

CISC 326

Game Architecture



Module 02:

Challenges In Game Development

**Ahmed E. Hassan (with slides from
Dr. Scott Grant and Nick Graham)**


World of Warcraft

- Released November 23, 2004 after a closed beta
- Over 100 million lifetime players and 500 million characters
- Nearly 1 million PvE instances and 700k PvP instances each day
- Nearly 3 million daily trades in the auction house



World of Warcraft: Azeroth by the Numbers

<http://us.battle.net/wow/en/blog/12346804/world-of-warcraft-azeroth-by-the-numbers-1-28-2014>

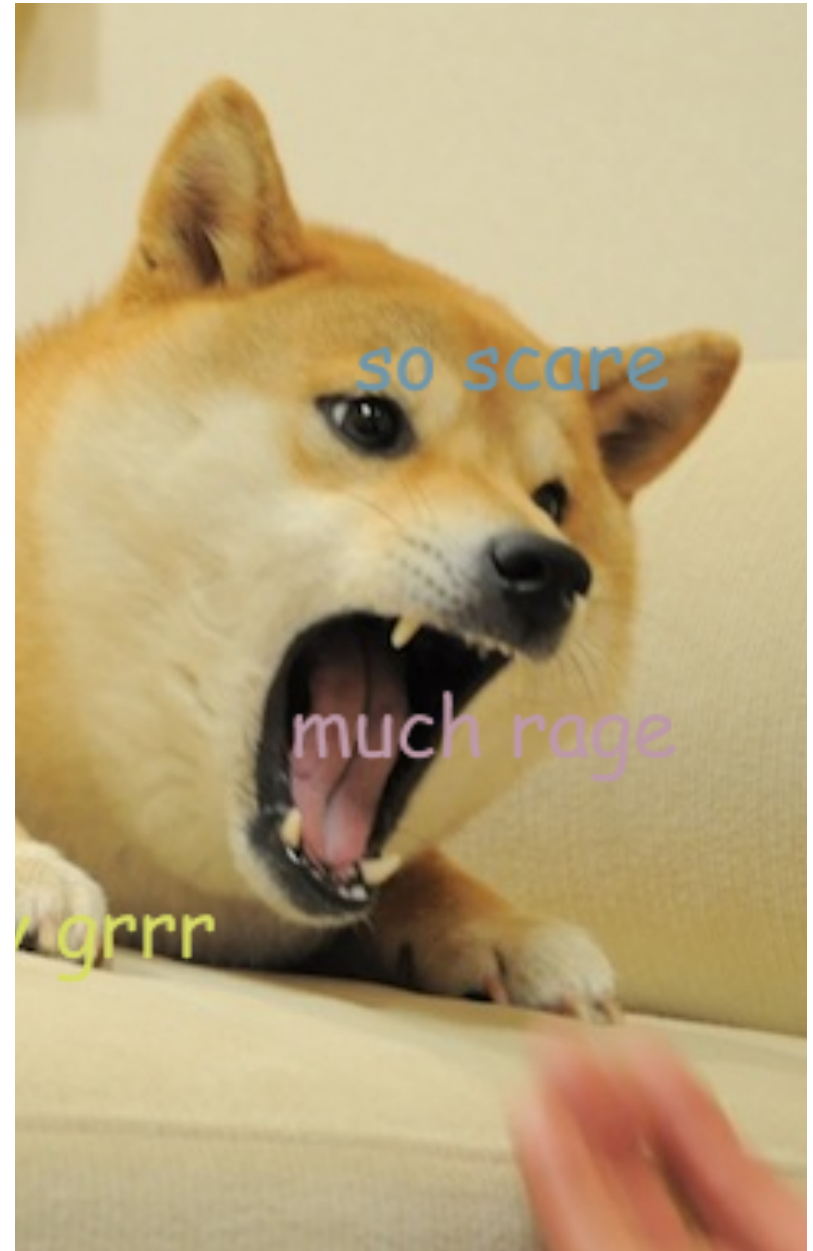


Eldre'Thalas is Full
Position in queue: 682
Estimated time: 68 min

Change Realm

Critical Lack of Server Capacity

- Stress testing was done in beta, but was not sufficient
- Long queue times prevented players from playing
- Server migration was unacceptable in many cases



SimCity 2013

- Released March 5, 2013
- Enormous sales success immediately following release
- Traditionally a single-player game
- New version required continuous access to EA's servers





SIMCITY™

ALERT

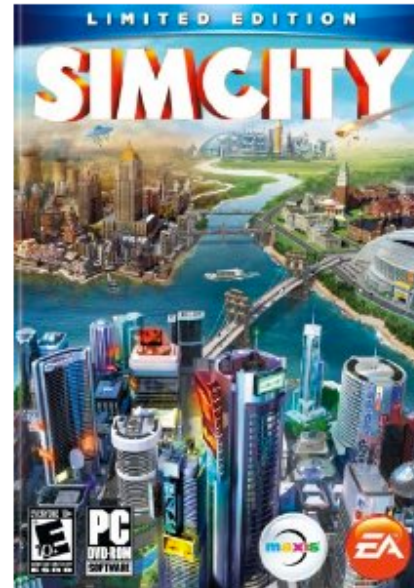
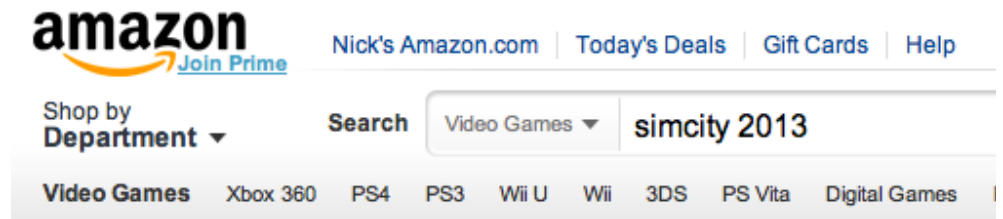
Unable to load the city at this time. Please try again.

OKAY



Critical Lack of Server Capacity

- Players unable to gain access to game
- EA responded by removing game features, adding new servers
- Amazon.com bombarded with negative reviews
- EA finally announced free game to all people who purchased SimCity



Roll over image to zoom in



[See all 35 customer images](#)

[Share your own customer images](#)

SimCity - Limited Edition

by [Electronic Arts](#)

Rated: [Everyone 10+](#)

☆☆☆☆☆ (2,996 customer reviews)

List Price: ~~\$59.99~~

Price: **\$59.96** & eligible for

You Save: **\$0.03**

In Stock.

Ships from and sold by Amazon.com

Want it Thursday, March 14?
Priority Shipping at checkout

Platform: **PC**



PC Download - \$

23 new from **\$49.99**



Important Note

Many customers are actively working to resolve this issue. We will be fixed.

information.

Making Games Is Easy?

- There is a lot more to games than fancy graphics
- World of Warcraft has 13,250 server computers with 75,000 CPU cores
- Managed by a staff of 68
- 10 data centres in US, Europe, Asia

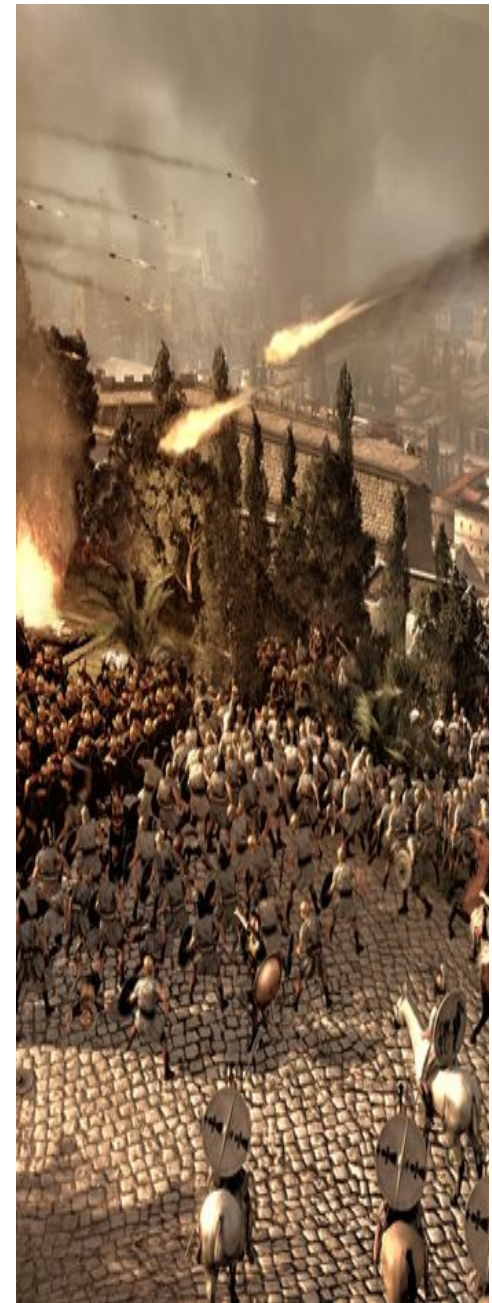


Source: Rich Miller, WoW's Back End: 10 Data Centers, 75,000 Cores, Data Centre Knowledge, Nov 25, 2009

Total War: Rome 2

Hi everyone and thanks for your attention.

We just wanted to reassure you that we do know it's an extremely annoying and frustrating time for some of you at the moment and we are working around the clock to sort out those issues that you are having. The first patch has just gone up - it's not trouble-free we know and are fixing with a hotfix, but there will be another next week and every week after that till the problems are gone.



Total War: Rome 2

At the moment it may seem that the changes are slight, but they aren't the only ones we are working on currently and bigger changes are happening now for future patches.

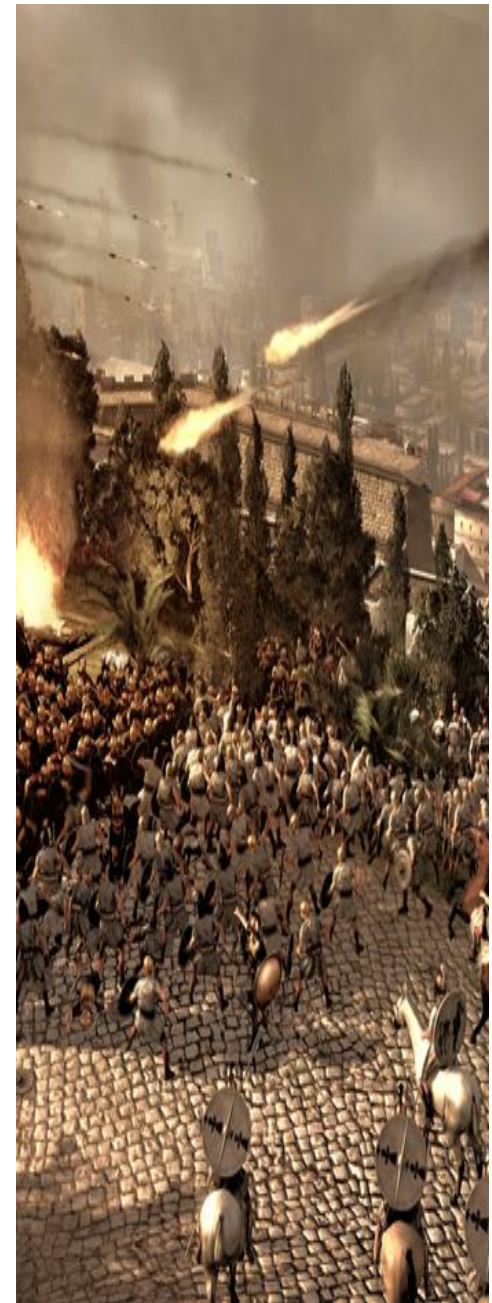
If you are having a problem, it is totally unacceptable and a big deal for us, please know that we are spending all our dev effort on fixing outstanding issues.

Mike Simpson, Creative Director,
Creative Assembly, Sept 6, 2013



Total War: Rome 2

- Big lesson
- Simpson claimed that game ran correctly on 98% of systems
- But 2% of several million is still a large number
- Vast plethora of PC hardware (different processors, memory, graphics cards, OS and driver versions, ...)





**Ad hoc techniques don't work.
Video games are software too.**

Challenges in Game Development

- Size of teams
- Strict timeline
- Range of cooperating roles
- Complex development environment
- Low success rates

Challenges in Game Development

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- **Strict timeline**
- **Range of cooperating roles**
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Game Development Teams

- ❖ For “AAA” games, teams typically 10-100 people

- ❖ Multi-disciplinary

- ❖ Producer

- ❖ Designer(s)

- ❖ Programmers

- ❖ Level designers

- ❖ Modellers

- ❖ Animators

- ❖ Sound Engineers

- ❖ Musicians

- ❖ Quest developers

- ❖ Writers

- ❖ Testers

- ❖ Actors

- ❖ ...

Red Alert 2

- ❖ 3 producers
- ❖ 10 designers
- ❖ 3 story writers
- ❖ 16 artists
- ❖ 18 programmers
- ❖ 3 audio
- ❖ 31 video production
- ❖ 21 quality assurance
- ❖ 9 marketing
- ❖ 41 live actors
- ❖ 26 voice actors



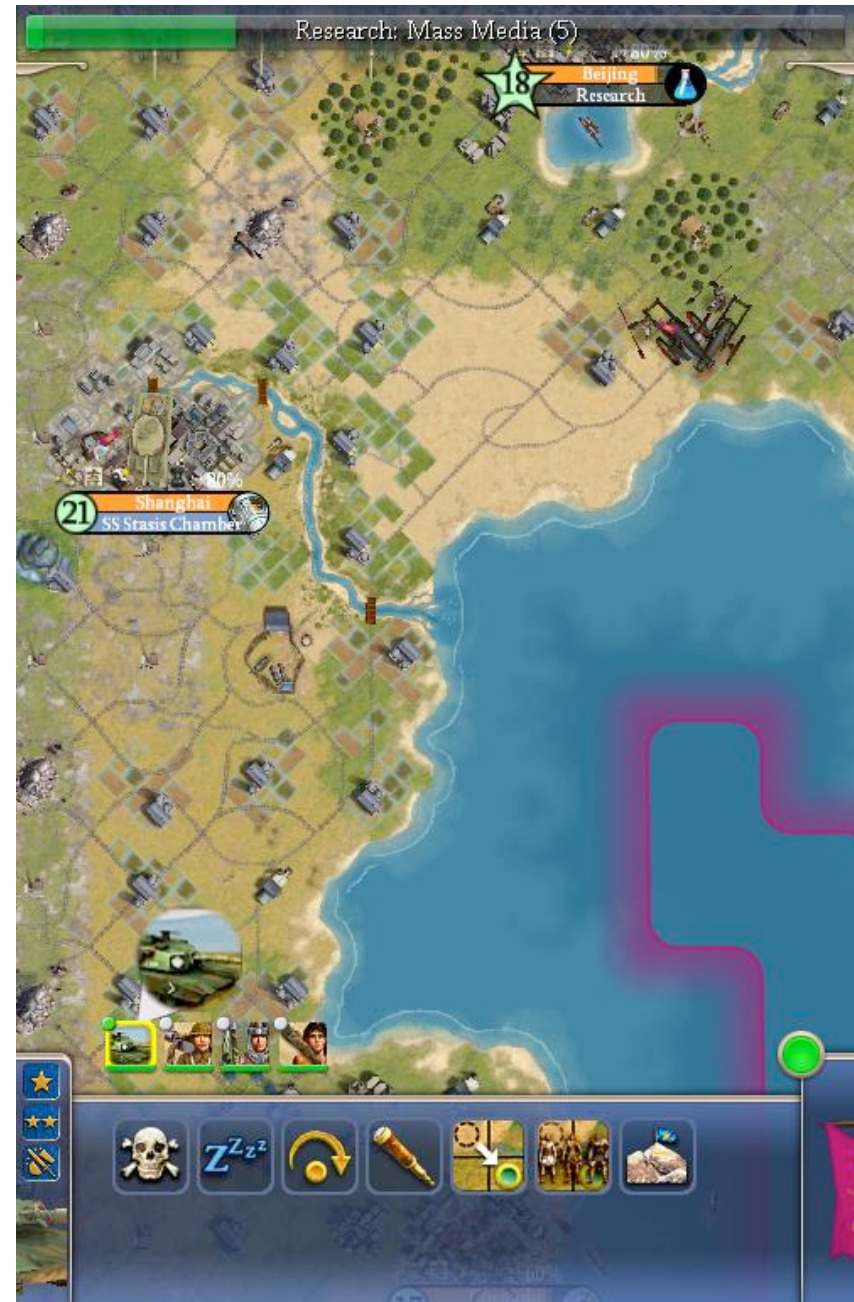
Battlefield 1942

- ❖ Producers: 2
- ❖ Designers: 3
- ❖ Programmers: 11
- ❖ Artists: 12
- ❖ Sound: 2
- ❖ Music: 1
- ❖ Testers: 51
- ❖ Documenters: 2
- ❖ Voice actors: 18



Civilization 4

- ❖ Producers: 3
- ❖ Designers: 2
- ❖ Programmers: 18
- ❖ Writers: 5
- ❖ Artists: 34
- ❖ Voice actors: 1
- ❖ QA: 26



But not all games are AAA

- ❖ Mojang: 3 at first, now 40
- ❖ Team Meat: 2
Programmer, Artist
(+Composer, QA, etc.)
- ❖ Frictional Games: 12
(+contractors, partners,
etc.)
- ❖ Subset Games: 2
Programmer, Artist
(+Writer, Composer)

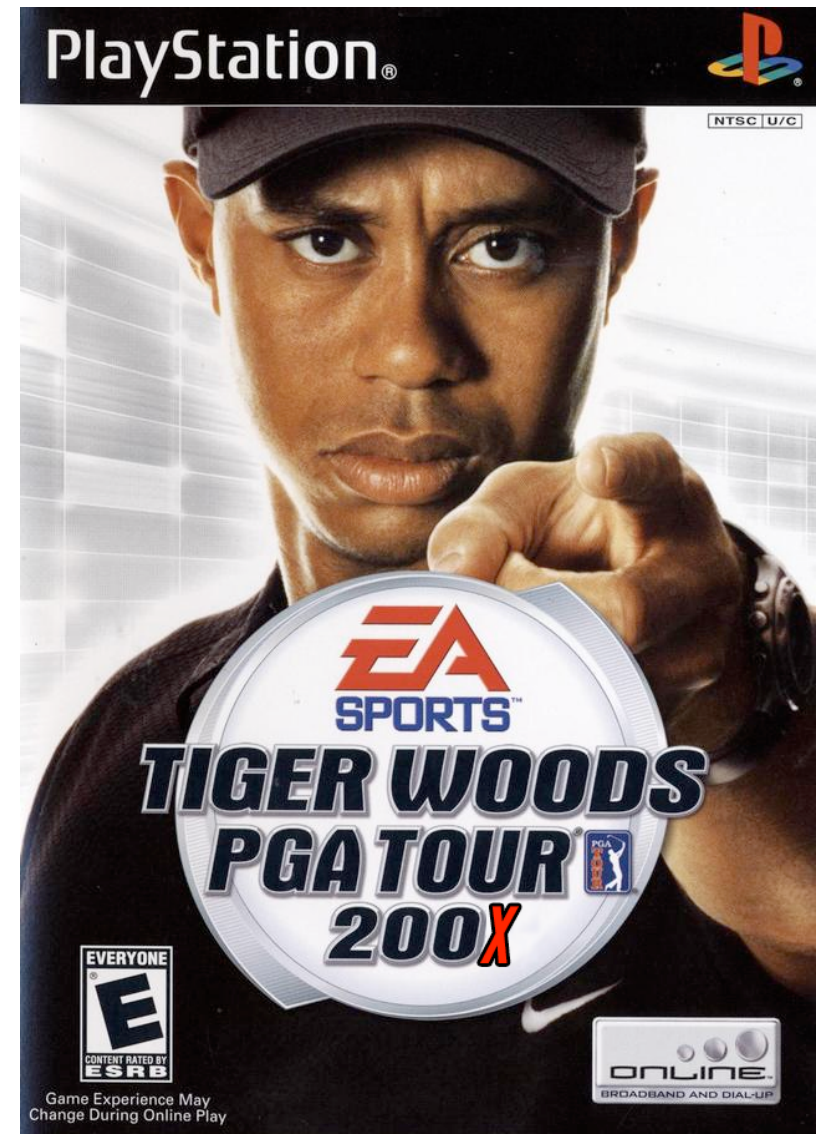


Challenges in Game Development

- Size of teams
- **Strict timeline**
- Range of cooperating roles
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Strict Timelines

- **Time-sensitive topics:** E.g., sports events, movie tie-ins
- **Need to recoup investment**
- **Changing technology makes game stale:** Duke Nukem Forever, development 1996-2011, changed engine at least twice requiring complete rewrite each time



Challenges in Game Development

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Range of Co-operating Roles

- Many sub-specialities on development team
 - Artists - modellers, animators, lighting specialists
 - Designers - level designers, quest designers, writers
 - Sound specialists
- Schedule dependencies
- Problems crossing organizational hierarchy

Challenges in Game Development

- Size of teams
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Xbox One

- Released November 22, 2013
- 2 x 1.75 GHz quad core AMD Jaguar processor
- 853 MHz AMD Radeon GCN
- 8 GB DDR3 RAM
- Up to 8 wireless game controllers



Playstation 4

- To released Nov. 15, 2013
- 8 core AMD x86-64 Processor
- 8 GB GDDR5 RAM
- AMD Radeon GPU



Playstation 3

- Released December 2006
- 3.2 GHz Cell Processor
- 7 SPE's – 128 bit SIMD RISC processor
- connected by 10 GBps bus
- 1 PPE as controller
- 256 MB system memory, 256 MB on graphics card
- Custom “Reality Synthesizer” Graphics Processor (NVIDIA/Sony)
- Up to 7 Bluetooth controllers



Consoles: Programming

- Current consoles introduced significantly different programming architectures
 - 6 cores in Xbox 360; 8 cores in Xbox One; 7 cores in PlayStation 3
 - Extensive vector processing capabilities
- Difficulty of finding this much parallelism in games
 - Obvious candidate: AI
- Difficulty of concurrent processing
- In Xbox 360, GPU and CPU share memory
- Many years required to learn how to develop for new consoles

Consoles: Development

- Proprietary software development kit available for Windows PCs
 - Develop, debug on PC
 - Cross-compile to console
- Consoles do not necessarily make it easy to port to other consoles
 - “native” vs. “ported” vs “cross-platform” implementation

Consoles: Software Delivery

- Still typically DVD/Blu-ray delivery
 - Digital download gaining traction
- Traditionally consoles had no/small HD, games played directly from DVD
 - Implies no opportunity for patching
 - First generation Xbox 360 came in “arcade” version with no HD!
- Compare to PC games where patches routinely delivered after release, require download by players
- Requires rock-solid software engineering, QA processes

Home Computer

- Enormous variety of hardware and SW platforms (e.g., OS: Windows, MacOS, Linux)
- Windows PC's have open hardware/software environments (contrast to consoles with uniform env.)
 - Video card, CPU, memory differ in capability by orders of magnitude
 - Different versions of DirectX, video card drivers cause enormous difficulties with QA

Portable Game Devices

- Handheld devices for gaming
- Extension into other entertainment areas – movies, MP3's, social networking
- E.g. PlayStation Vita, Nintendo 3DS



Mobile Devices

- Cell Phones\Tablets
 - Touch-based input
 - Powerful 3D GPUs
 - iPhone: Objective C
 - Android: Java / C
 - Windows Phone: C#/XNA
- Largest install base of all gaming platforms
- Programming challenge in diversity of devices



Cross-Platform Development

- Several game development engines now support wide range of platforms
 - **Unreal:** Windows, OS X, Linux, PlayStation, Wii, iOS, Android, HTML 5
 - **Unity:** iOS, Android, BBOS, Windows Phone, Windows, Mac, Linux, PlayStation, Xbox
 - **Source:** Windows, MacOS, Linux, Xbox, PlayStation
 - **Frostbite:** Windows, Playstation, Xbox

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Many games fail to make a profit



- Apple App Store
 - ~59% of games don't break even
 - ~80% of developers can't sustain a business on apps alone
- Profitable vs. Financial Success

A Rapidly Growing Market

The Road To 1M Users



9 Years



9 Months



9 Days



3 Days

\$16,910.556
(Avg. Daily Revenue
Nov 2012)



51% (All of 2012)

\$3,402.544



Google play

43% (Aug-Nov 2012)

NASDAQ

7.7% (All of 2012)

Games drive
most of the revenue and downloads

**30 – 35% of all downloads are
Games
over 60% of revenues from Games**





How many apps before Angry bird?



1st app

10th app

20th app

Over 50 apps



How many apps before Angry bird?



1st app

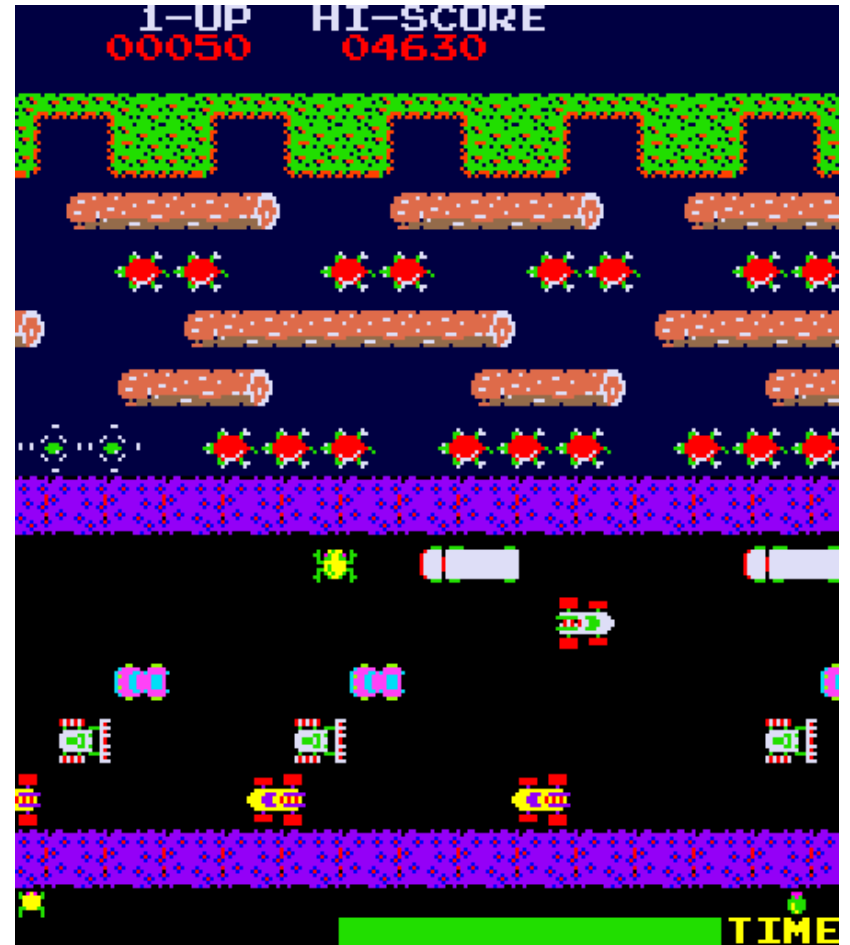
10th app


20th app

Over 50 apps

How much does it cost?

- **Frogger (1982):** \$5 million
 - (mostly marketing)
- **EverQuest (1999):** \$3 million
- **Lord of the Rings: The Two Towers (2002):** \$20 million
- **Half-Life 2 (2004):** \$40 million
- **World of Warcraft (2004-2008):** \$200 million
- **Rift (2011):** \$60-70 million

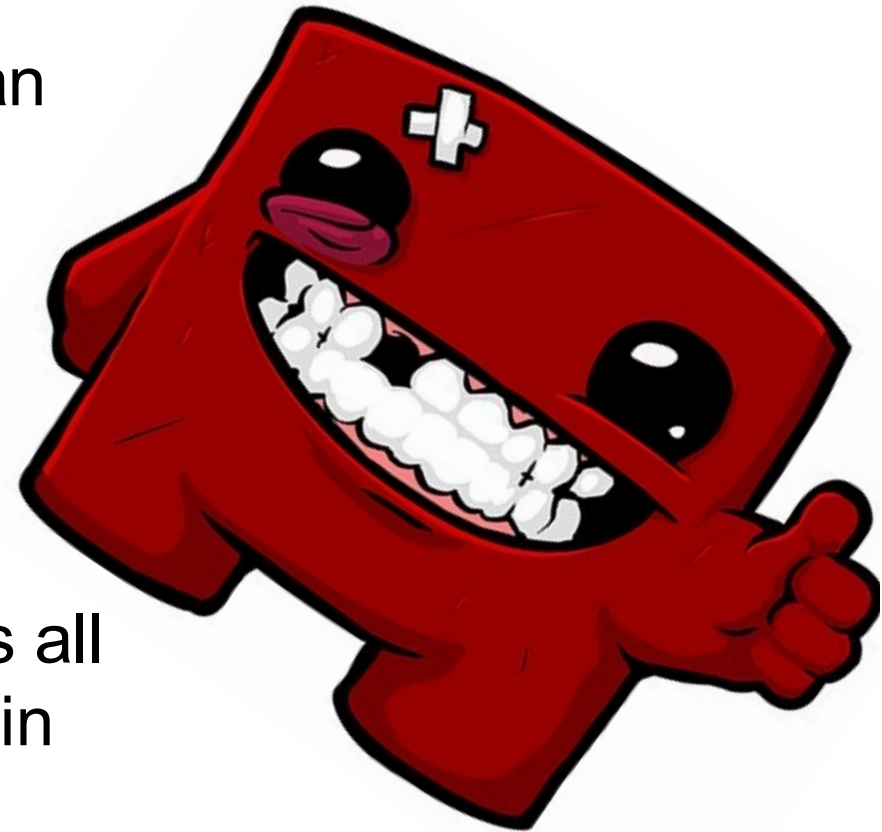




50% of developers make \$682/year
35K average cost of developing an app
51 years to break-even!!
Angry Bird is Rovio's 52nd app!!

The Indie Path

- Solo indie developers earned an average income of \$11,812 in 2013, down 49% from 2012's \$23,130 average
- 57% of indie game developers (including both solo indies and members of indie teams across all pay ranges) made under \$500 in game sales



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Software Architecture

- The blueprint underlying complex software systems
- Deliberate design
- Trade-off analysis
- Investigation of system properties before implementation
- Discovery of potential reuse

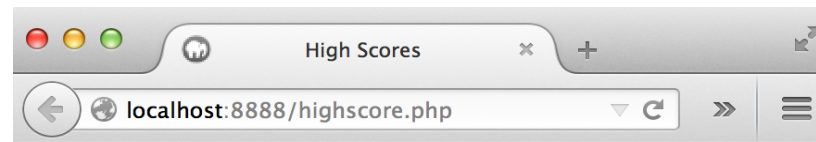


Early Architecture

- Architectural design is often the first stage in the software design process
 - Identifies the main structural components in a system and the relationships between them
- Even in agile software process models, the early development process should be concerned with establishing an overall system architecture
 - Refactoring components is easy
 - Refactoring architectures is hard

Example

- We wish to build a single player game with an online high score list available through the web

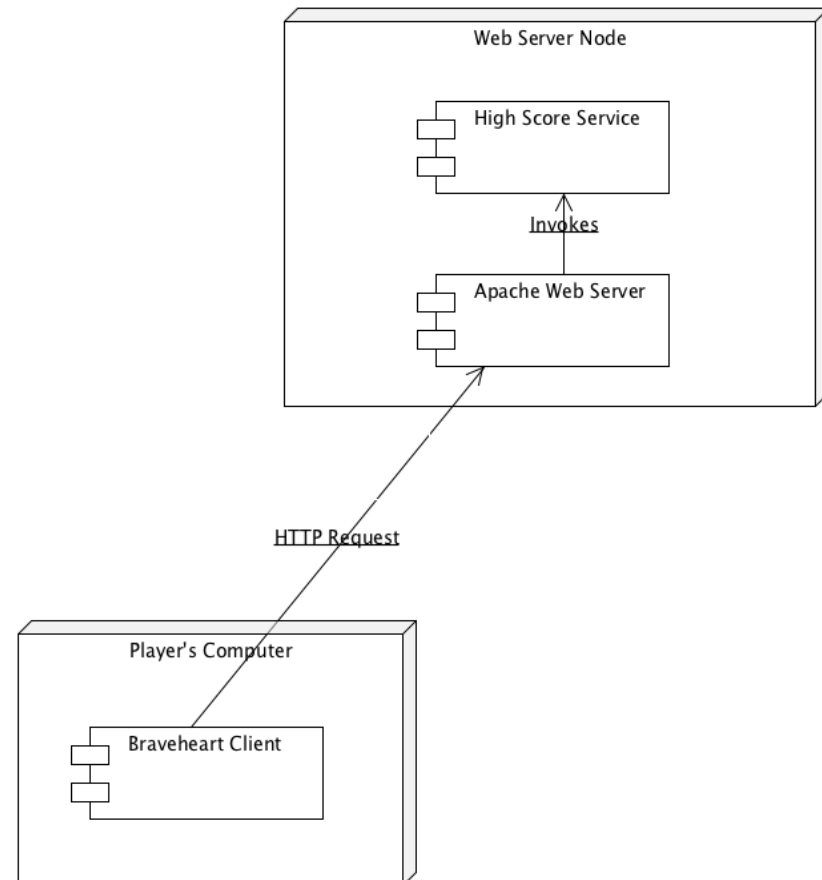


High Scores

Name	Score
Iron Man	2850000
Black Widow	2720000
Thor	2365000
The Wasp	1955000
Captain America	1440000
Hawkeye	1435000
Black Panther	1252000
Ant Man	1125000

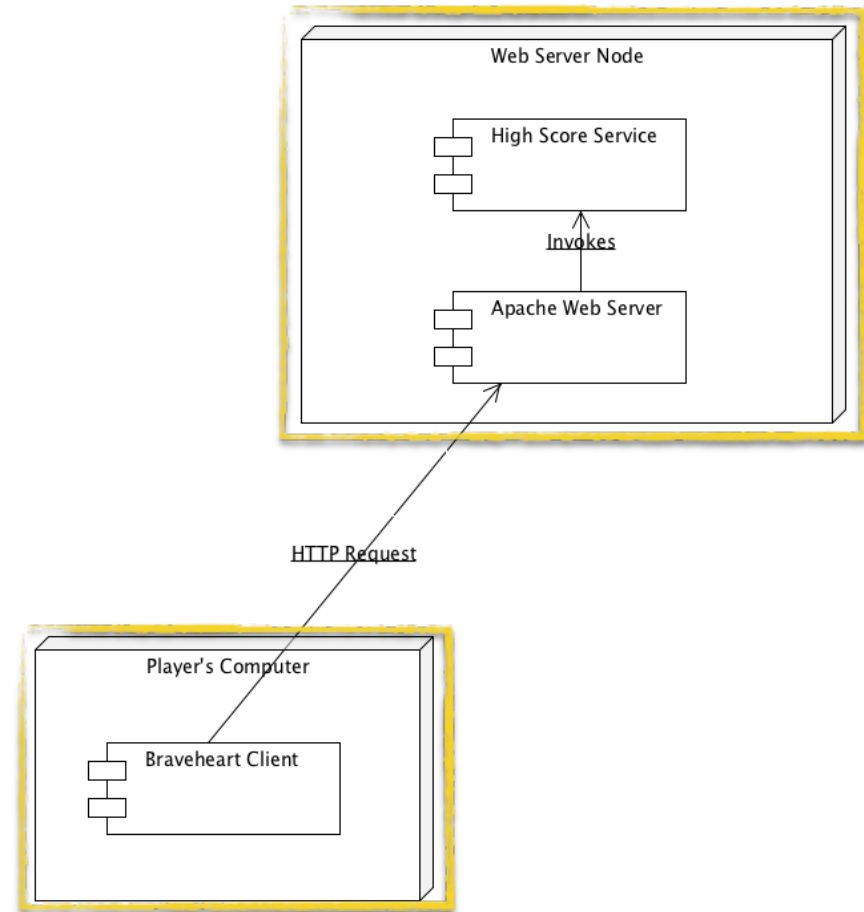
First Draft

- Two nodes represent the player's computer and the computer hosting the web server
- The player's computer has a component running the game
- The web server node has a component representing the web server, and another component representing the high score web application



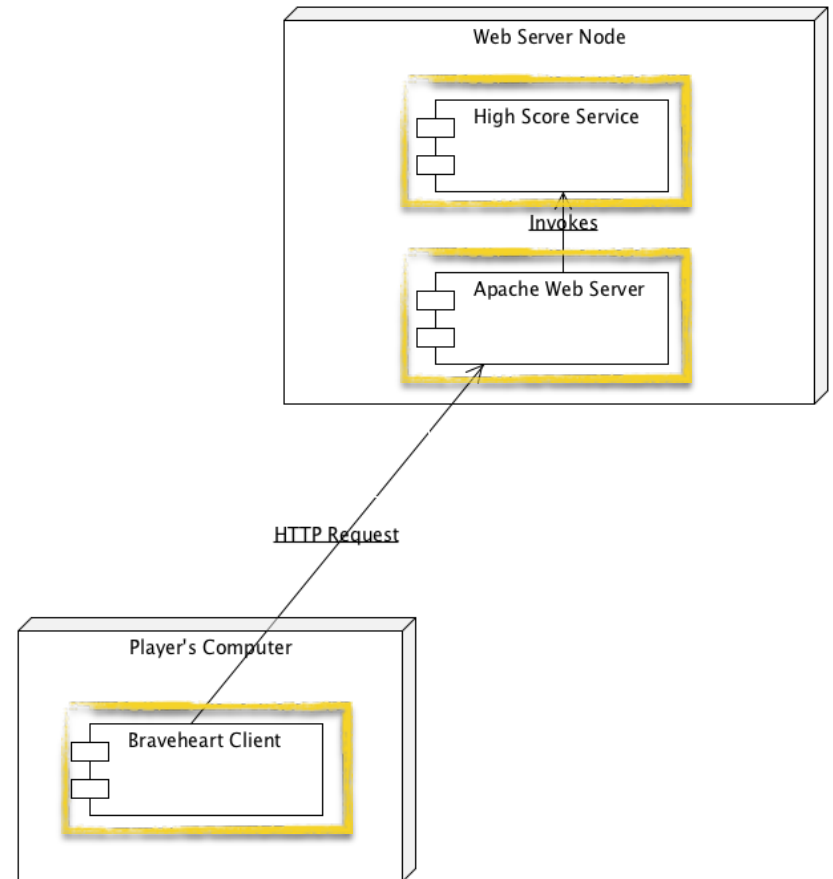
Legend

- A **node** is a computational platform such as a:
 - physical computer
 - virtual machine
 - process



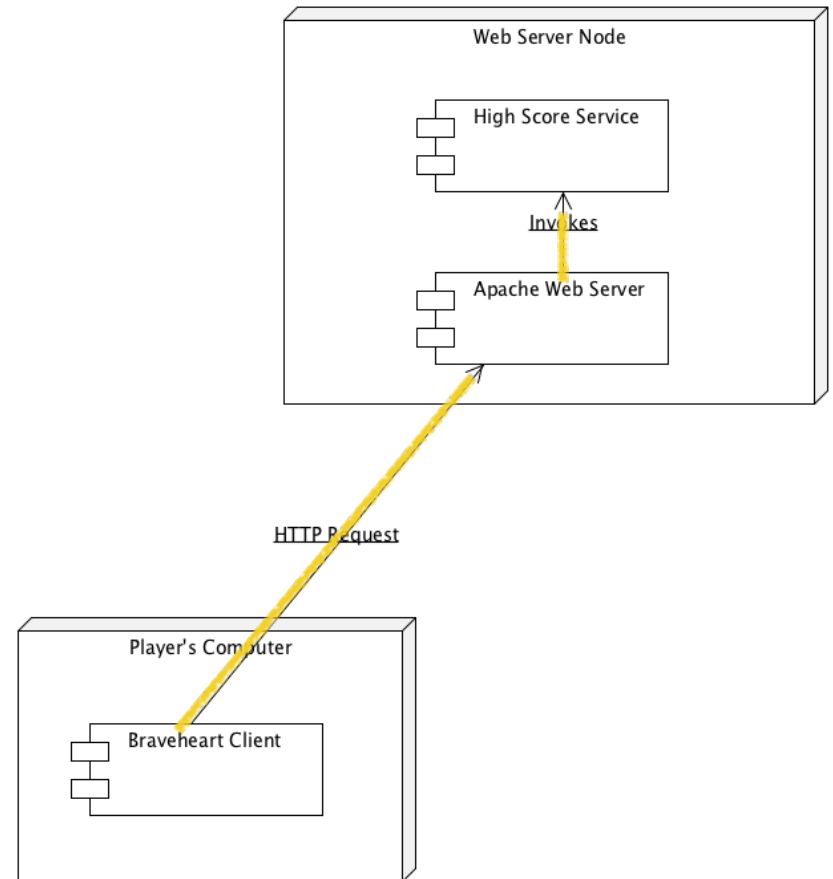
Legend

- A **component** is a modular part of the system such as:
 - A web server comprising > 1,000,000 lines of C++ code
 - A simple service for generating high scores written in PHP
 - A game client of a few thousand lines of code
- A component has an **interface** specifying how other components communicate with it



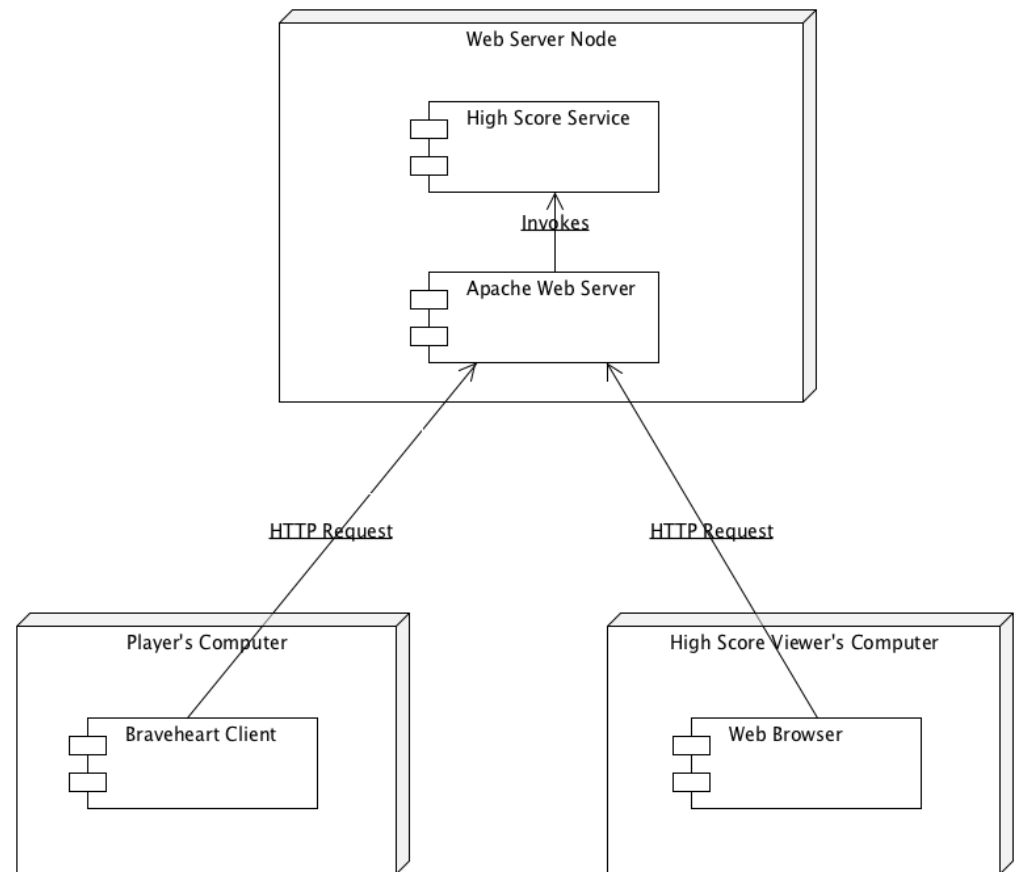
Legend

- A **link** represents some relationship between nodes or components such as:
 - An HTTP connection between a web browser or other software component and a web server
 - A read/write relationship between a process and a file
 - A method call between two processes in a program



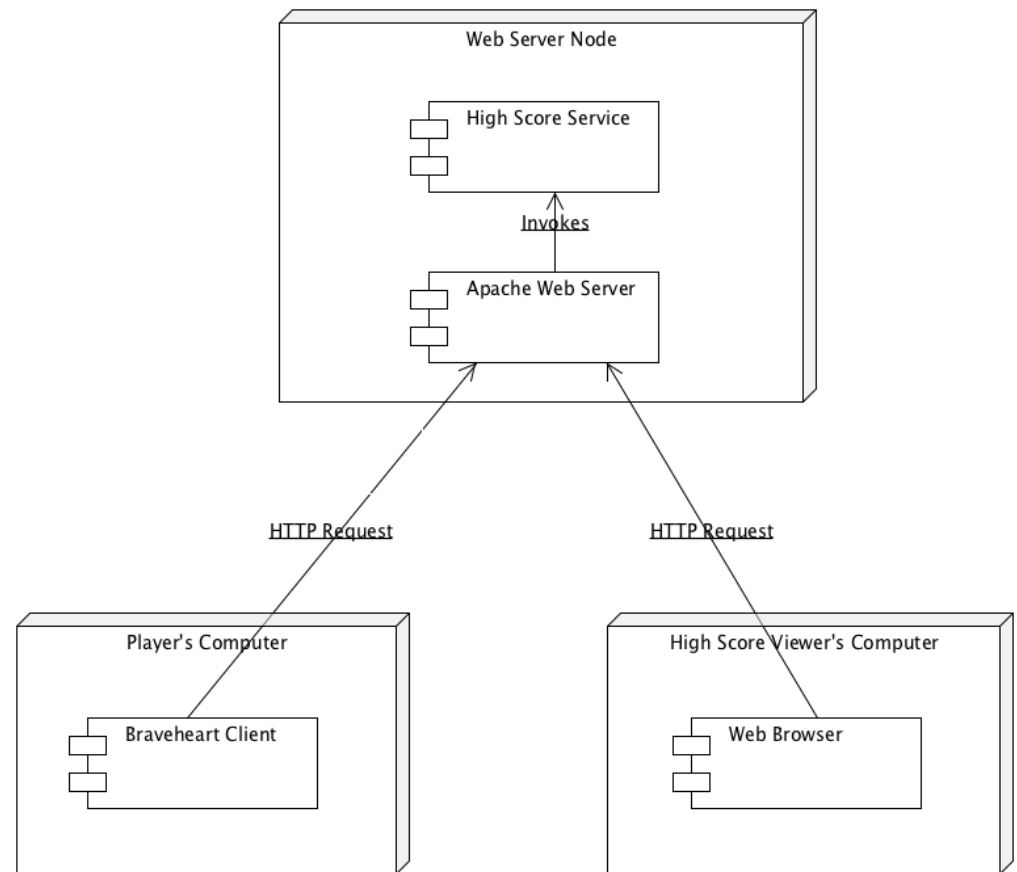
Adding High Score Viewer

- A new node represents the computer of someone trying to access the high score via a standard web browser
- Uses web server to access high score



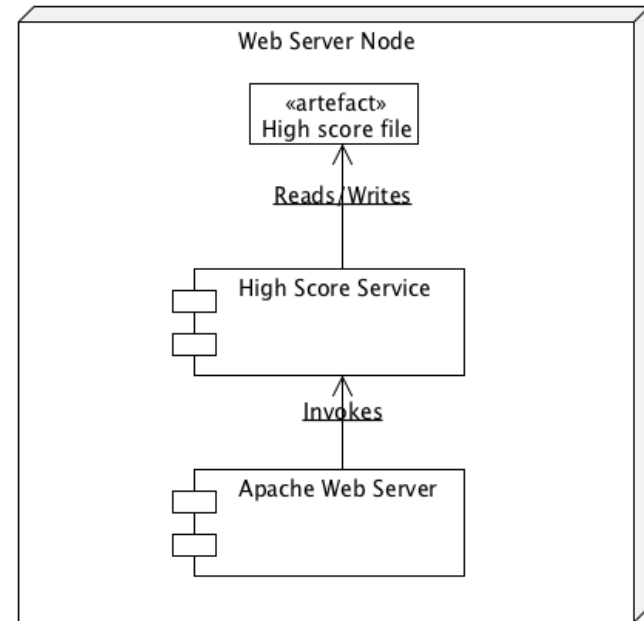
Adding High Score Viewer

- In fact, any number of players, high score viewers can connect to web server
- Web browser and game client could be on same node



Where is the high score file stored?

- **Option 1:** use a file on the web server
- Use XML/JSON format to store file

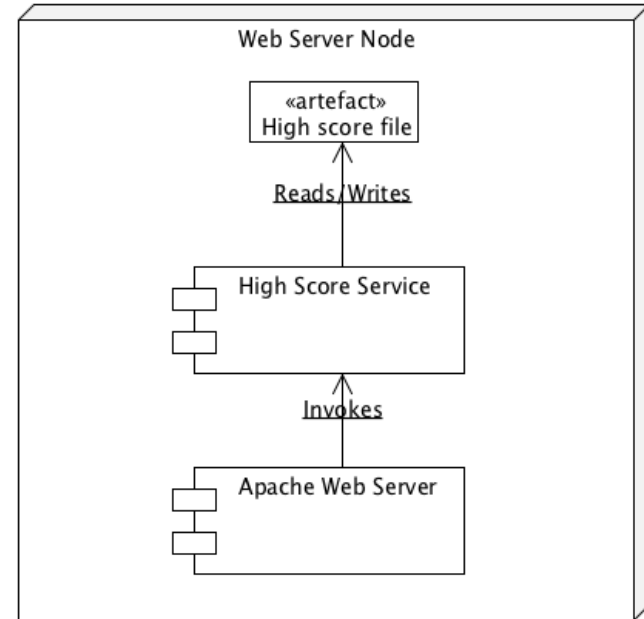


```
<highscorefile>
  <highscore name="Iron Man"
    score="2850000" />
  <highscore name="Black Widow"
    score="2720000" />
  ...
</highscorefile>
```

Problems

■ Scalability

■ Availability



```
<highscorefile>
  <highscore name="Iron Man"
    score="2850000" />
  <highscore name="Black Widow"
    score="2720000" />
  ...
</highscorefile>
```


Where is the high score file stored?

■ **Option 2:** store the data on a database

■ Pro:

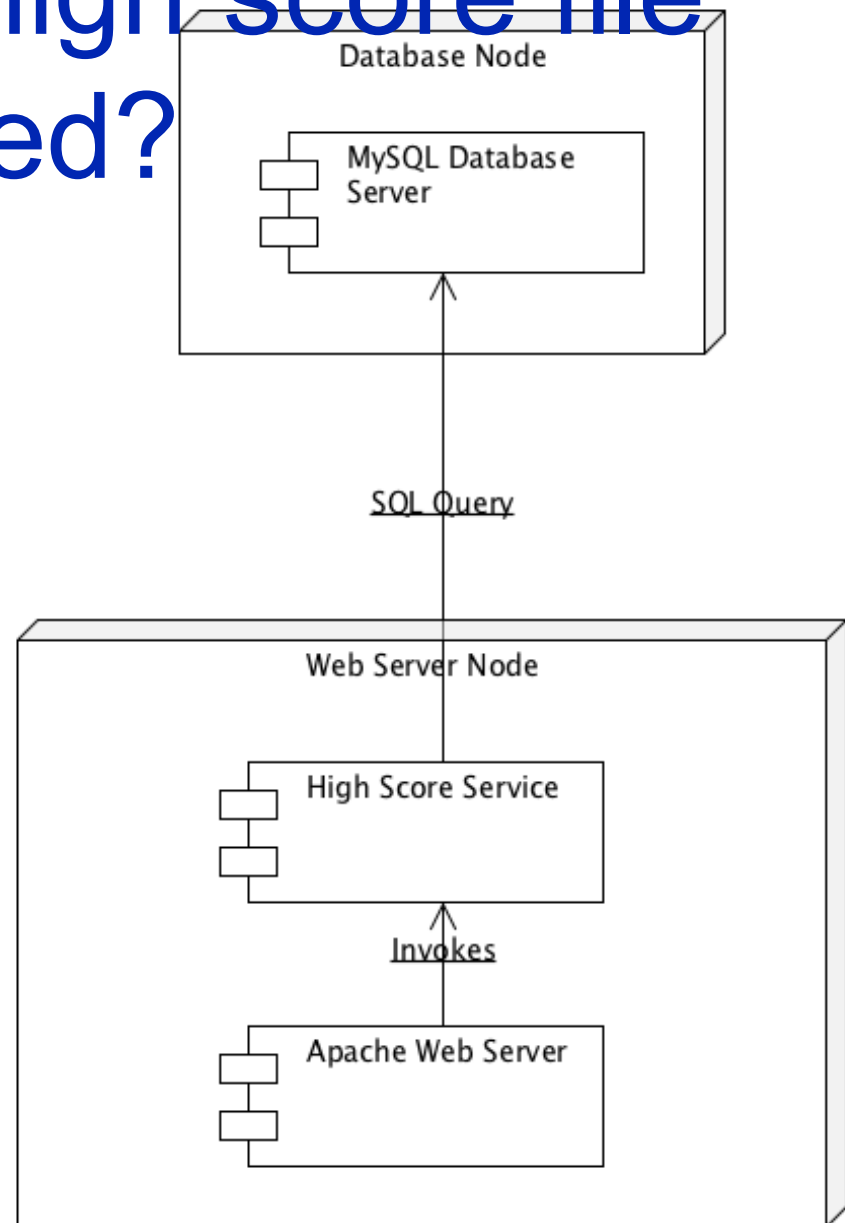
– Code reuse

■ Con:

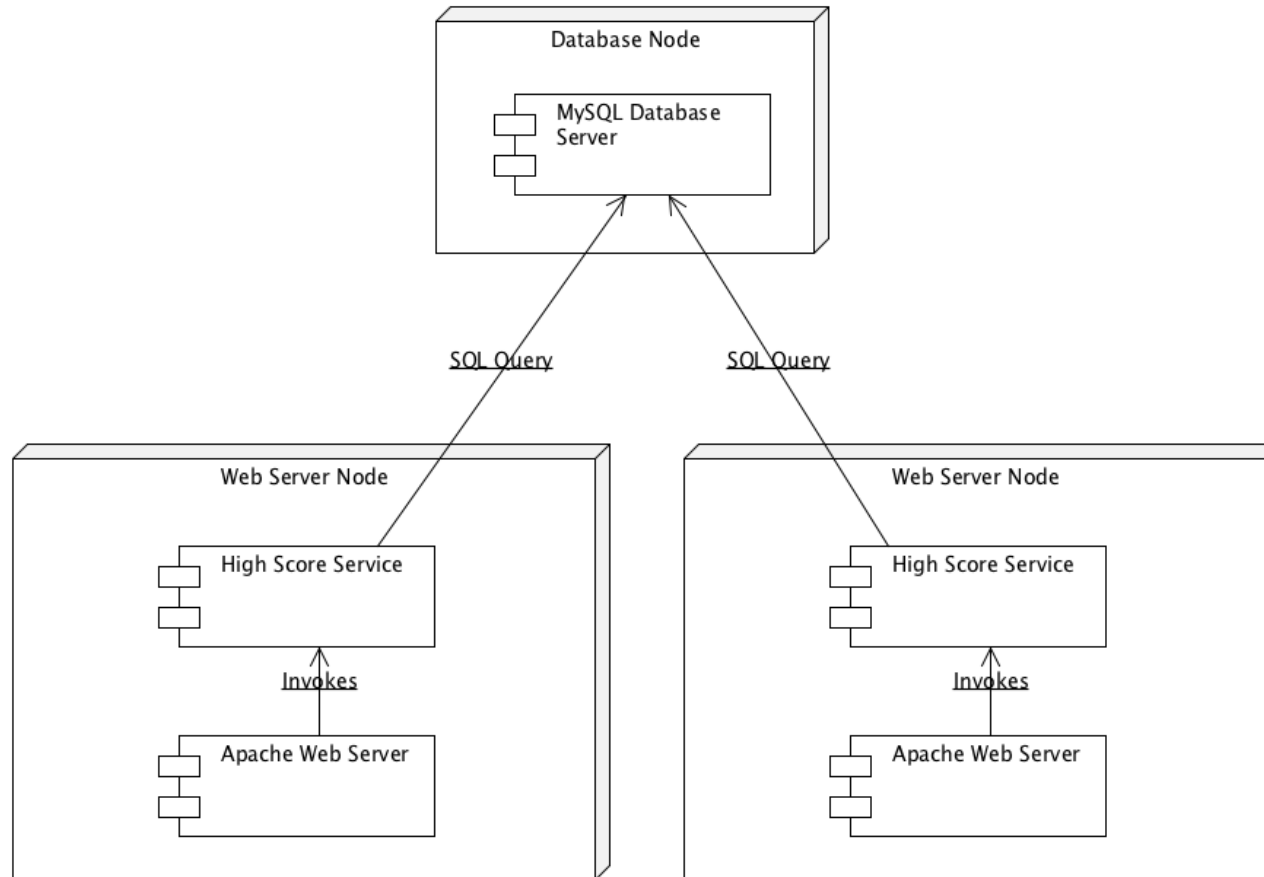
– Scalability

– Code Complexity

– Cost



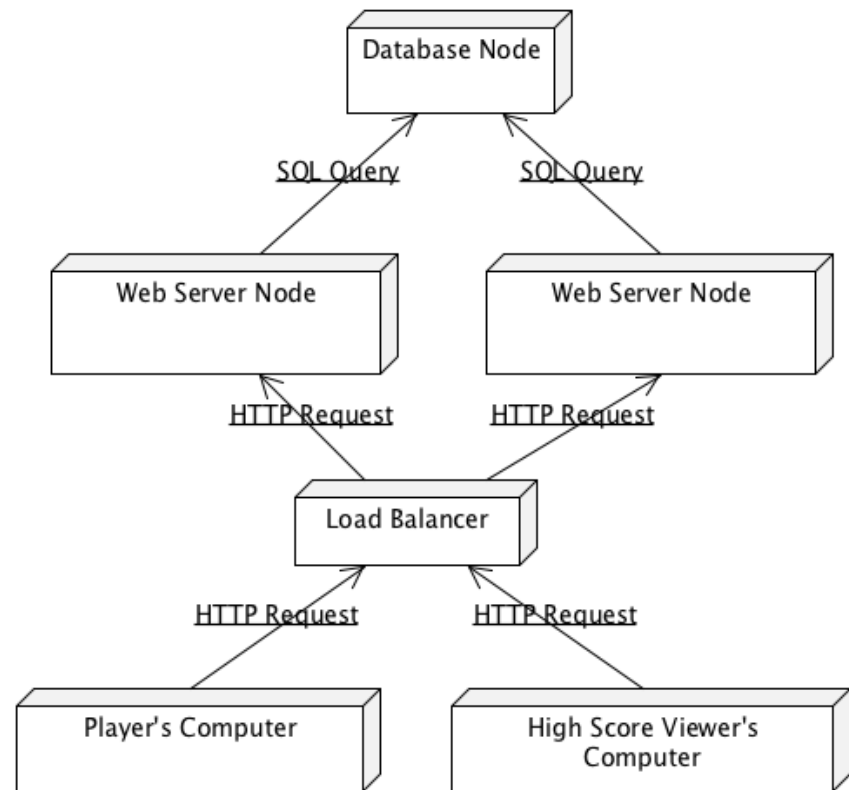
Availability, Scalability



- Can have redundant web servers

Final solution

- Load balancer forwards requests to one of a pool of web servers
- **Availability** - if one web server fails, another can take its place
- **Scalability** - arbitrary since always possible to add more web servers to pool



Similar Architectures

- Although each software system is unique, systems in the same application domain often have similar architectures that reflect the fundamental concepts of the domain

Question of the day:

What is your favourite gaming device?

Your answer

Submit

Leaderboard

Name	Count
PC	23
XBOX 360	3
N64	3
ps3	2
Gameboy Advance	2
PS4	2
PSP	1
PSvita	1
Nintendo SP	1
chess board	1

Trade-offs

- Development, deployment time
- Reuse (existing database versus custom file format)
- Scalability
- Availability
- ...important to know requirements to help make best choice
- ...architectural thinking can help expose requirements

Trade-offs

■ Performance

- Localize critical operations within a small number of components on the same computer vs. distributing them across the network

■ Availability

- Include redundant components so that it is possible to replace and update components without stopping the system