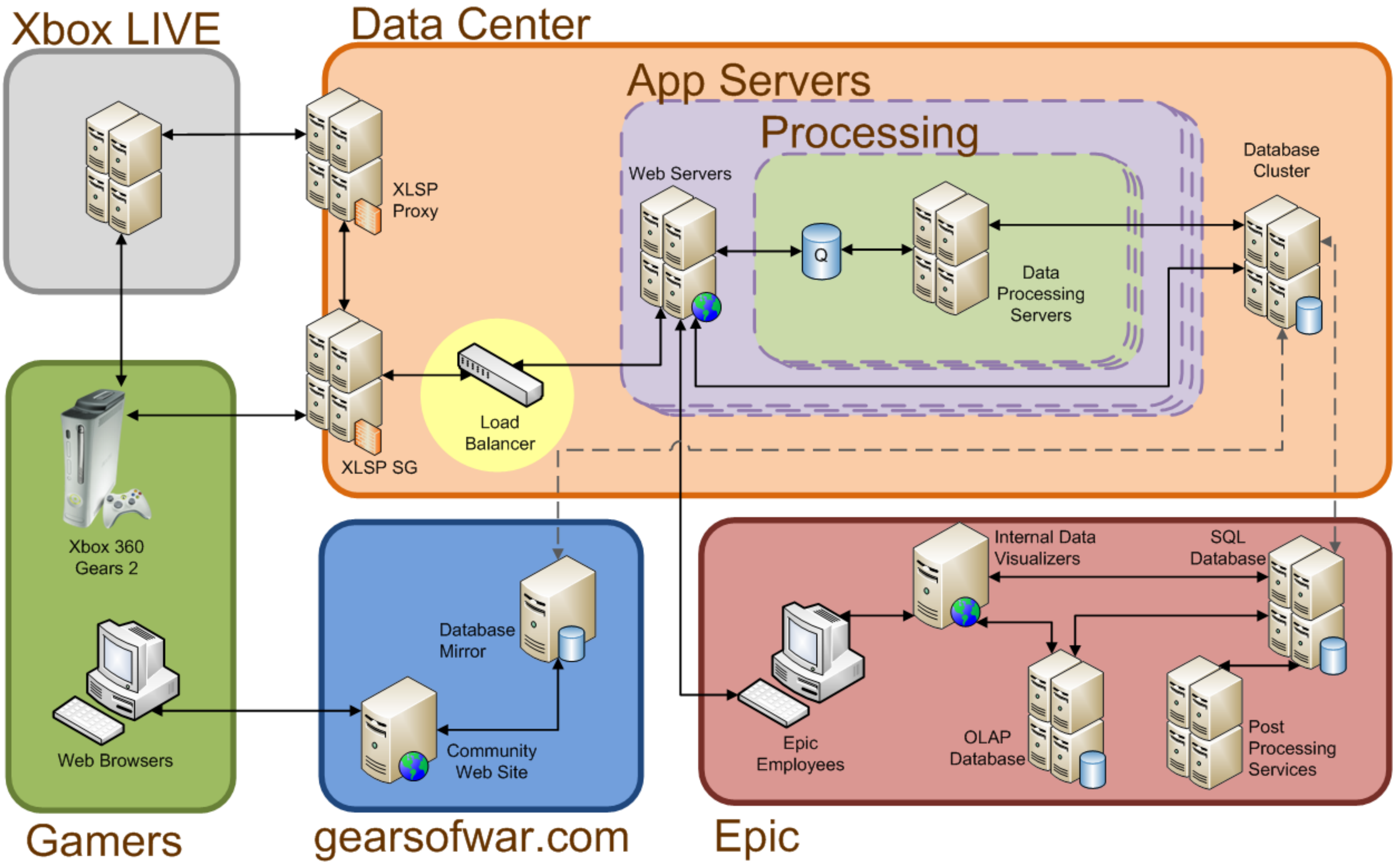
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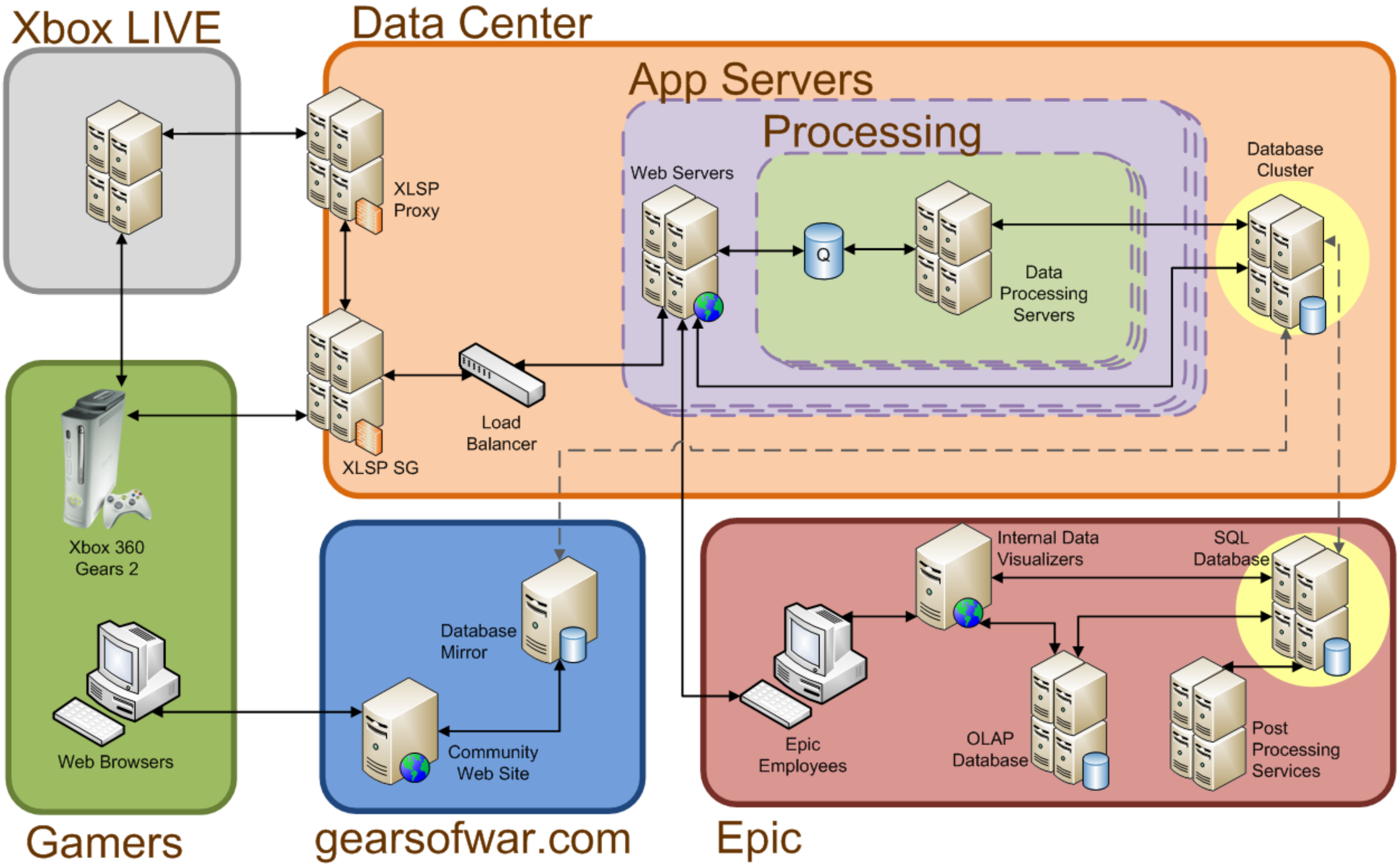
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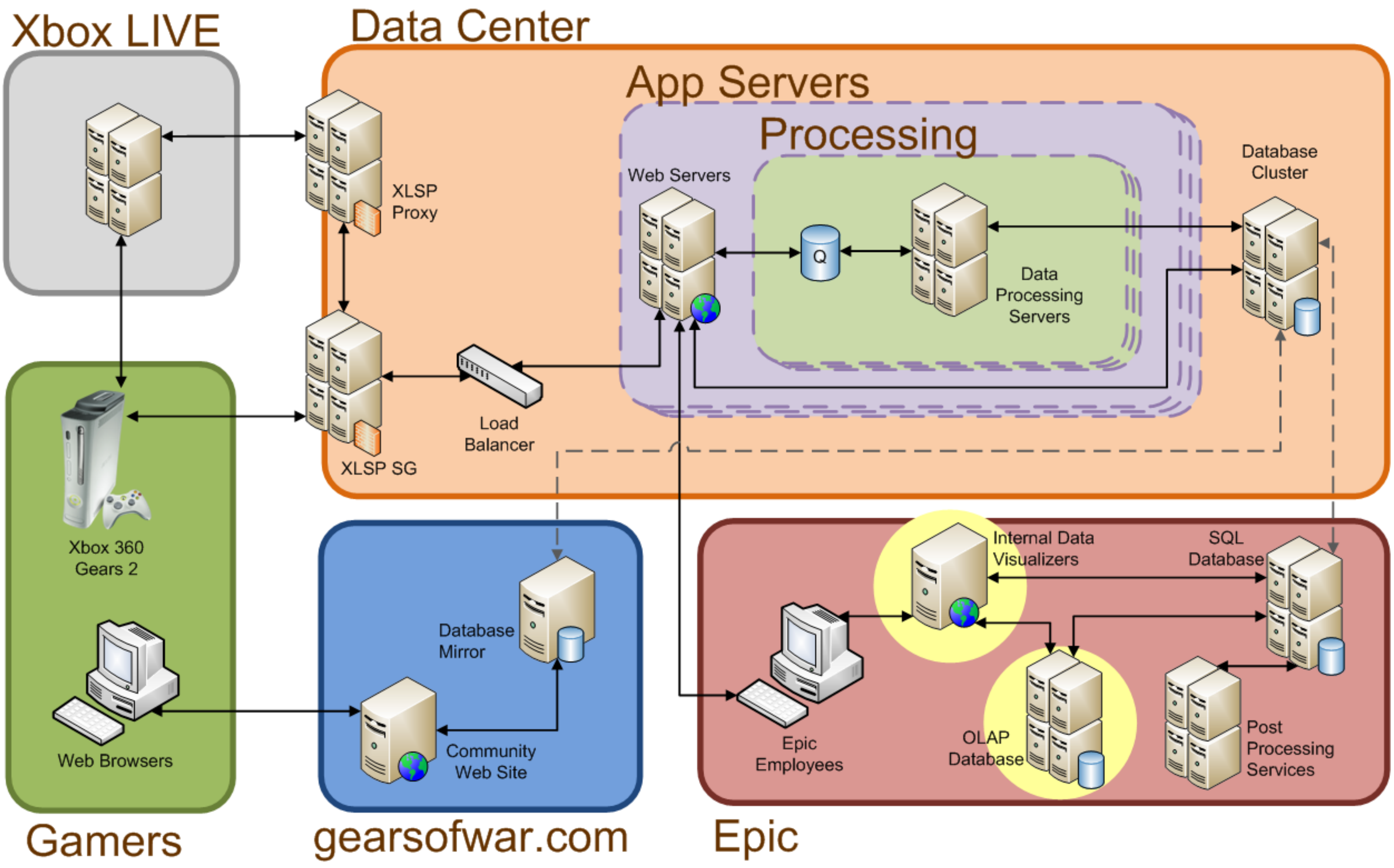
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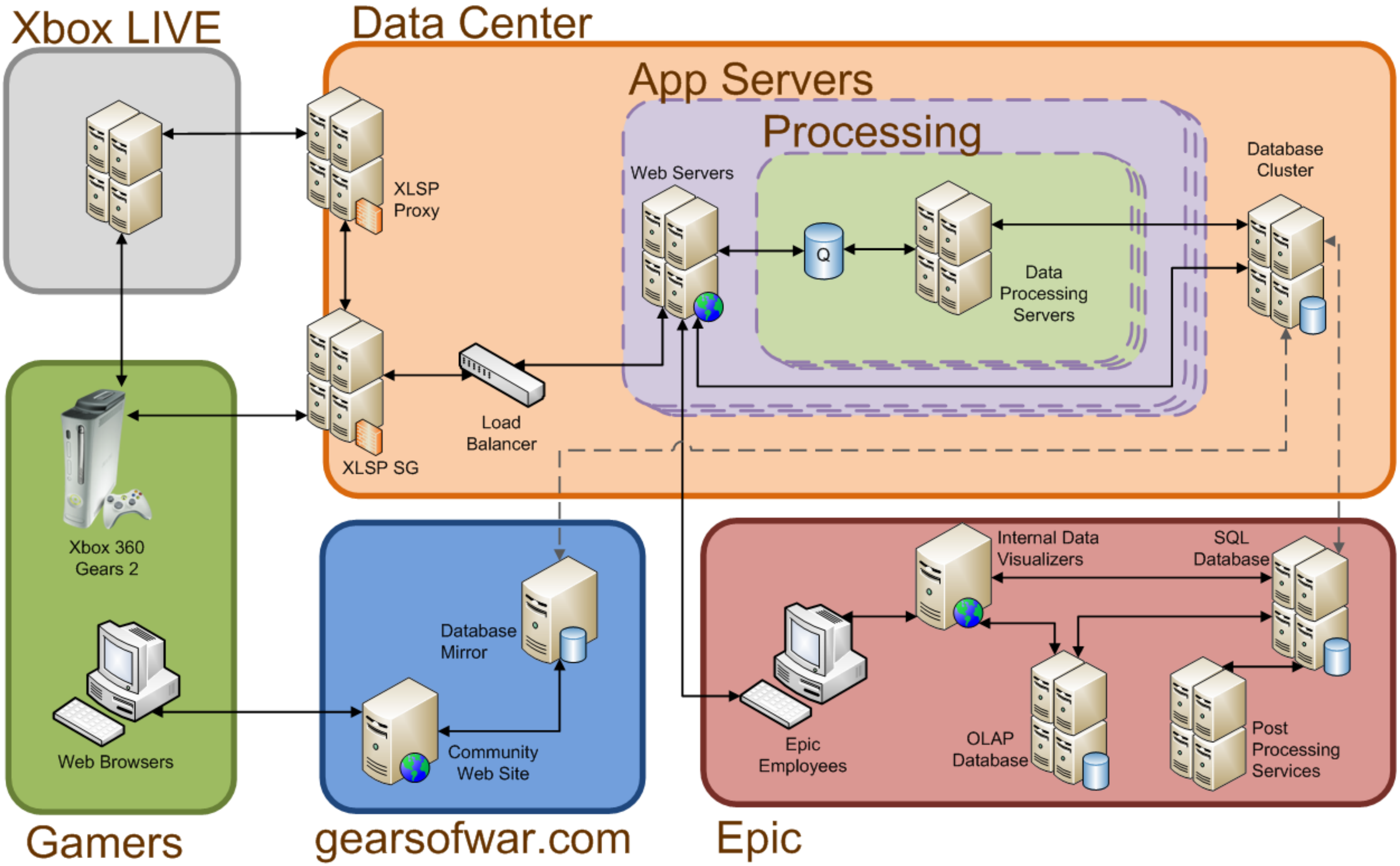
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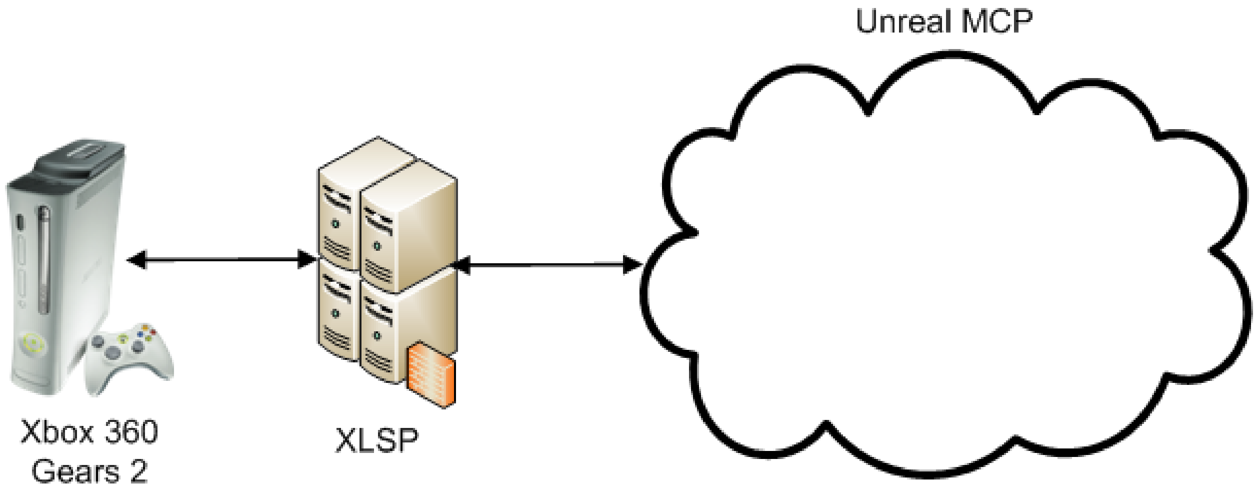
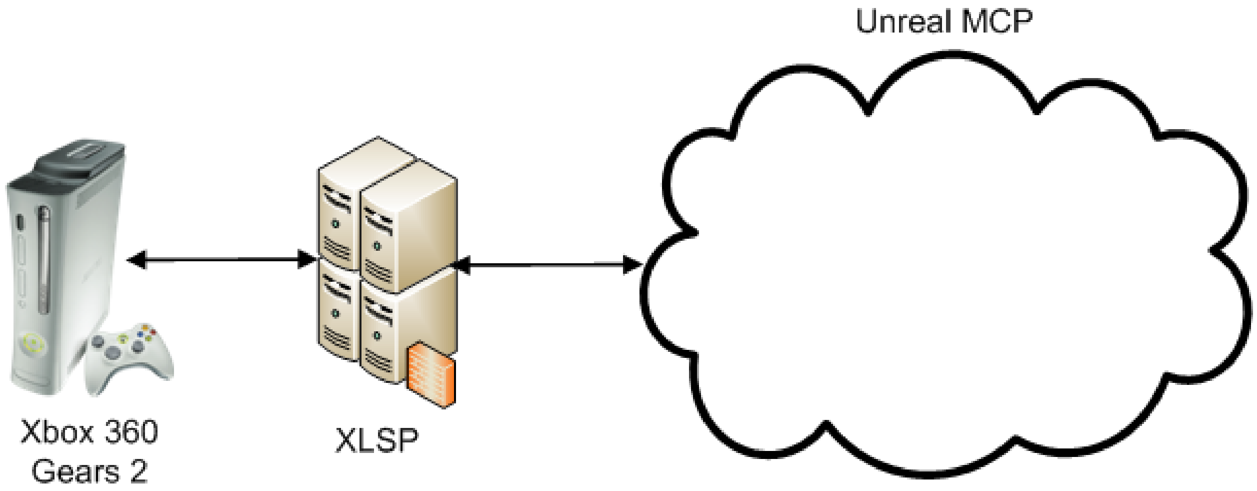
XLSP

- Xbox LIVE Server Platform
- Used when adding custom online features to Xbox LIVE games
- Provides a secure and trusted channel of communication



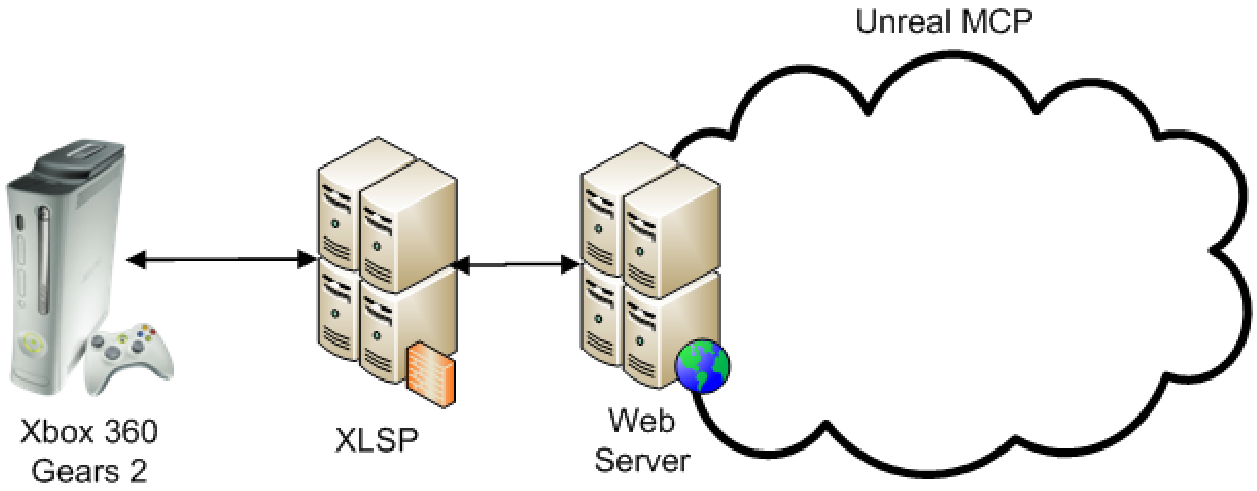
Getting Started

- XLSP
- Game to backend data
- Backend to game data



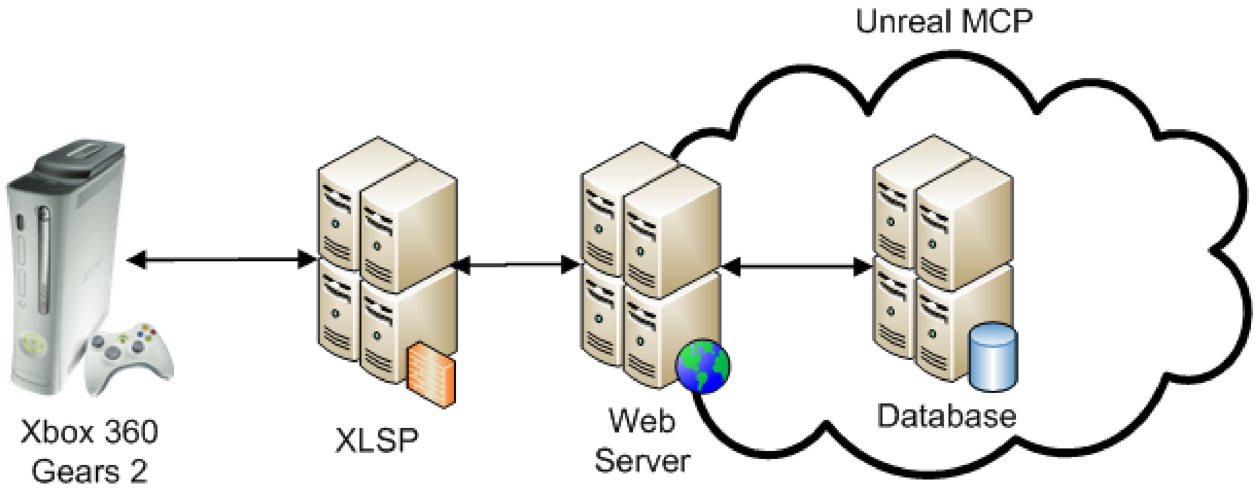
Getting Started
Web Server

- Game's interface to the backend
- HTTP is a simple protocol
  - Less work
  - Less risk



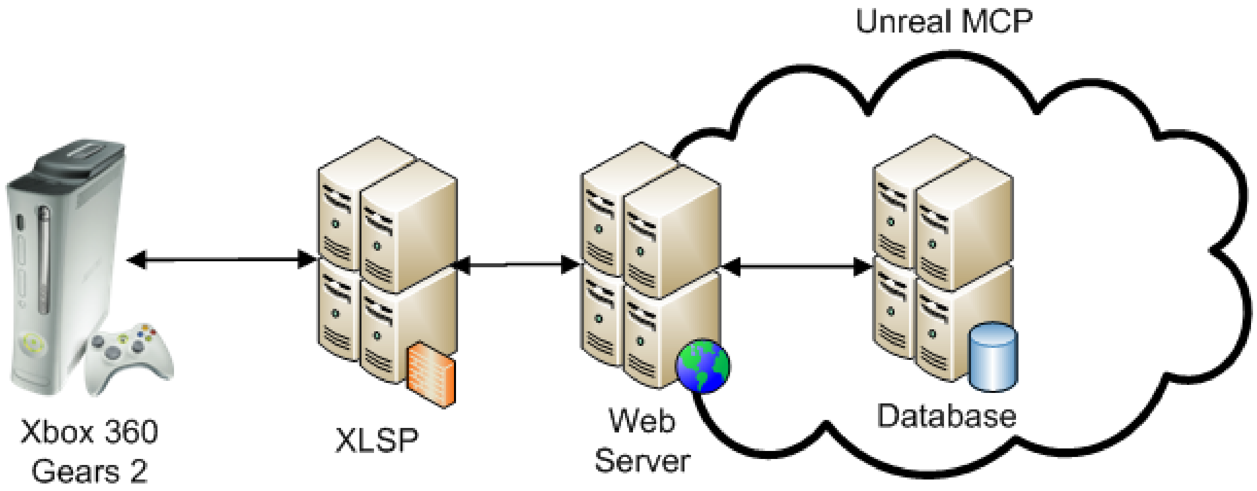
Getting Started
SQL Database

- Stores incoming data
- Stores outgoing data



Getting Started
Web Server & Database

- Mature
- Well-known
- Quick startup



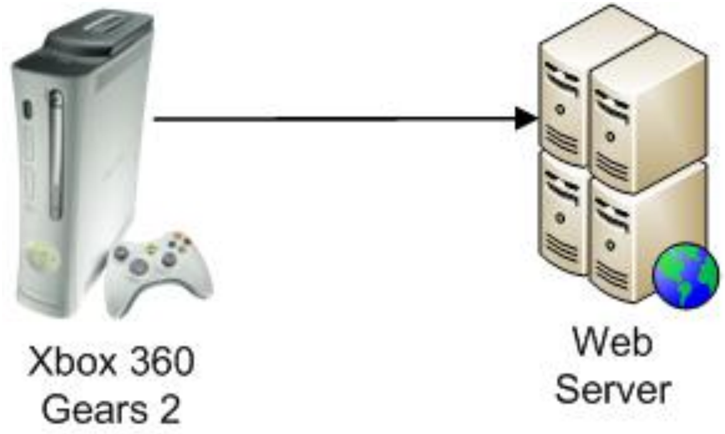
Service Types

- Bidirectional Service
  - Game sends a request
  - Game receives data in response
  - Example: message of the day
- Asynchronous Service
  - Game sends data
  - Fire and forget
  - Example: game stats reports

Bidirectional Services Example: MOTD

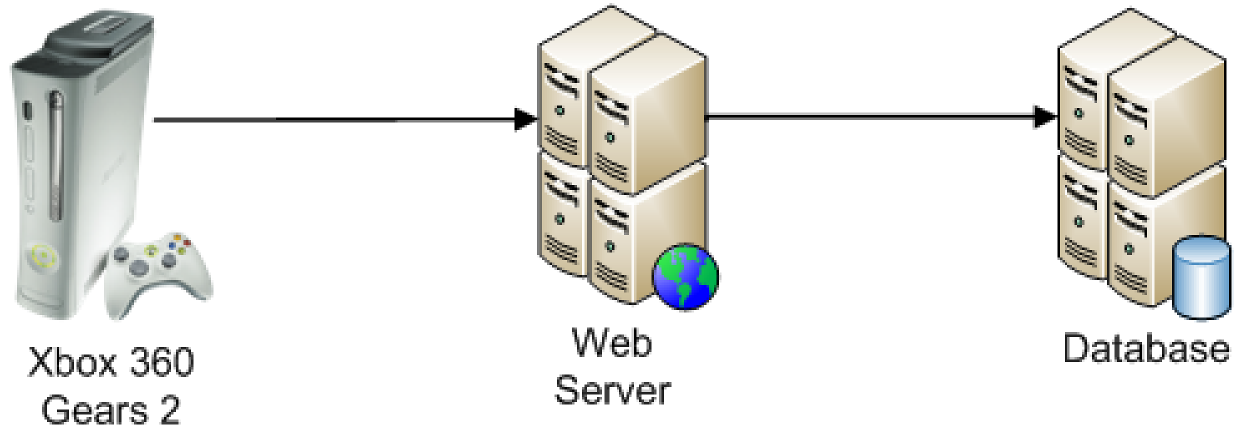
Bidirectional Services Example: MOTD

- Game sends request to the web server



Bidirectional Services Example: MOTD

- Game sends request to the web server
- MOTD is pulled from the database



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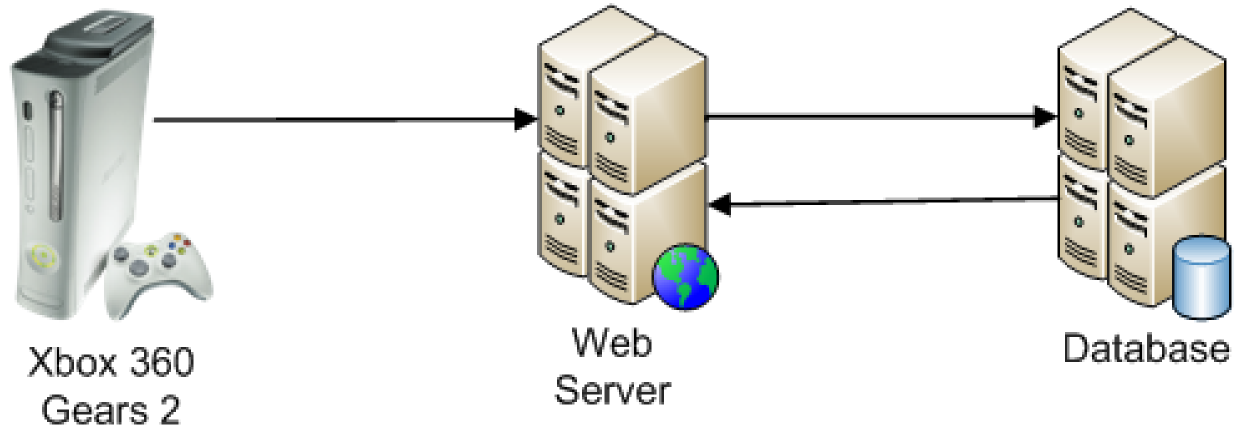
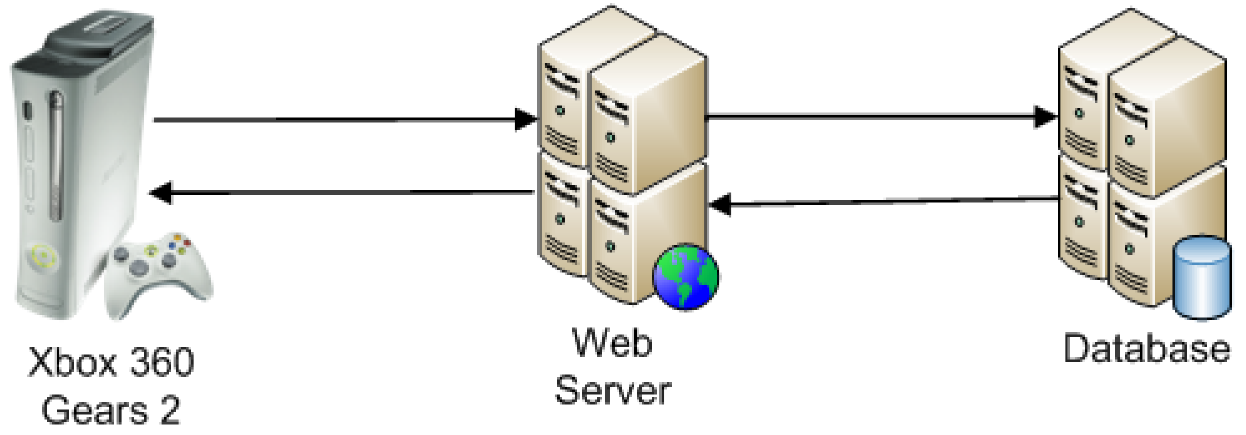


Bidirectional Services Example: MOTD

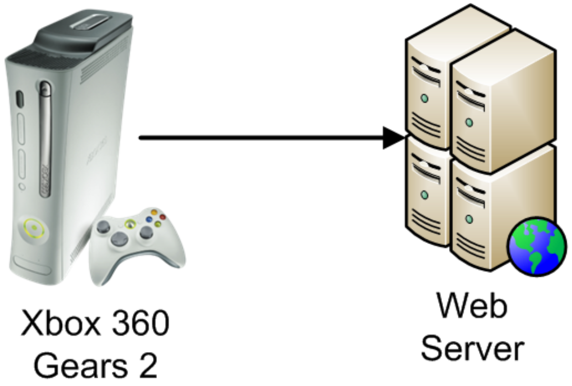
- Game sends request to the web server
- MOTD is pulled from the database
- Game receives MOTD via HTTP response



Asynchronous Services Example: Game Stats

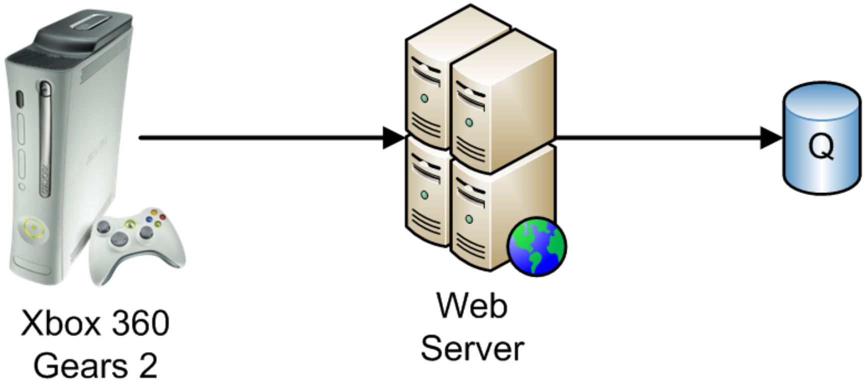
Asynchronous Services Example: Game Stats

- Game uploads a stats report



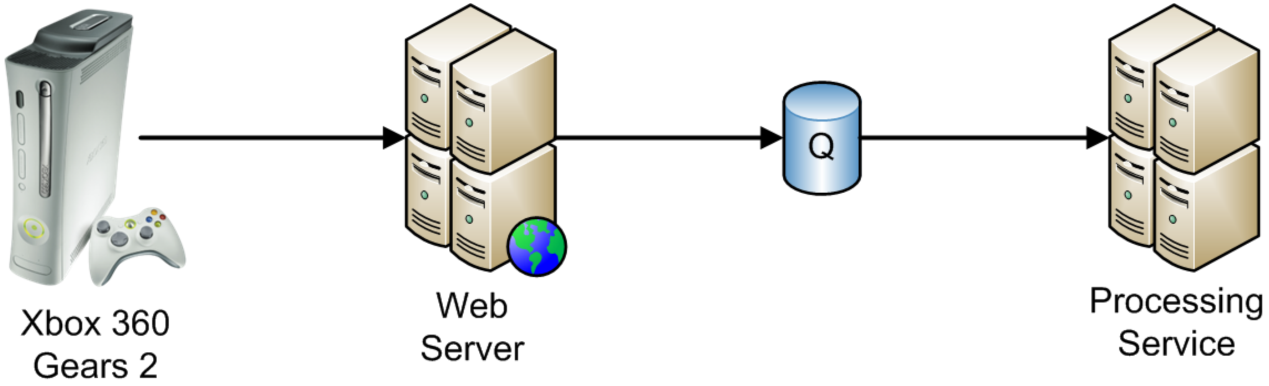
Asynchronous Services Example: Game Stats

- Game uploads a stats report
- Web handler puts it in a queue



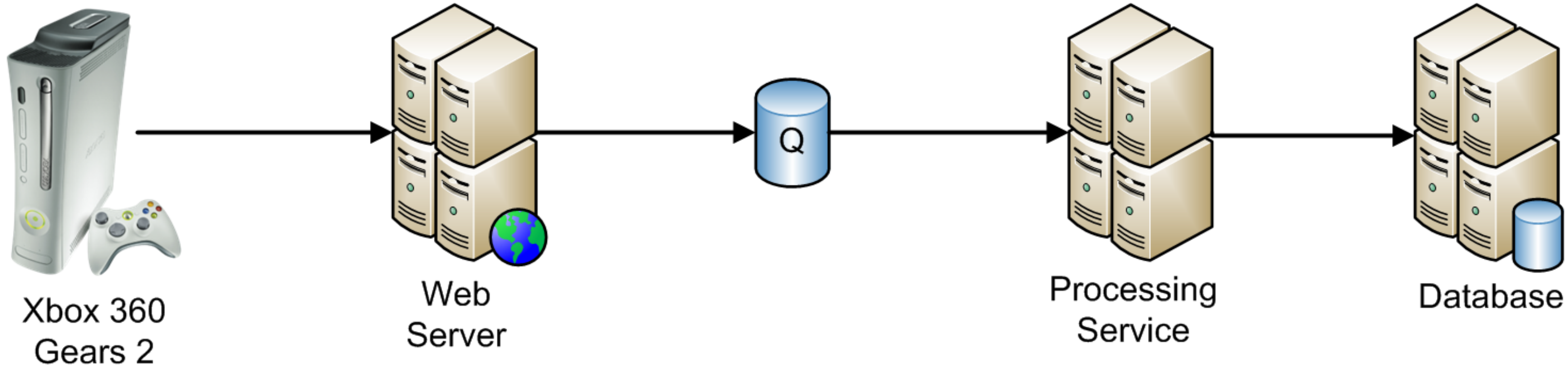
Asynchronous Services Example: Game Stats

- Game uploads a stats report
- Web handler puts it in a queue
- Processing service pulls it



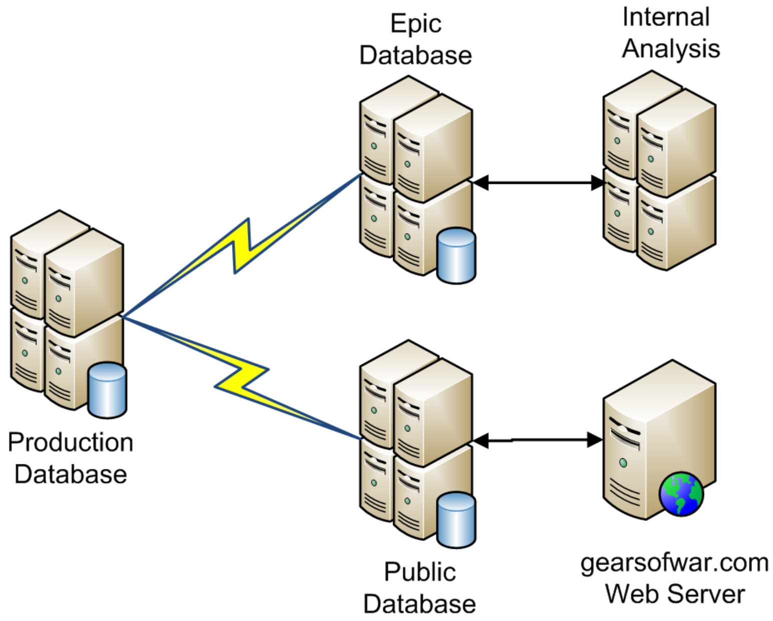
Asynchronous Services Example: Game Stats

- Game uploads a stats report
- Web handler puts it in a queue
- Processing service pulls it
- Game info is stored in the database



Asynchronous Services Example: Game Stats

- The data is replicated to two other databases
  - Epic for data analysis
  - www.gearsofwar.com



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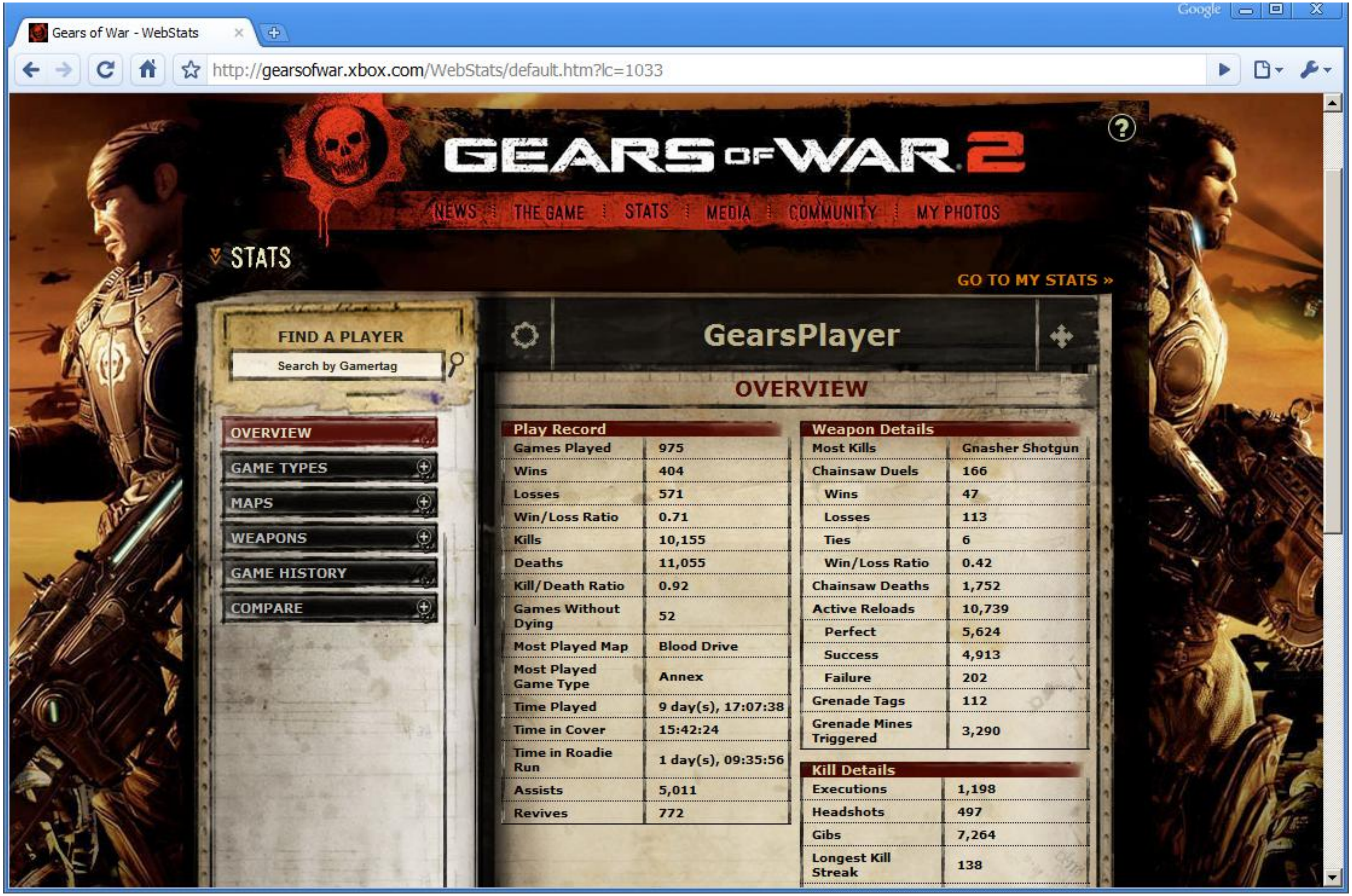


GearsPlayer

OVERVIEW

Play Record	
Games Played	975
Wins	404
Losses	571
Win/Loss Ratio	0.71
Kills	10,155
Deaths	11,055
Kill/Death Ratio	0.92
Games Without Dying	52
Most Played Map	Blood Drive
Most Played Game Type	Annex
Time Played	9 day(s), 17:07:38
Time in Cover	15:42:24
Time in Roadie Run	1 day(s), 09:35:56
Assists	5,011
Revives	772

Weapon Details	
Most Kills	Gnasher Shotgun
Chainsaw Duels	166
Wins	47
Losses	113
Ties	6
Win/Loss Ratio	0.42
Chainsaw Deaths	1,752
Active Reloads	10,739
Perfect	5,624
Success	4,913
Failure	202
Grenade Tags	112
Grenade Mines Triggered	3,290

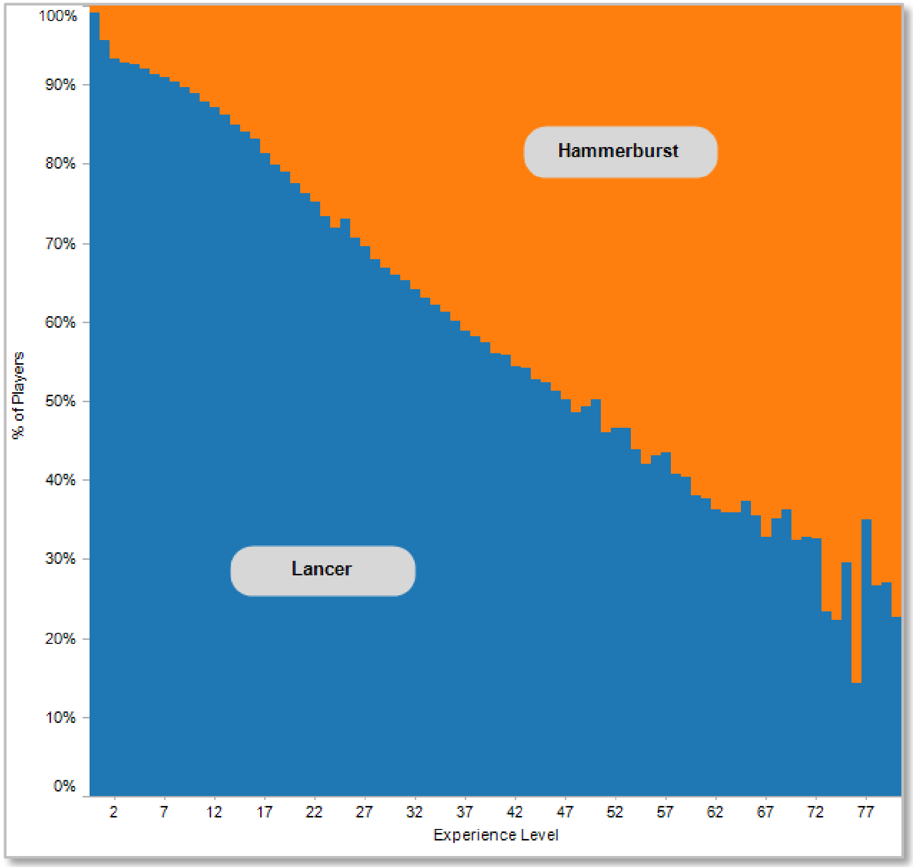
Kill Details	
Executions	1,198
Headshots	497
Gibs	7,264
Longest Kill Streak	138

Data Analysis
Internal

- Internal uses
  - Website
  - Custom reports
- Visualizations
  - Charts
  - Graphs
  - Heatmaps
  - Numbers

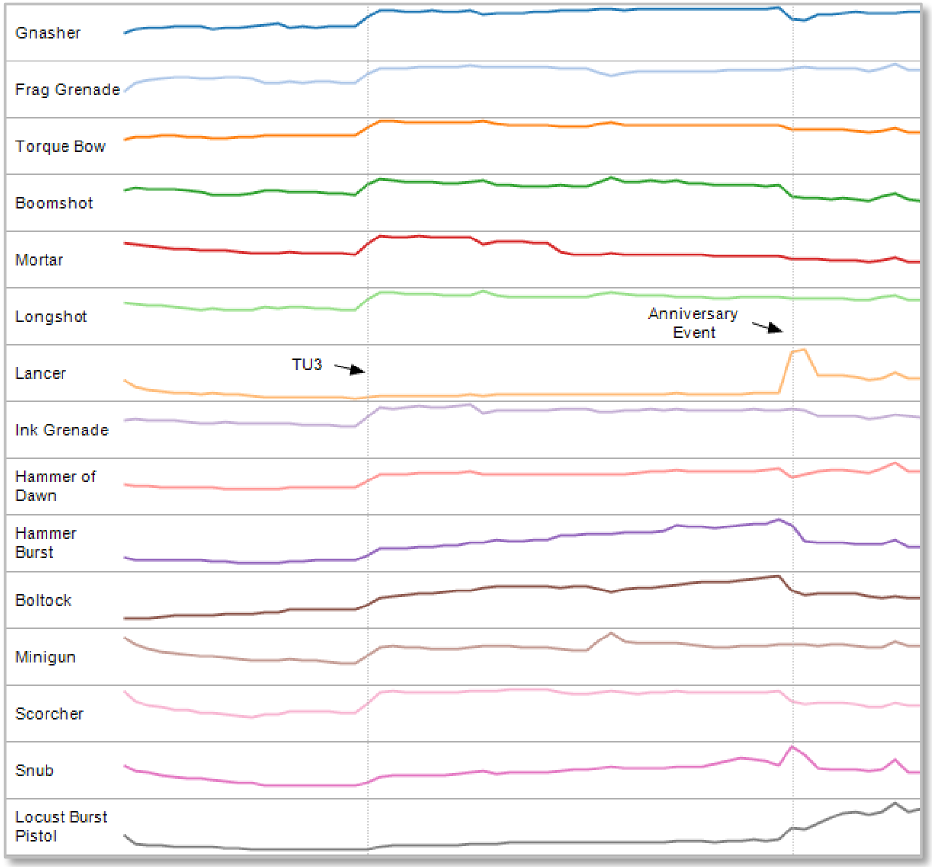
Data Analysis Internal

- Default Weapon by Experience Level



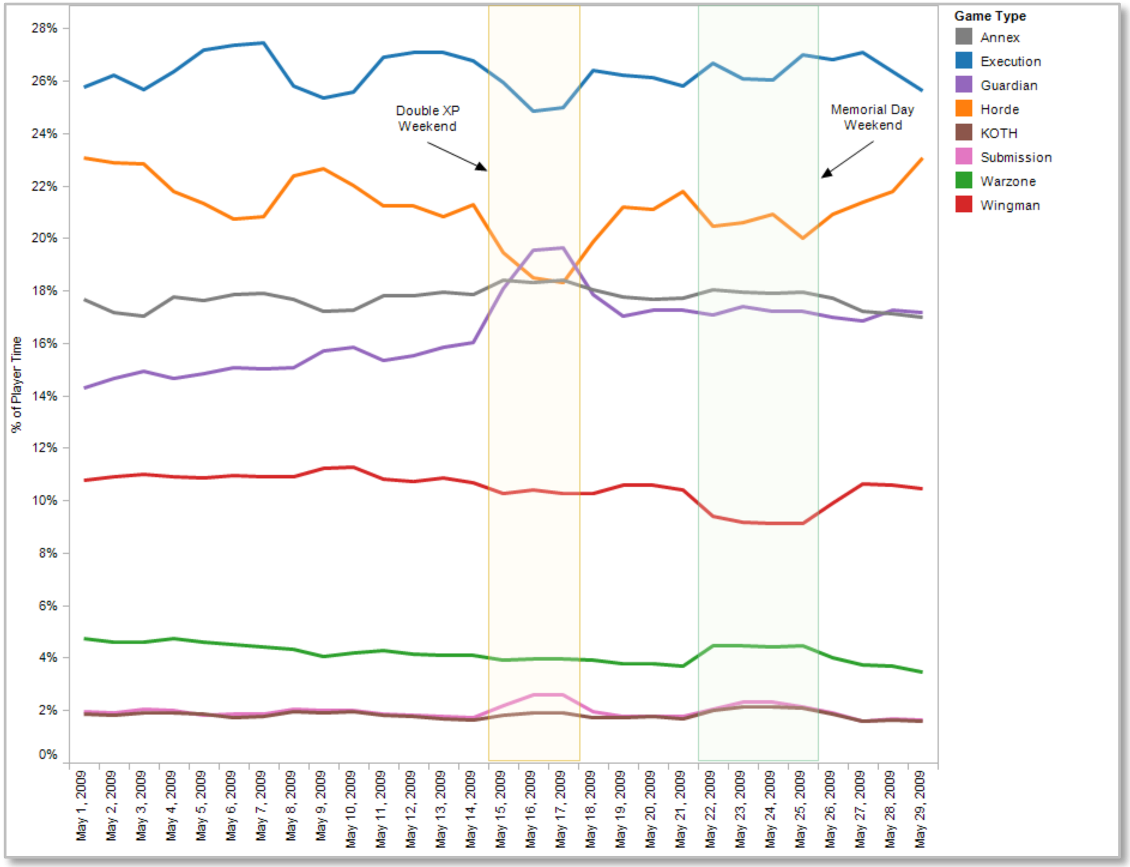
Data Analysis Internal

- Weapon Kill Trends



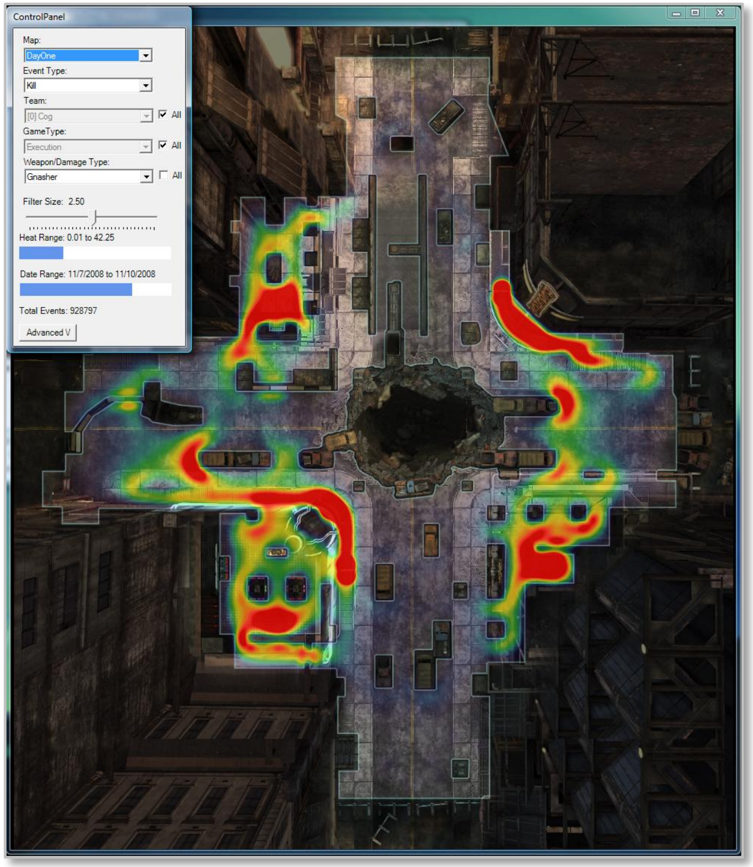
Data Analysis Internal

- Game Type Trends



Data Analysis
Internal

- Shotgun Kills on Day One



ControlPanel

Map: DayOne

Event Type: Kill

Team: [0] Cog ☑ All

GameType: Execution ☑ All

Weapon/Damage Type: Gnasher □ All

Filter Size: 2.50

Heat Range: 0.01 to 42.25

Date Range: 11/7/2008 to 11/10/2008

Total Events: 928797

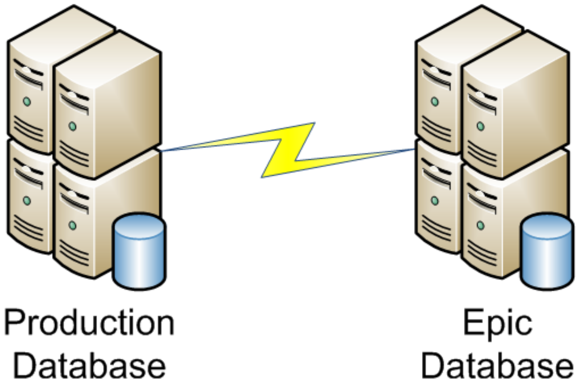
Data Analysis Post-Processing

- Asynchronous services do minimal processing in production
- For further analysis, more processing is needed
- Custom post-processing apps dig further into the data
- Use the Epic replicated database
- No direct effect on production backend

Data Analysis
Post-Processing

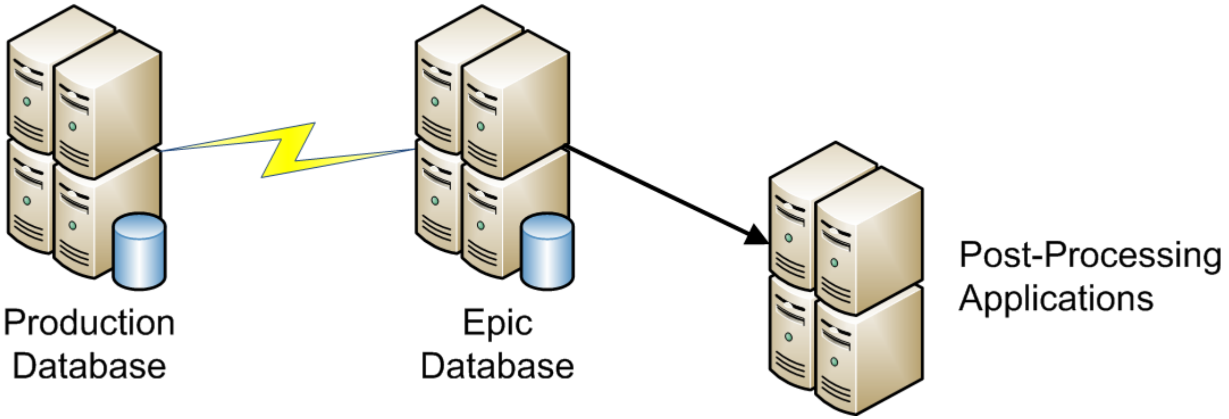
Data Analysis Post-Processing

- Replicated data arrives



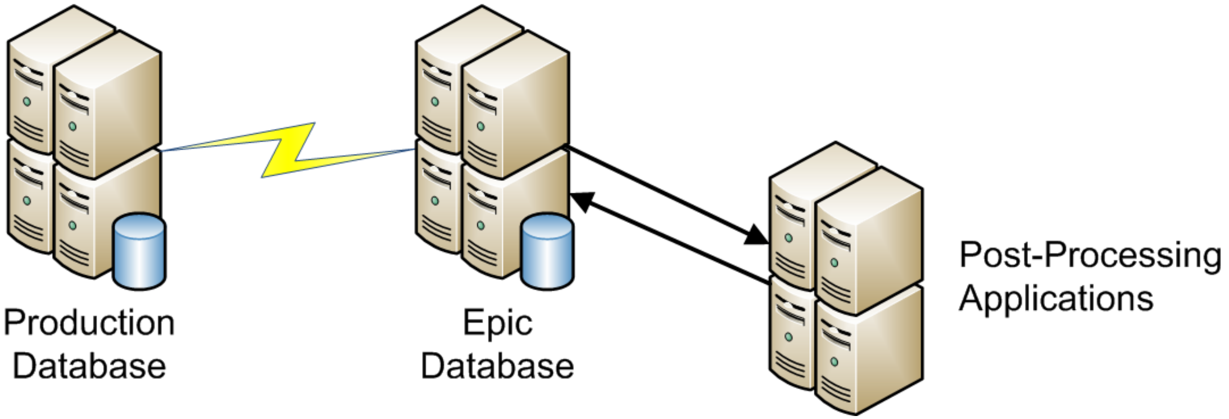
Data Analysis Post-Processing

- Replicated data arrives
- Apps post-process the data



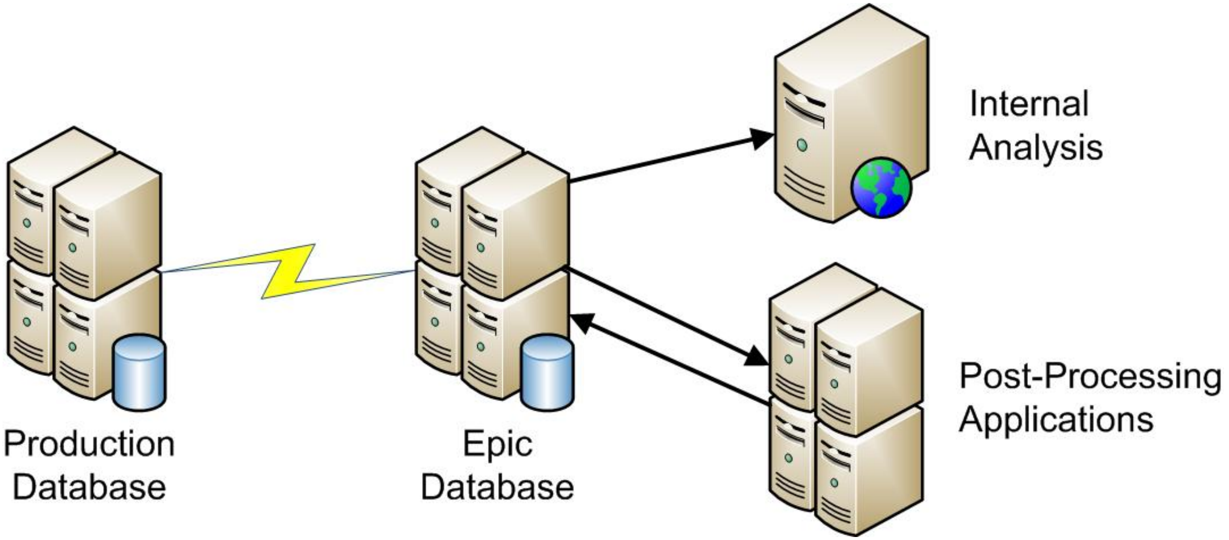
Data Analysis Post-Processing

- Replicated data arrives
- Apps post-process the data
- Store details back in the database



Data Analysis Post-Processing

- Replicated data arrives
- Apps post-process the data
- Store details back in the database
- Post-processed data used for analysis



Data Analysis
SQL Trouble

- Initially used SQL for analysis
- Trouble after Gears 2 release
- Queries were very slow
- Huge table of weapon data
- SQL-based analysis was impractical
- Internal website was unusable

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Data Analysis
OLAP to the Rescue

- SQL
  - Relational database
  - Great for storage
  - Bad for analysis
- OLAP (OnLine Analytical Processing)
  - Complements SQL
  - Aggregates data in “cubes”
  - Great for analysis

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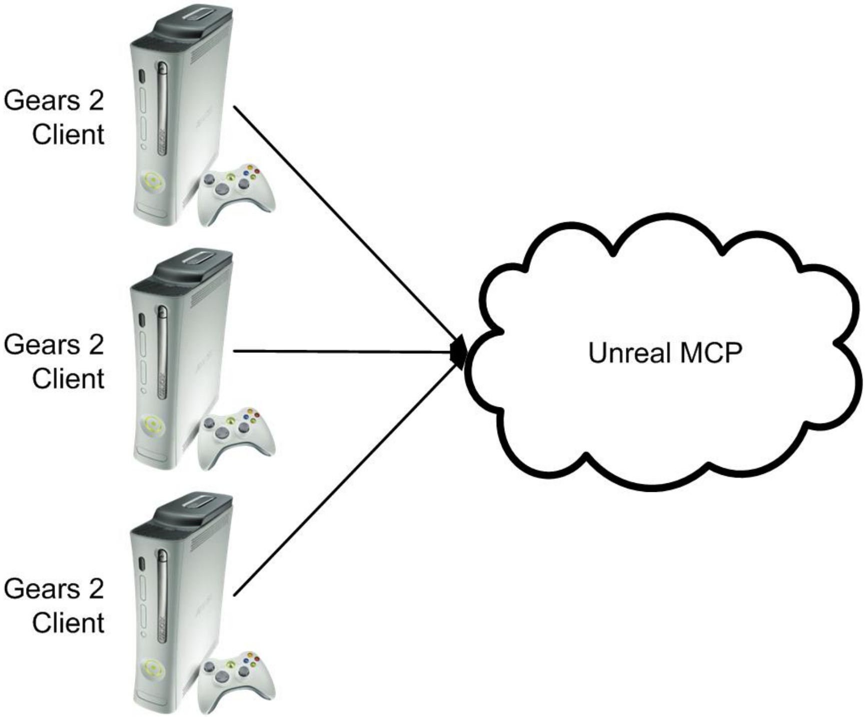
Scalability & Performance

- Estimates
  - 100s of transactions per second
  - Gigabytes of data per day

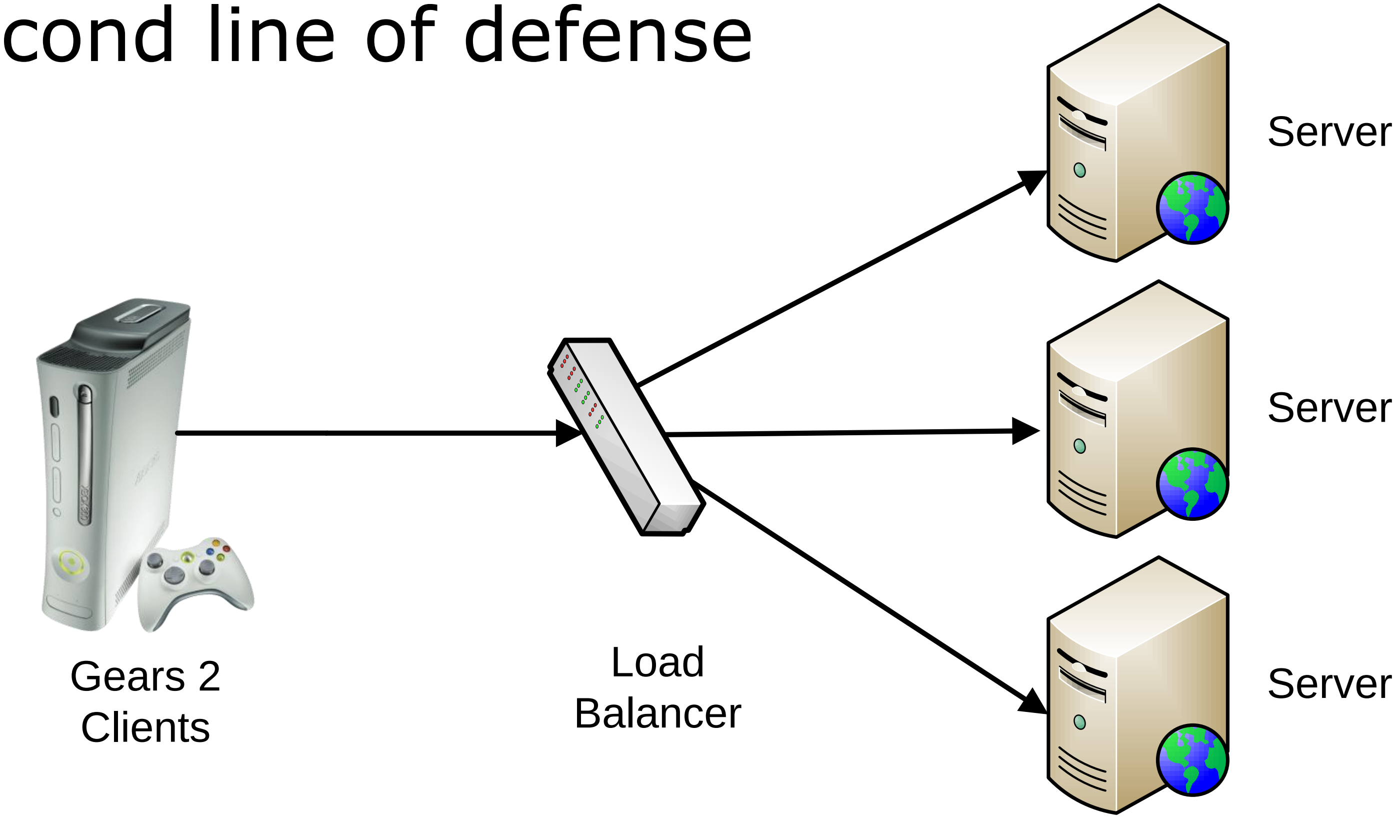
Scalability & Performance

- Game clients
- First line of defense



Scalability & Performance

- Load balancer
- Second line of defense



Scalability & Performance Application Servers

- Horizontally scalable machines
- Each application server has:
  - Web server
  - For each Asynchronous Service
    - One queue
    - One processing service
- Self-contained
- Only talk to the database
- Add servers to add capacity

Scalability & Performance
Multi-threaded Apps

- Multi-core servers
- Web server (IIS)
- Queues (MSMQ)
- Database (MS SQL Server)
- Processing services (custom C#)

Scalability & Performance
Asynchronous Services

- Local queues
  - Each web server has a queue
- Minimize processing
  - Example: game stats upload
  - Originally XML
    - Too large
  - Then compressed XML
    - Too slow
  - Finally, custom binary
    - Small and fast

Scalability & Performance Bidirectional Services

- Cache when possible
  - Reduces DB load
  - Reduces turnaround time
  - Example: MOTD caching

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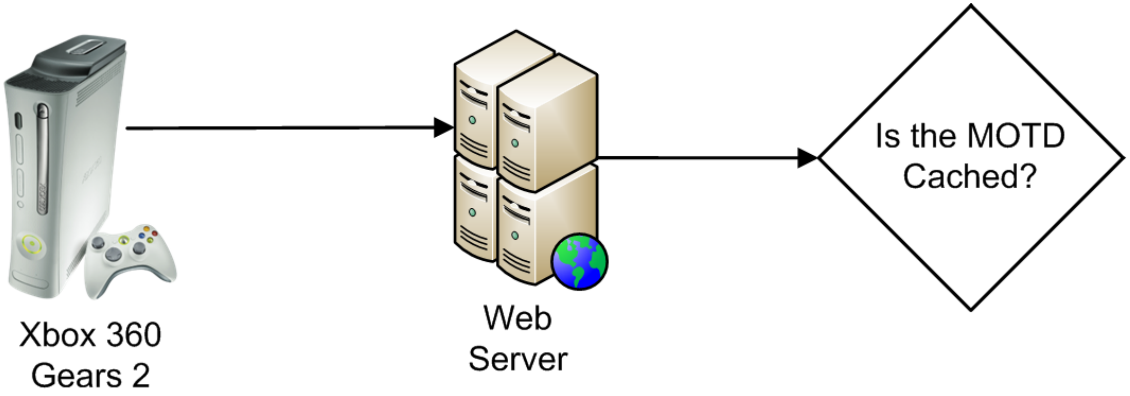

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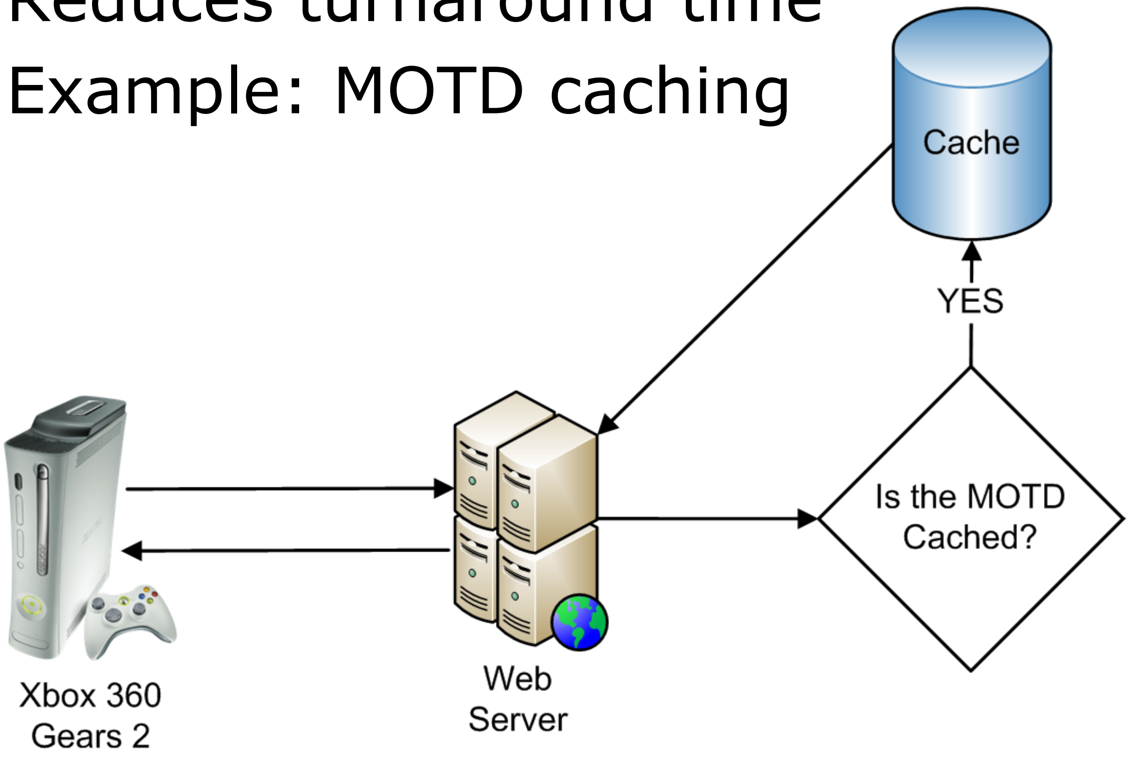

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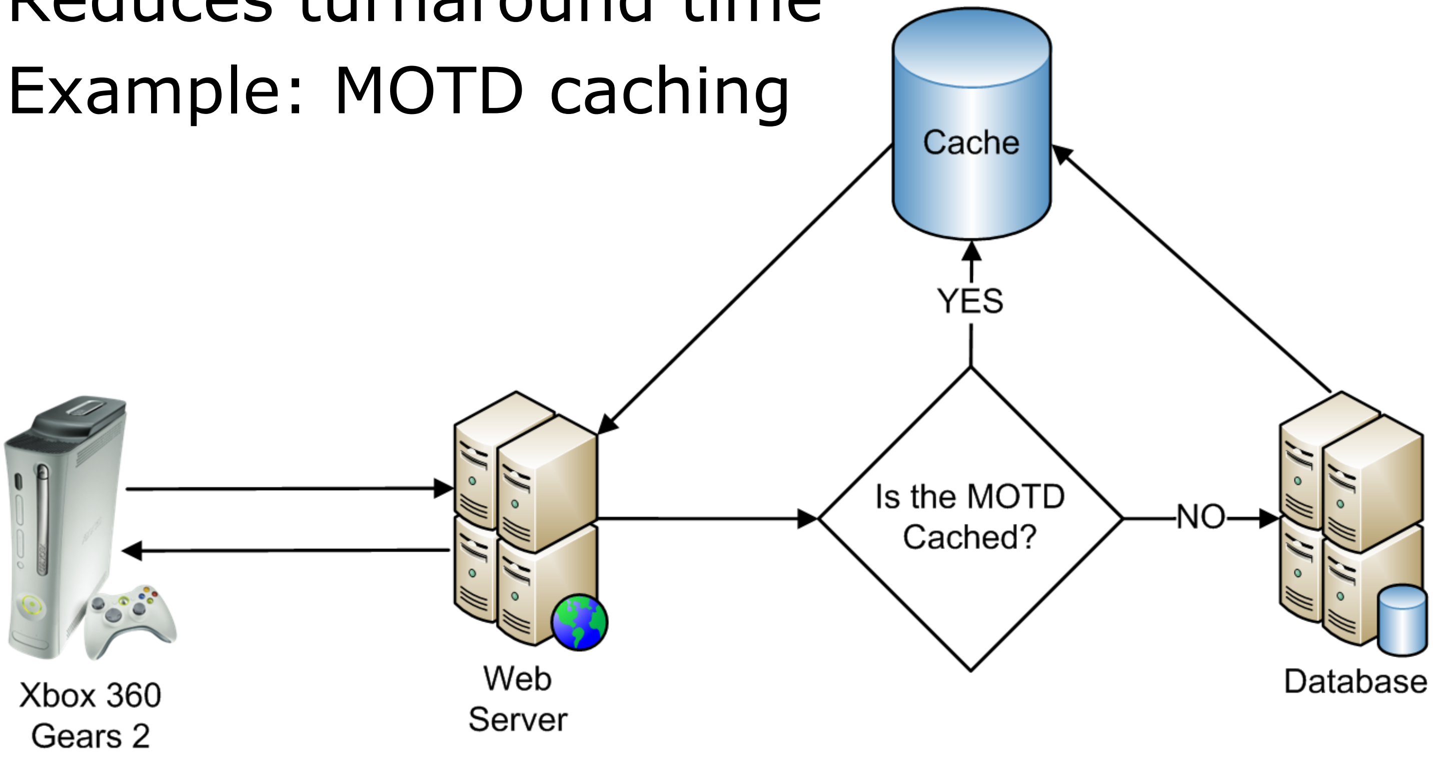
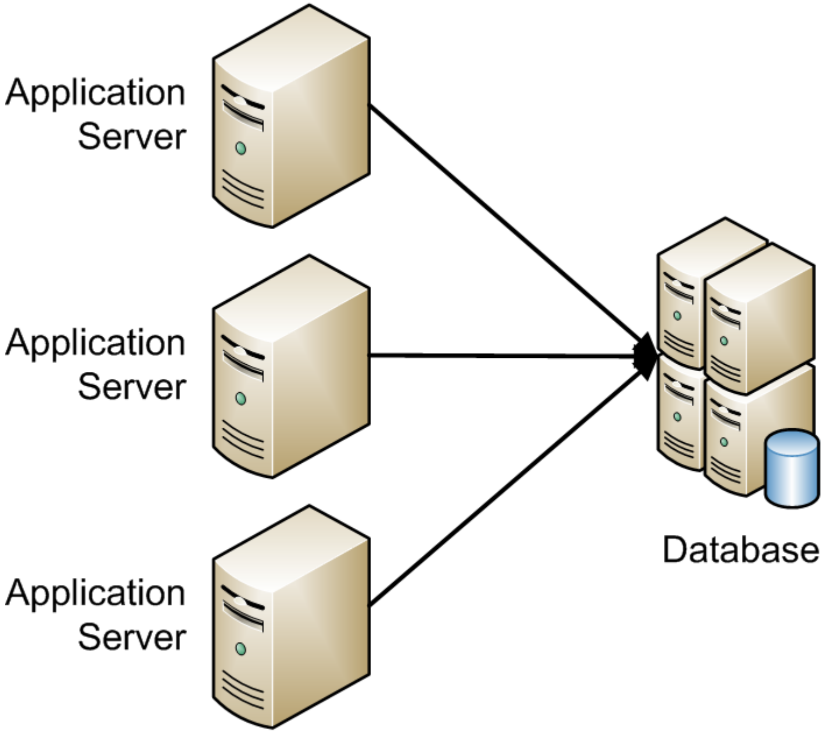


Scalability & Performance Database

- Multiple application servers
- Single database is a bottleneck



Scalability & Performance Database - Replication

- Production database
- Replicated to:
  - www.gearsofwar.com
  - Epic internal
- Expensive queries don’t run on production

Scalability & Performance Database – Profile Caching

- Matches a player to a profile ID
- Performance bottleneck
- Cache profiles when possible
  - Web handlers
  - Asynchronous processing services
  - Post-processing services
- Pro: Increased performance
- Con: Cache management

Scalability & Performance Database – Profile Caching

```
GetOrAddProfile(Player)
{
  if(PlayerInLocalCache)
     return ProfileID from Cache
  if(PlayerInProfilesTable)
     return ProfileID from Table
  AddPlayerToProfilesTable(Player)
     return ProfileID from Table
}
```

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Scalability & Performance Database – Profile Caching

```
BeginTransaction()
  ProfileID = GetOrAddProfile(Player)
  AddProfileIDToLocalCache(ProfileID)
  DoOtherDatabaseOperations()
CommitTransaction()
```

Scalability & Performance Database – Profile Caching

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BeginTransaction()
  ProfileID = GetOrAddProfile(Player)
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Scalability & Performance Database – Profile Caching

```
BeginTransaction()
  ProfileID = GetOrAddProfile(Player)
  ~~AddProfileIDToLocalCache(ProfileID)~~
  DoOtherDatabaseOperations()
CommitTransaction()
if(TransactionSucceeded)
  AddProfileIDToLocalCache(ProfileID)
```

Stress Testing

- Stress test client
- Simulates game operations
  - MOTD requests
  - Game stats uploads
  - etc.
- Configurable
  - Operations per second
  - Number of threads
  - Length of run
  - etc.

Stress Testing

- Find bottlenecks
- Test optimizations
- Example: game stats uploads
    - Identify problem area
    - Test alternatives
    - Measure performance change

Stress Testing

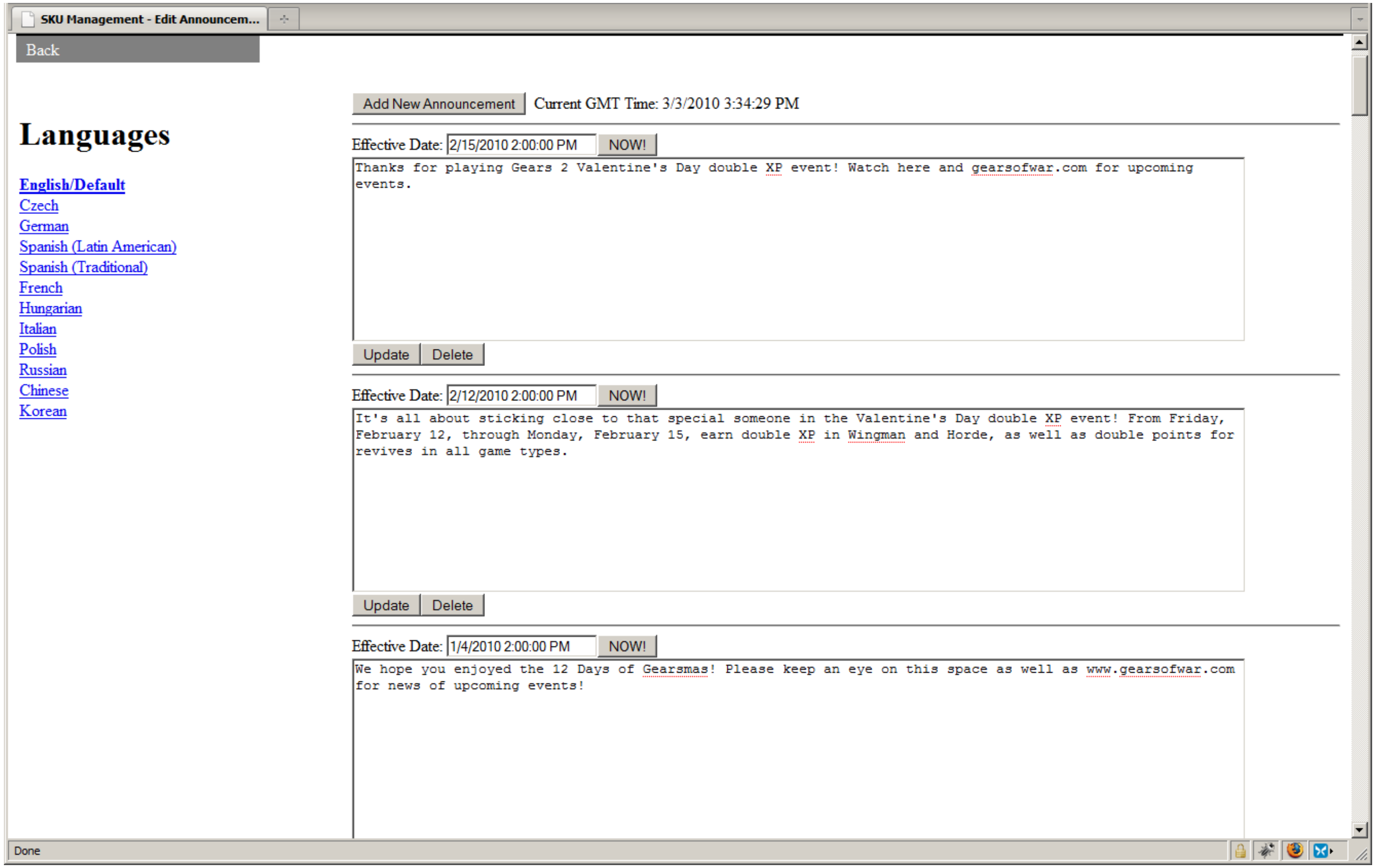
- Find bugs
- Test fixes
- Example: database deadlock
  - Identify and fix bug
  - Verify fix

Administration

- Web-based
- No direct access to production
- Did not know who would be administering MCP
- Already using web server
- Web browser as admin client

Administration Features

- Message of the day



Current GMT Time: 3/3/2010 3:34:29 PM

Languages

English/Default
Czech
German
Spanish (Latin American)
Spanish (Traditional)
French
Hungarian
Italian
Polish
Russian
Chinese
Korean

Effective Date: 2/15/2010 2:00:00 PM

Thanks for playing Gears 2 Valentine's Day double XP event! Watch here and gearsofwar.com for upcoming events.

Effective Date: 2/12/2010 2:00:00 PM

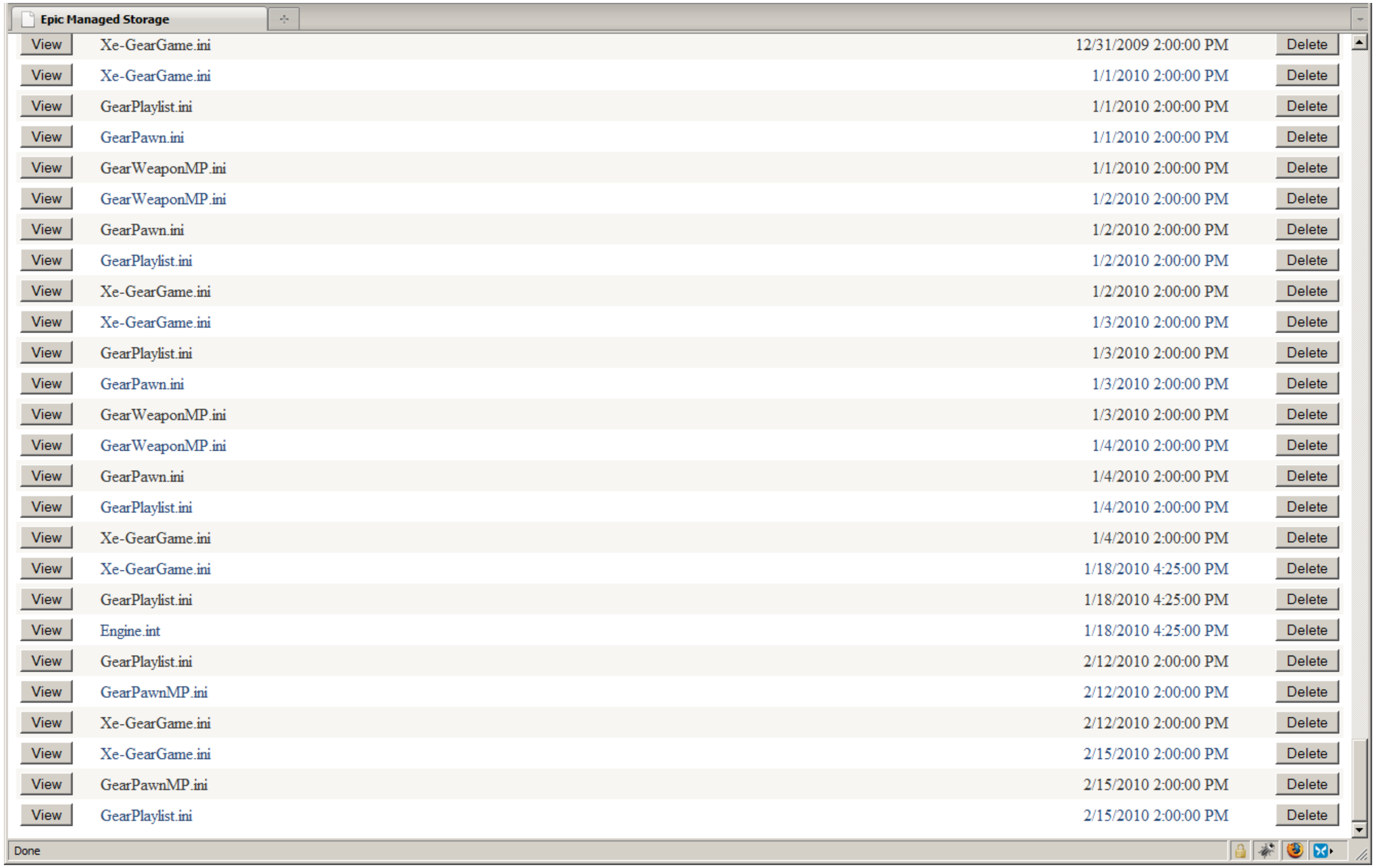
It's all about sticking close to that special someone in the Valentine's Day double XP event! From Friday, February 12, through Monday, February 15, earn double XP in Wingman and Horde, as well as double points for revives in all game types.

Effective Date: 1/4/2010 2:00:00 PM

We hope you enjoyed the 12 Days of Gearsmas! Please keep an eye on this space as well as www.gearsofwar.com for news of upcoming events!

Administration Features

- Custom game settings



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View	Xe-GearGame.ini	1/1/2010 2:00:00 PM	Delete
View	GearPlaylist.ini	1/1/2010 2:00:00 PM	Delete
View	GearPawn.ini	1/1/2010 2:00:00 PM	Delete
View	GearWeaponMP.ini	1/1/2010 2:00:00 PM	Delete
View	GearWeaponMP.ini	1/2/2010 2:00:00 PM	Delete
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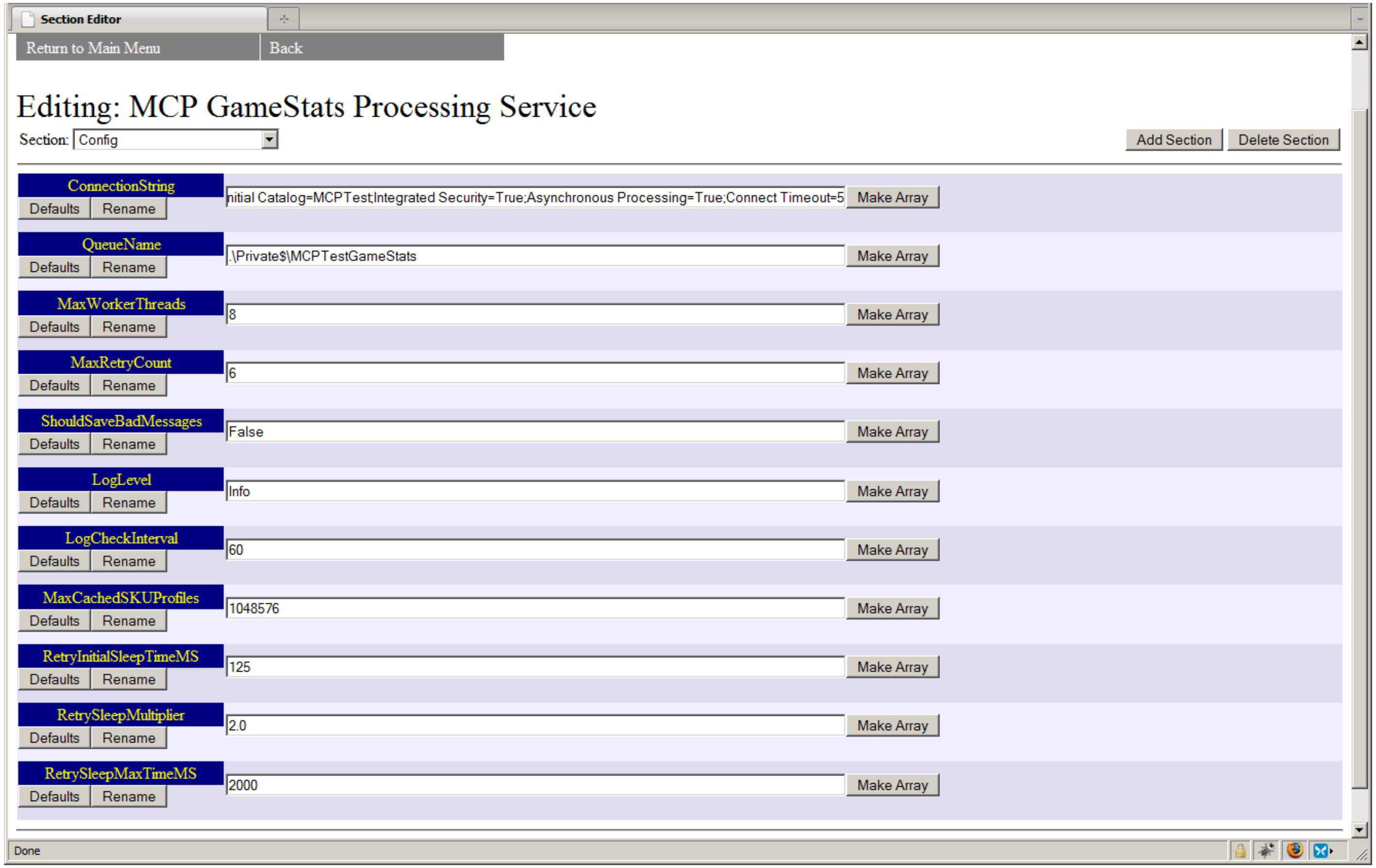
View	Xe-GearGame.ini	1/18/2010 4:25:00 PM	Delete
View	GearPlaylist.ini	1/18/2010 4:25:00 PM	Delete
View	Engine.int	1/18/2010 4:25:00 PM	Delete
View	GearPlaylist.ini	2/12/2010 2:00:00 PM	Delete
View	GearPawnMP.ini	2/12/2010 2:00:00 PM	Delete
View	Xe-GearGame.ini	2/12/2010 2:00:00 PM	Delete
View	Xe-GearGame.ini	2/15/2010 2:00:00 PM	Delete
View	GearPawnMP.ini	2/15/2010 2:00:00 PM	Delete
View	GearPlaylist.ini	2/15/2010 2:00:00 PM	Delete

Administration Features

- Edit MCP configuration



Editing: MCP GameStats Processing Service

Section: Config

ConnectionString	nitial Catalog=MCPTest;Integrated Security=True;Asynchronous Processing=True;Connect Timeout=5
QueueName	.\Private$\MCPTestGameStats
MaxWorkerThreads	8
MaxRetryCount	6
ShouldSaveBadMessages	False
LogLevel	Info
LogCheckInterval	60
MaxCachedSKUProfiles	1048576
RetryInitialSleepTimeMS	125
RetrySleepMultiplier	2.0
RetrySleepMaxTimeMS	2000

Administration
Special Events

- Schedule custom game settings
- Schedule MOTDs
- Valentine’s Day Event
- Old School Weekend
- Fourth of July Weekend

Administration
Special Events

- 12 Days of Gearsmas
  - Different MOTDs and game settings each day
  - 150+ MOTDs scheduled in multiple languages

Administration

- Can be cumbersome for common uses
- Setting up MOTD can be time consuming
- Post-release updates helped
- Uses cases are important

Hosting

Hosting

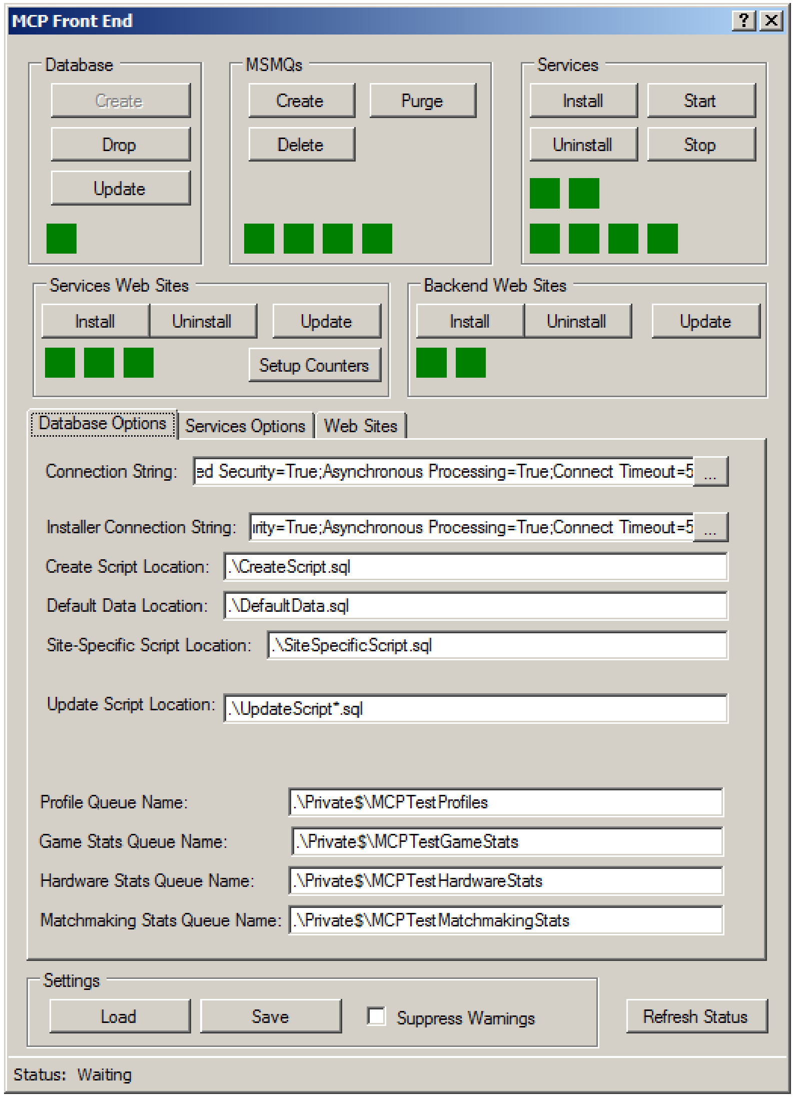
- Microsoft hosts Gears 2 MCP
- We do not have direct access
- Only web admin access
- Changes can take weeks
- Update checklist

Hosting
Update Checklist

- Database Scripts
- Functional Tests
- Stress Tests
- Front End
- Web Backend
- Upgrade Doc
- Health Model
- Nightly MOM Data
- Perf Counters
- Error Handler
- Replication
- Data Aging
- Post Processing
- Reporting/Charting

Hosting
MCP Front End

- Deployment and verification tool
- Helps with MCP installation
- Also used for local development



Connection String: ed Security=True;Asynchronous Processing=True;Connect Timeout=5

Installer Connection String: urity=True;Asynchronous Processing=True;Connect Timeout=5

Create Script Location: .\CreateScript.sql

Default Data Location: .\DefaultData.sql

Site-Specific Script Location: .\SiteSpecificScript.sql

Update Script Location: .\UpdateScript*.sql

Profile Queue Name: .\Private$\MCPTestProfiles

Game Stats Queue Name: .\Private$\MCPTestGameStats

Hardware Stats Queue Name: .\Private$\MCPTestHardwareStats

Matchmaking Stats Queue Name: .\Private$\MCPTestMatchmakingStats

□ Suppress Warnings

Status: Waiting

What could possibly go wrong?

Data Center Problems

- Failed cooling system
  - Machines overheating
  - Multiple day downtime
  - Luckily, not production

Data Center Problems

- Failed cooling system
  - Machines overheating
  - Multiple day downtime
  - Luckily, not production
- Failed power supply
  - Redundant backup failed
  - Outage and lost data
  - Unfortunately, production

Monitoring

- MOM (SCOM)
- Health model
  - Performance counters
  - Event logs
- Lots of iteration
  - Warning thresholds
  - Error thresholds
- Hard to predict real world

Monitoring Problems

- Thresholds were set too low
  - We did not want to miss any issues
  - But we ended up with false alarms
- Event log was not cleared before release
  - Simulation had filled the event log
  - Alerting was turned on
  - Flood of false alerts
  - We crashed a phone
  - SMS charges $$$

Monitoring Ongoing…

- Problems can always happen
- Need to continue monitoring
  - For the life of the game
  - Or as long as online is supported

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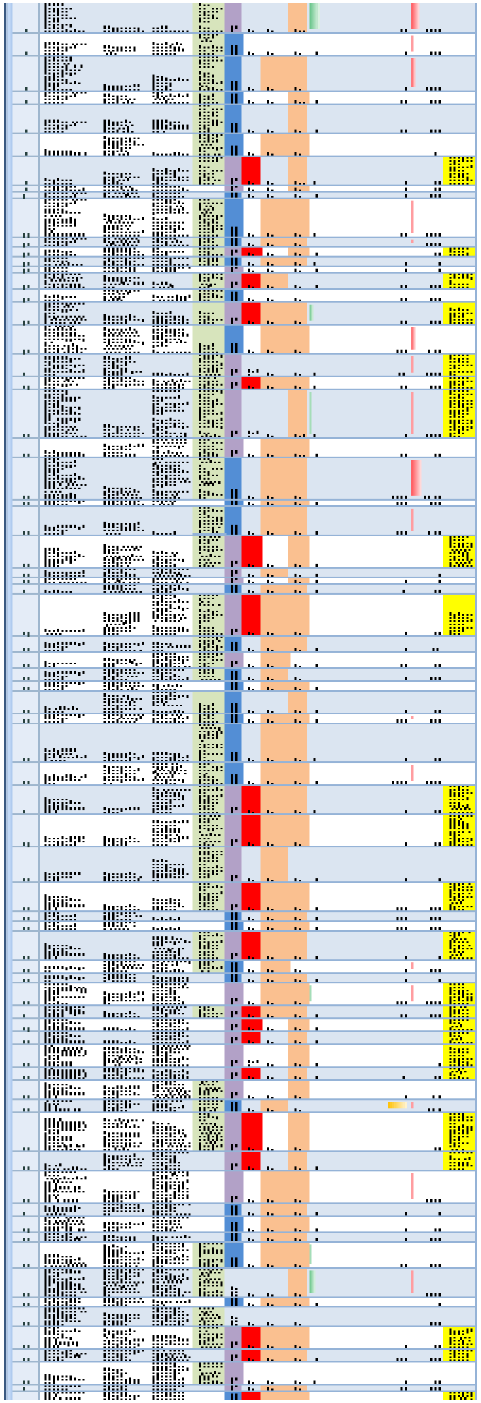

Launch

- Testing had been done
  - Local, PartnerNet, Production
- But Production testing was done from inside the network
- External connections had not been tested – and did not work
- We could only sit and wait
- Was fixed less than 2 minutes before our midnight release

Success!

- Great for Gears 2
  - New features
  - Gameplay feedback
  - Special events
  - Held up under load
- Platform for future products
  - Using with the UDK (Unreal Development Kit)
- Available to Unreal Engine licensees

Q&A

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