

Albion Online

Software Architecture of an MMO

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Who am I?

- David Salz
- 15 years in the industry
- CTO, Co-Founder of Sandbox Interactive
 - 35 people
 - based in Berlin
 - we only do Albion Online!



In this talk:

- What is Albion Online?
- Middleware + Design Decisions
- Server Architecture
- How we use Unity (and how not)



NOGARE
56332 / 62417
318 / 318



RIKO
12087 / 18787
128 / 237



JAYFIGU
TRINITY

26,000

100



SULFUR
[00]INSANE

ARIANE
[00]FACEPUNCH

RAGE MIR
[00]SCIOATAEL

GRODAR
[00]SCIOATAEL

SAL KHAR
[00]INSANE

DEARWELL
[00]INSANE

SNUFFO
[00]FACEPUNCH

JONES
[RS]HAMMER AND SICKLE

TORVIC
[RS]HAMMER AND SICKLE

WARSMOKE
[00]FACEPUNCH

EVESHIN
[00]INSANE

STORMSHOOTER
[00]INSANE

ADEN PLAYS
[00]FACEPUNCH

ONEMEAN GREEN BEAN
[00]FACEPUNCH

EXODUS
[RS]HAMMER AND SICKLE

TOWNSY
[00]HORSE RIDERS

WARD
[RS]KAL WAS HAM

ZULKIR
[00]SCIOATAEL

XSIDER
[00]INSANE

ISTVAN
[00]SCIOATAEL

MIRK
[00]INSANE

GRAY
[RS]HAMMER AND SICKLE

PANCAEMERAR
[RS]HAMMER AND SICKLE

GRAY
[RS]HAMMER AND SICKLE

NRG
[RS]HAMMER AND SICKLE

GURGO
[00]FORSAKEN

KSARDAS
[00]INSANE

TIGER
[00]SCIOATAEL

MIRK
[00]INSANE

STVAN
[00]SCIOATAEL

SCOOTER
[RS]HAMMER AND SICKLE

NAZARIN
[RS]HAMMER AND SICKLE

BEARFAST
[RS]HAMMER AND SICKLE

Novice Adventure 0 / 1
You must craft 7 of 7 Beginner's Pickaxe

DESTINY BOARD

FPS: 29
16:41 (UTC)

BEARFAST

Albion Online



- Sandbox MMORPG
- Cross-Platform (Windows/OSX/Linux/Android/iOS)
- One World (no „Shards“ or „Servers“, not even for different platforms)
- Player-Driven Economy (everything is player-crafted)
- No Character Classes („you are what you wear“)
- Strong focus on PvP + Guilds
- Hardcore („Full Loot“ in PVP Areas)
- Pay-to-play model

- 4 years in the making
- Currently in Closed Beta w/ 80.000+ „founding“ players
- „Release“ in Q4/2016

Albion Online

- The initial pitch (2012)
 - Play-crafted equipment, buildings
 - One World (like EVE Online)
 - Guild vs. Guild Territorial conquest
 - Top-Down perspective + Combat (like League of Legends)

- Simple graphics, „can even be 2D“
- PVP focus, no PVE, no Mobs, no Dungeons
- Release in 2013 😊

Middleware Selection

- Engine Selection
 - Unity made sense – inexpensive, accessible
 - Cross-Platform was a „target of opportunity“
- Database Selection
 - One world → need a very scalable database, NoSQL
 - Cassandra sounded suitable
 - still use SQL for query-heavy problems
- Networking Middleware
 - Photon!
 - can use C# on server (like in Unity!)
 - works with all Unity platforms



Apache Cassandra

- NoSQL Database
 - Originally developed by Facebook
 - Open Source (Apache-License)
 - Java
-
- Concept: everything is a hash table
 - in-memory (as much as possible)
 - optimized for high throughput
 - scales horizontally (just add servers)
 - redundant (no single point of failure)
 - CQL: SQL-like language (w/ massive restrictions – it's NoSQL)



Apache Cassandra

- funny story from public Alpha Test...
- all buildings disappeared during lunch break
- found this in Cassandra Changelog:

```
* Fix possible loss of 2ndary index entries during  
compaction (CASSANDRA-6517)
```

- W(
- lesson learned: careful with cutting edge technology



Apache Cassandra

- Cassandra uses timestamps to resolve conflicts between database nodes
- also requires exact time sync between servers
- i.e. ntp service



Hosting

- Hosted with Softlayer
 - good, but quite expensive
 - bare-metal machines only
 - currently: 8x 10-Core Intel Xeon, 32 GB RAM
 - Should be able to handle ~15k CCUs
- Originally:
 - Hosted across 2 Datacenters (better ping for players)
 - Worked, but bad idea! (inter-server disconnects, latency)

The logo for SoftLayer, an IBM company. The word "SOFTLAYER" is in a bold, black, sans-serif font. The letter "E" is stylized with three horizontal red bars. Below it, "an IBM Company" is written in a smaller, black, sans-serif font.

SOFTLAYER[®]
an IBM Company

Networking

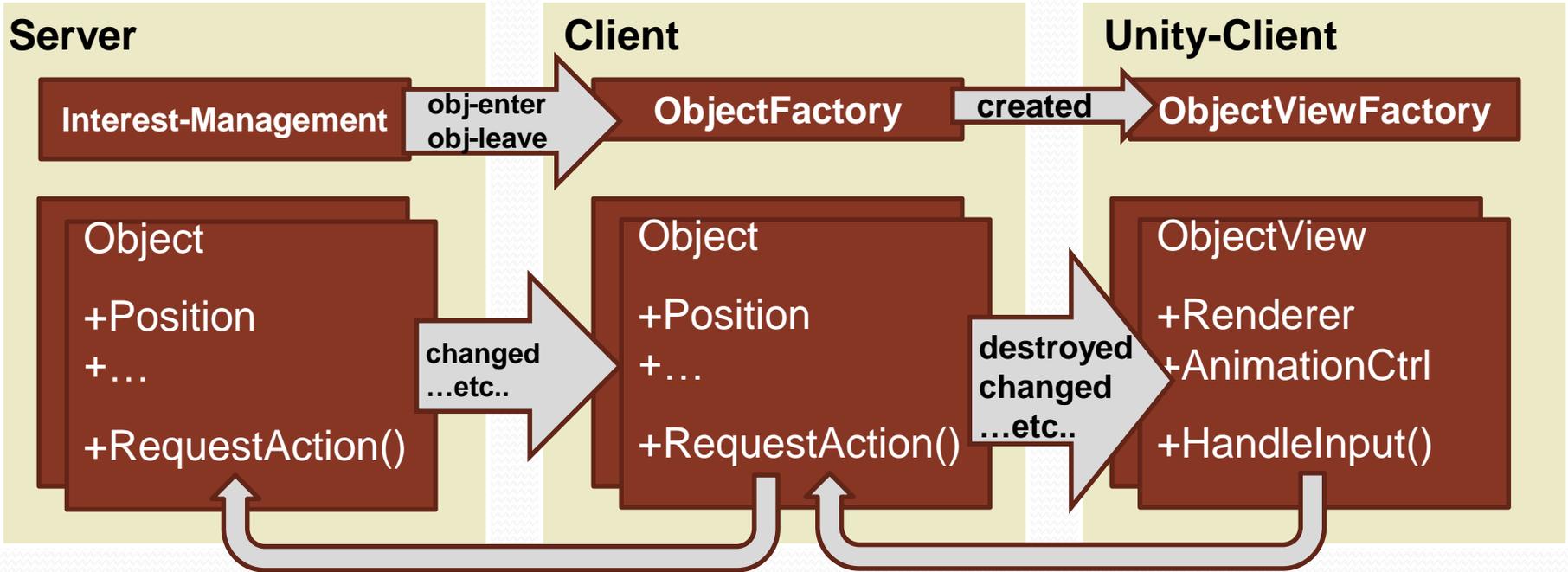
- Photon
 - UDP-based protocol (reliable/unreliable as needed)
 - TCP for chat, inter-server communication
 - use only basic message functionality (no Photon frameworks)
 - mostly simple messages, in rare cases JSON content
 - Had to implement secure TCP-reconnect abilities
- Chat
 - Tried IRC...
 - ... was only trouble (difficult to secure, customize)
 - Implemented own system in a couple of days



Consequences

- Server needs to work without Unity
- Ideally, client works without Unity, too!
 - think: tools, stress-test-bots!
- Use Unity only as rendering front-end
- cannot rely on Unity features for basic functions!
 - levels / game objects
 - collision
 - pathfinding

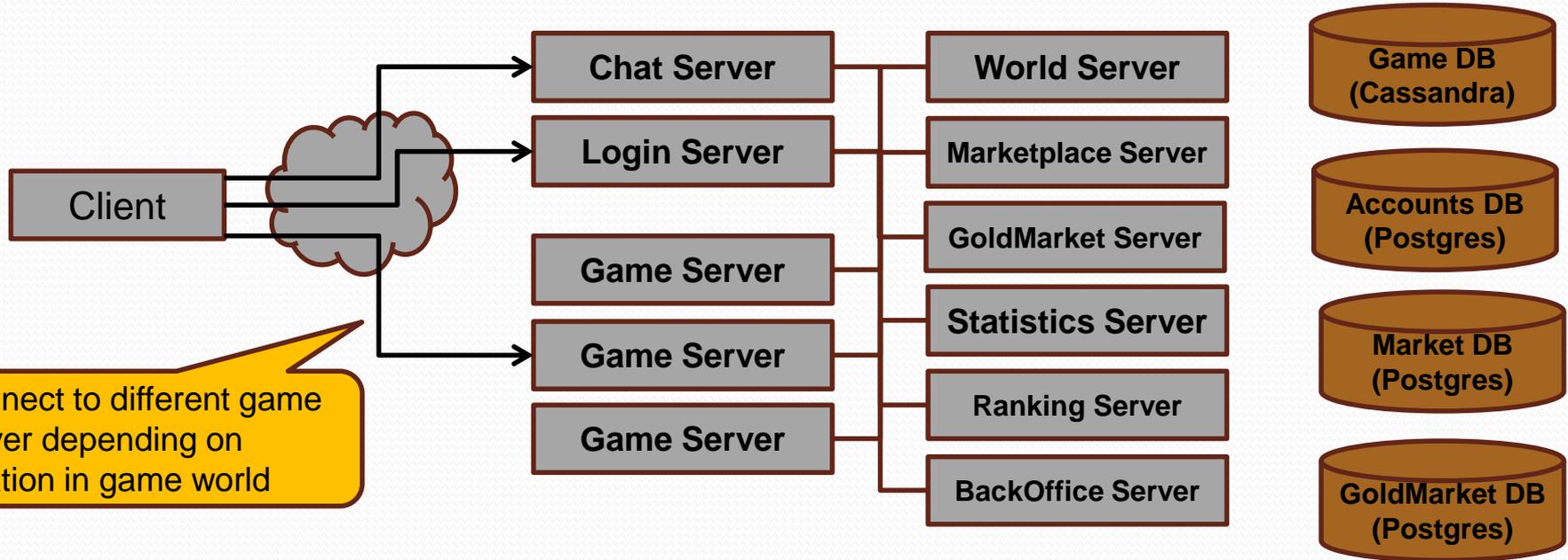
Separation





Server

Server Farm



Connect to different game server depending on location in game world

MADDAVE
 1317 / 1317
 144 / 144

CURRENCY EXCHANGE

TRADE FOR GOLD

SELL GOLD

Enter amount:

Enter amount:

n/a

n/a

BUY ORDER

SELL ORDER

AVERAGE: 928



366 12,000

- [Global] **Aristodikos**: gf
- [Global] **Besna**: NEW SK/ CZ GUILD DE PLAYERS PM.
- [Global] **Mercurytea**: What armor is good
- [Global] **Gaa**: GUILD BR ABUZZIVOS R PVP / GVG TS3 OBRIGATORIO PM ME
- [System] SIERR has bested Vaa in honor
- [Global] **ThECKthee**: Looking For T6
- [Global] **Supertazz**: wts 6.6 heavy helm 2
- [Global] **Hashkush**: Healer 4 2 LFG
- [Global] **Tues**: Looking to buy cheap food.
- [Global] **RavenlOrd**: what does the pickaxe dude does it with the hamemr

HOME

BUY/SELL

ORDERS

Rabbit Hide

Ping: 117
 17:52 (UTC)
 16.67 ms

QUEENSMARKET

6%

Q
W
E
R
D
F

Friendly: 27

MADDAVE
 1317 / 1317
 144 / 144

TURN

[Global] **Igdrazil**: WTB direbear /w me wit
 [System] Vaa has challenged giannispert
 [Trade] **Sznur**: WTB CLAWS 8.3 ---PM
 [System] You are no longer invisible
 [Global] **Theckthee**: Looking For T6
 [System] Vaa has bested giannisperti in t
 [Recruit] **Rexord**: jajaja
 [Recruit] **Rexord**: recluto jugadores active
 [Recruit] **Ebabushka**: >>> Вступай в "Th
 запрос в друзья >>> /friend Ebabushka
 [System] Vaa has challenged SIERR to a
 [System] Vaa has bested SIERR in honorab
 [Global] **Theckthee**: Looking For T6 Fa

366

MARKET OFFERS

SEARCH... X REFRESH C

Consumable Tier All All Spells

Item	Name	#	Price	Total	Time	Info
	POTION	3	500	1500	25 D 22 H	BUY
	MINOR REVIVE FLASK	55	500	2750	2 D 22 H	BUY
	MINOR RESISTANCE POTION	45	600	2700	25 D 4 H	BUY
	MINOR RESISTANCE POTION	137	600	8220	3 D 1 H	BUY
	MINOR CHILLING FLASK	50	700	3500	16 D 23 H	BUY
	MINOR RESISTANCE POTION	135	700	9450	24 D 5 H	BUY

BUY SELL ORDER COMPLETE

6%

Friendly: 31

16.67 ms

QUEENSMARKET

Game Servers / World Server

- game world split into unique „clusters“ of $\sim 1 \text{ km}^2$
 - current world: ~ 600 , next world: $\times 2$
 - distributed among game servers
 - player changes servers when travelling
 - handoff done through database (even on same server)
- Instances are dynamically created
 - world server coordinates this
- World Server
 - responsible for everything „global“
 - guilds, parties, coordination of guild battles etc.



ALBION

Kingsmarket

Redlake

Winterknot

Low Anchor

Beacon Hill

Silvago Band

Heartspring

Sapwood

Loamholw

Tangleford

Martensholm

Jawbone Stair

Starlingsroost

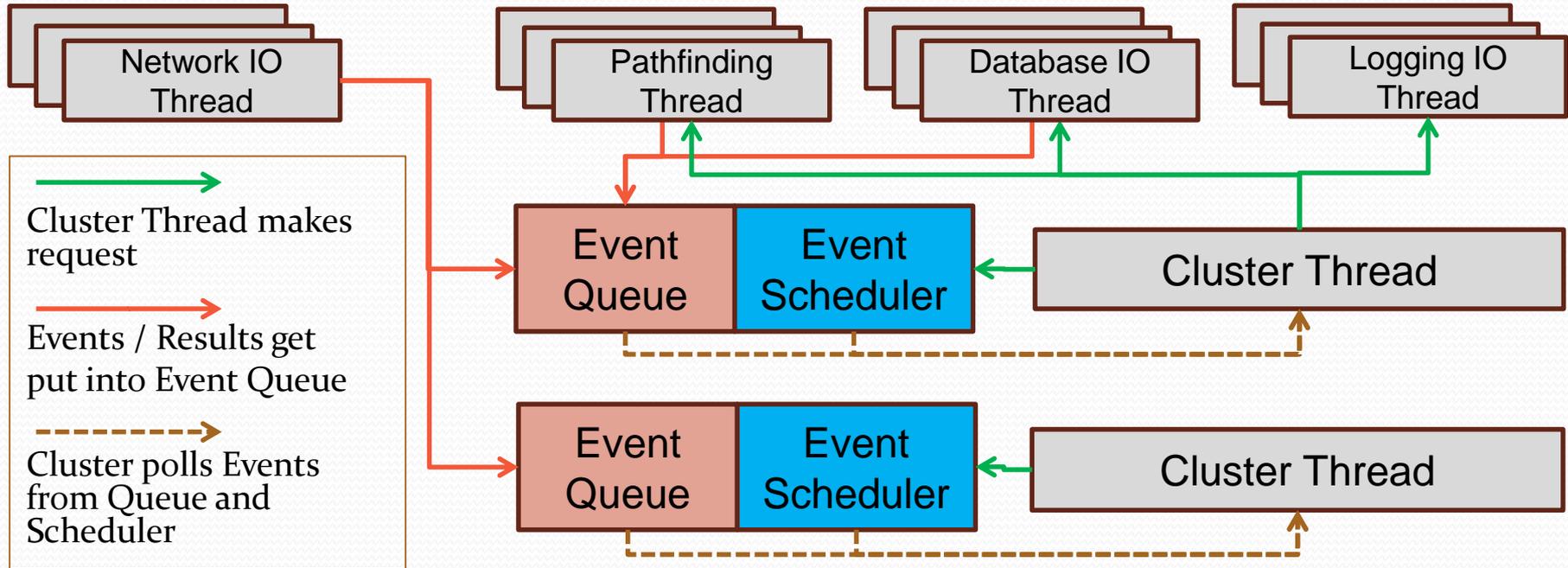
Offshore Islands

RESET CAMERA

- NONE
- GUILD
- ALL



Threading Model (Game Server)



Threading Model

- Game logic for one game area („cluster“) is single-threaded
 - Interactions between game objects too complicated otherwise; would require lots of locking
 - Objects „sleep“ whenever possible (especially mobs)
- All IO (Network, Database, Logging) and other „heavy lifting“ (pathfinding) offloaded to worker threads
- Instances (Player islands, instanced dungeons) are combined in thread pools
- Other servers (chat, rankings) are completely multi-threaded

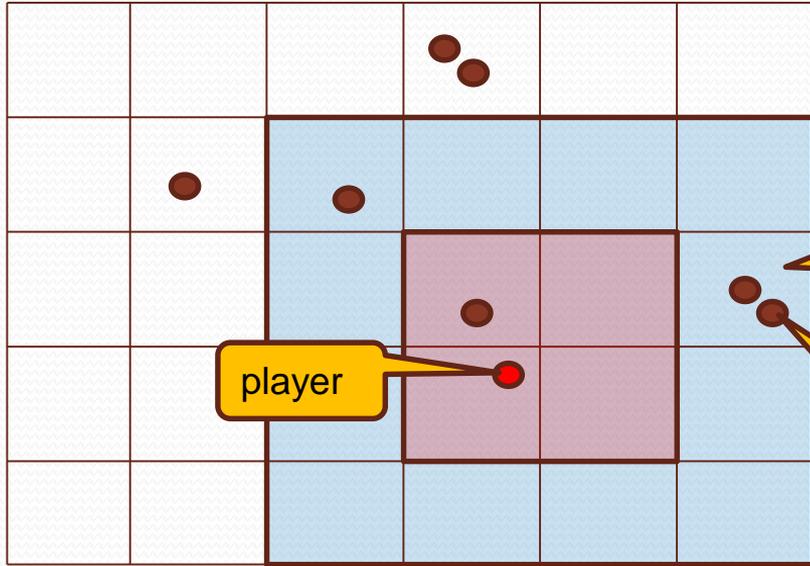
There is no spoon!

- **There is no game loop!**
 - i.e. no Update() or Tick() functions for game objects
 - Gameplay thread processes events in order of arrival
- Events are:
 - Network input, i.e. player commands
 - Timers (Event Scheduler)
 - If an object needs a tick (Mobs do), it creates a recurring timer
 - Results from DB queries (asynchronous)
 - Results from pathfinding
 - ...

Interest Management

- Players should only „see“ (network-wise) what's on their screen
 - important to reduce traffic...
 - ... and prevent cheating!
- Find objects a player can „see“ (and update when things move)
- Objects send messages to all players that „see“ them
- Needs to be efficient!
 - ~500 mobs / cluster
 - > 10.000 interactive objects (mostly trees)
 - up to 300 players

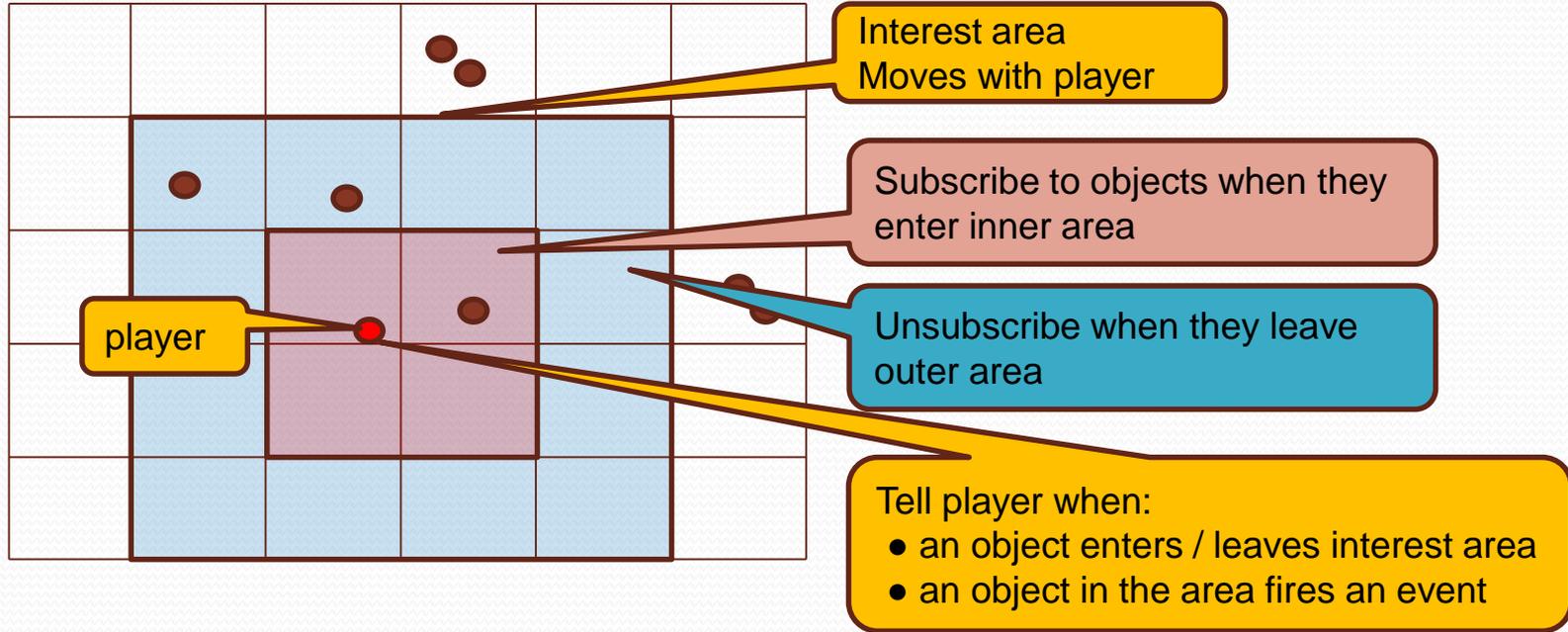
Interest Management



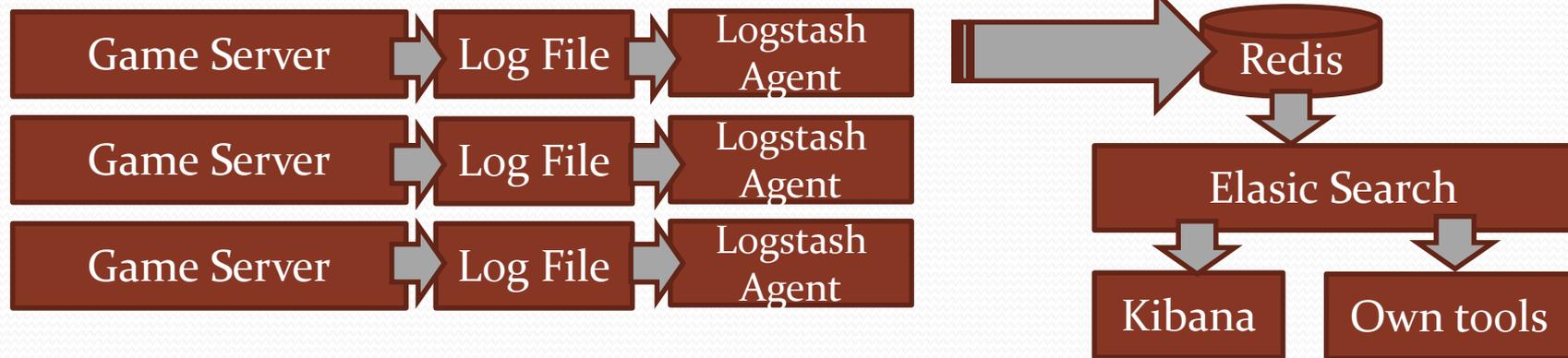
- cells contain list of objects inside
- list is updated by object itself when moving
- cells fire events:
 - ObjectEnteredCell()
 - ObjectLeftCell()

- objects also fire events
 - ObjectMoved()
 - ObjectDestroyed()
 - EventFired()

Interest Management



Logging infrastructure

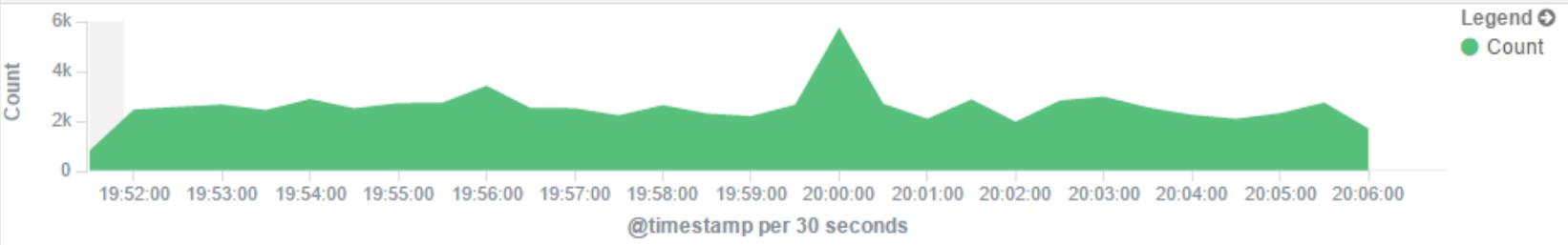


- track errors, generate statistics
- classic ELK stack (Elastic Search, Logstash, Kibana)
- kind of unreliable for us
- Also use Cassandra Counters a lot!

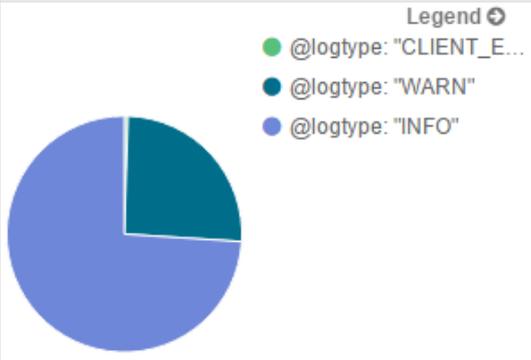
* Q



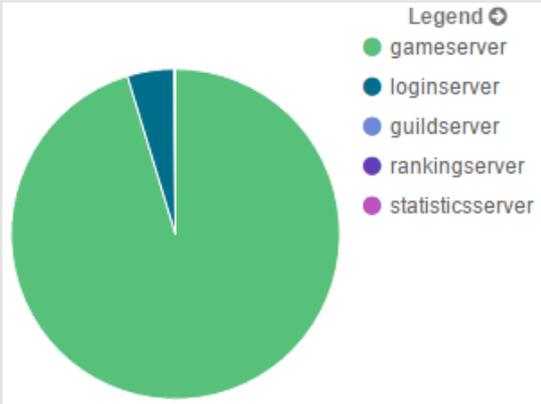
TIMESTAMP



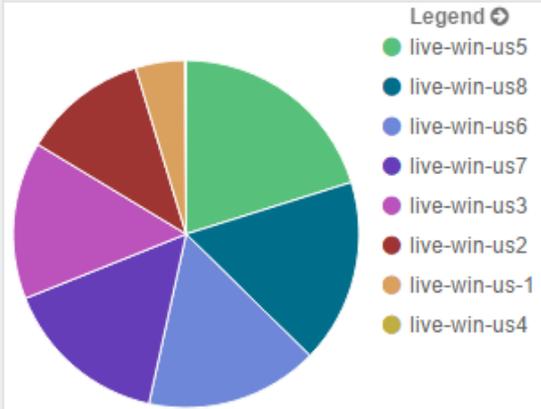
LOG_TYPE (log level)



TYPE



SOURCE



Kibana

Time ▾	@source	@type	@logtype	@message
▶ April 17th 2016, 20:06:23.181	live-win-us6	gameserver	INFO	Building: FinishInitFromDb
▶ April 17th 2016, 20:06:23.177	live-win-us6	gameserver	INFO	Building: FinishInitFromDb
▶ April 17th 2016, 20:06:23.106	live-win-us6	gameserver	INFO	Building: FinishInitFromExtern
▶ April 17th 2016, 20:06:23.075	live-win-us7	gameserver	GUILD_TAX_PAID	Guild Tax Payed
▶ April 17th 2016, 20:06:22.684	live-win-us7	gameserver	PLAYER_KILLS_MOB	Player kills mob
▶ April 17th 2016, 20:06:22.532	live-win-us7	gameserver	PLAYER_JOINCLUSTER	Character Joins Cluster
▶ April 17th 2016, 20:06:22.269	live-win-us5	gameserver	PLAYER_JOINCLUSTER	Character Joins Cluster
▶ April 17th 2016, 20:06:22.252	live-win-us6	gameserver	GUILD_TAX_PAID	Guild Tax Payed
▶ April 17th 2016, 20:06:22.246	live-win-us6	gameserver	GUILD_TAX_PAID	Guild Tax Payed
▶ April 17th 2016, 20:06:22.242	live-win-us6	gameserver	GUILD_TAX_PAID	Guild Tax Payed
▶ April 17th 2016, 20:06:22.085	live-win-us2	gameserver	ITEM_SALVAGED	Item salvaged
▶ April 17th 2016, 20:06:22.085	live-win-us2	gameserver	ITEM_SALVAGED	Item salvaged
▶ April 17th 2016, 20:06:22.035	live-win-us7	gameserver	PLAYER_JOINCLUSTER	Character Joins Cluster
▶ April 17th 2016, 20:06:22.032	live-win-us5	gameserver	CLUSTER_TAX_PAID	Cluster Tax Payed
▶ April 17th 2016, 20:06:22.006	live-win-us5	gameserver	ITEM_TRASHED_BY_PLAYERDEATH	item was trashed



Client

Level Design

- Zones built in Unity (Unity scenes)
- Consist only of Unity prefabs („tiles“)
 - ~ 30.000 / level
- Collision is painted for each tile
- Level gets exported to XML format
 - level loading independent from Unity (for server, client)
 - in Unity: instantiate prefabs
 - actually faster and more controllable!



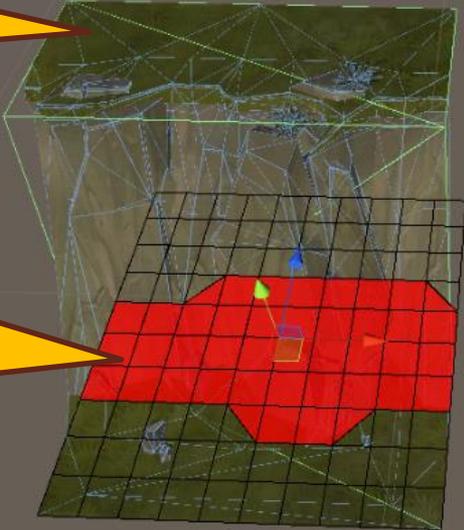
Level consists of „tiles“ (Unity prefabs)

Object (non-ground) tile

Tile has 3d collider (for mouse picking + ground height definition)

2d collision is painted per tile (blocks movement / blocks shots / blocks placement etc.)

Ground tile



MADDAVE
1269 / 1269
144 / 144

26%

Gameplay icons: sword, shield, hammer, pickaxe, axe, bow, crossbow, staff, scroll, book, key, etc.

Collision of all tiles is blended together

Beginner Skinner
Gather 0/8 Rabbit Hide

FPS: 60
Ping: 119
18:33 (UTC)
16.40 ms

Mini-map and game title: **GRAVESTOW**

Unity Features we (don't) use...

- Do:
 - Editor: cool and customizable (but often too slow)
 - Sound: yes, but want to switch to Wwise or FMOD
 - Mechanim: now, after a long struggle (memory usage!)
- Not or very limited:
 - Scenes – only to load GUIs (but not levels)
 - Collision/Physics – only raycasts @ ground
 - GUI – use modified NGUI instead
 - Network – use Photon instead
 - Baked light – scenes way too large

Unity troubles

- funny story...
- 64 bit editor came just in time for us
- 32bit editor was no longer able to build our project
 - used > 2.7 GB RAM during build with is the max for win32 processes
 - headless was still working!

Character rendering

- Character + Equipment gets baked into one mesh
 - want 1 draw call / character (well, + special effects)
 - real-time
- parts of character mesh hidden depending on equipment
- Only one material for character + all equipment items
- Only one texture; also use vertex colors, specular
- Limit number of characters drawn (esp. on mobile)





Debugging

- Can run and debug complete environment locally on developers machine
- Human-readable network log file
- Server and client errors caught in log files
 - Searchable, with context
- Public staging system
 - Community can preview patches, updates
 - QA freelancers from the community
 - Frequently mirror live database to public staging system
- Can download live database to developer machines

Cheaters

- people started using memory debuggers and packet sniffers pretty much on day 1
 - Absolute server authority is king!
 - Includes what information you reveal to client!
- only one serious cheat ever found
 - mistake on our side –“believed“ data from client without proper check
- Gold Sellers / Account Stealing
 - adding email verification greatly improved this

Cheaters

- .NET code very accessible for analysis
 - camera hacks (minor problem because of interest management)
 - found internal tools , cheats in code (not working on live)
- extracted data from client
 - maps, player rankings
 - cool community projects!
- Users built bots directly into client ☹
 - Difficult to prevent
- Obfuscation – helps, but not much
- We are doing more integrity checks now!
- Future: Unity IL2CPP ?

226.50, 195.27

DANIBA

1646 / 1646

162 / 162

56%

Harverst Bot

Harverst

Tier	Resource Type
4	<input type="checkbox"/> Harverst Wood
4	<input type="checkbox"/> Harverst Ore
4	<input checked="" type="checkbox"/> Harverst Fiber
4	<input type="checkbox"/> Harverst Hide
4.1	<input type="checkbox"/> Harverst Stone
4.1	<input type="checkbox"/> Farm Fame

Combat Routine

Slot	Spell Type
0,1,2	Agressive Spell
	Interruptable Spell
4	In Combat Heal / Protect / Buff
3	Out Of Combate Heal
5	Movement Speed Buff

Avoid Mobs

Current Cluster Configuration

Cluster Name: cluster (A-PVP-0003)
 Is Configuration OK?: True
 Gate To City (position near the gate to city)
 400.00,52.00

Harverst Cluster Configuration

Cluster Name: cluster (A-PVP-0003)
 Is Configuration OK?: True
 Cluster to Farm (position anywhere inside the map to farm)
 cluster (A-PVP-0003)
 Exit To Harverst (position at City, Exit Way: City -> Harverst)
 299.78,340.71

 Exit To City (position at Harverst, Exit Way: Harverst -> City)
 400.00,52.00

Misc

Action: No Resources Near... Going to check T4: HIDE @ 202.99,223
 Pathfinder CalcLength: 78.16064

AOAssist.com

[Global] Jamesbondage: please to a thud for bows

[Global] Sheepsh: xbow dps ilg 15 dg

[Global] Wix: anyone know ethe 15 dungeons are?

[Global] Jamesbondage: lol @ drunky

[Global] Wickvape: 3rd for bows

[Global] Gun: WTB explorers house

[Global] Drunky: lol

[Global] Ypsinc: is scripting macros allowed?

[Global] Jowlem: do mobs in dungeon spawn the same rate as mobs outside the dungeon?

[Global] Xxoks: GM. HAVE TO LOW THE TP PRICE ARE TO HIGH

[Global] Nexou: it's " fuk your life and play 24/7" @drunky

[Global] Muzabi: wtb 6.3 double blade staff

Grandmast... 555.882 / 648.000

Gain 648.000 fame in any way

FPS: 60

Ping: 188

03:49 (UTC)

Future Challenges

- Growing player base...
- Want a more diverse world
 - exploring more modular level design right now
- Keeping iOS / Android version in sync with server
 - ability to download data files without patching
 - clients support old server / server supports old clients

Thank you!

Questions / Comments?

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<https://albiononline.com/en/jobs>

