



MAKING "BIG DATA" WORK FOR HALO: A CASE STUDY

TOM MATHEWS
SR SOFTWARE ENGINEER
343 INDUSTRIES

GAME DEVELOPERS CONFERENCE March 14–18, 2016 · Expo: March 16–18, 2016 #GDC16



GDC



Tom Mathews

Software Sr. Software EngineerEngineer

Microsoft, 343 Industries

ALL ACCESS - SPEAKER

SPEAKER

FUN NUMBERS FIRST: LAUNCH RESULTS

- Events/Second
 - Averaged 701k/s (2.5B/hr)
 - Peak 831k/s
- Bad Events
 - Composer event 446k/s (peak second)
 - Post Game Update 90k/s (peak second)

OVERVIEW

- Where we started
- Goals
- Implementation
- Results

WHERE WE STARTED: LOG_EVENT MACRO

```
LOG_MESSAGE(EC_Users, "PlatformEventManager - User Engaged! ActiveUserIndex: %d %I64u", userIndex, xuid);
```

- Legacy 'DataMine' system
- Good:
 - Easy to use
- Bad:
 - No strong typing
 - Unenforced parameter naming
 - Transmits zipped strings at end of match
 - Slow - *not compiled in Release*

WHERE WE STARTED: BINARY LOG

- Binary Log Format
- Good
 - More compressed
 - Easy dev use
- Bad
 - No shared schema: Nightmare for services
 - Requires source to understand
 - Transmits at end of match

```
// this is the player-chosen loadout definition
// blf: PlayerLoadoutSlot
// blf: PlayerProfileInterface
struct s_custom_loadout_slot
{
    // these are indices into the appropriate global multiplayer object arrays. the
    // string id for the object referenced needs to be derived from this.
    long primary_weapon_index;
    long secondary_weapon_index;
    byte primary_weapon_variant_index;
    byte secondary_weapon_variant_index;
    byte pad[2];
    long equipment_index;
    long grenade_index;

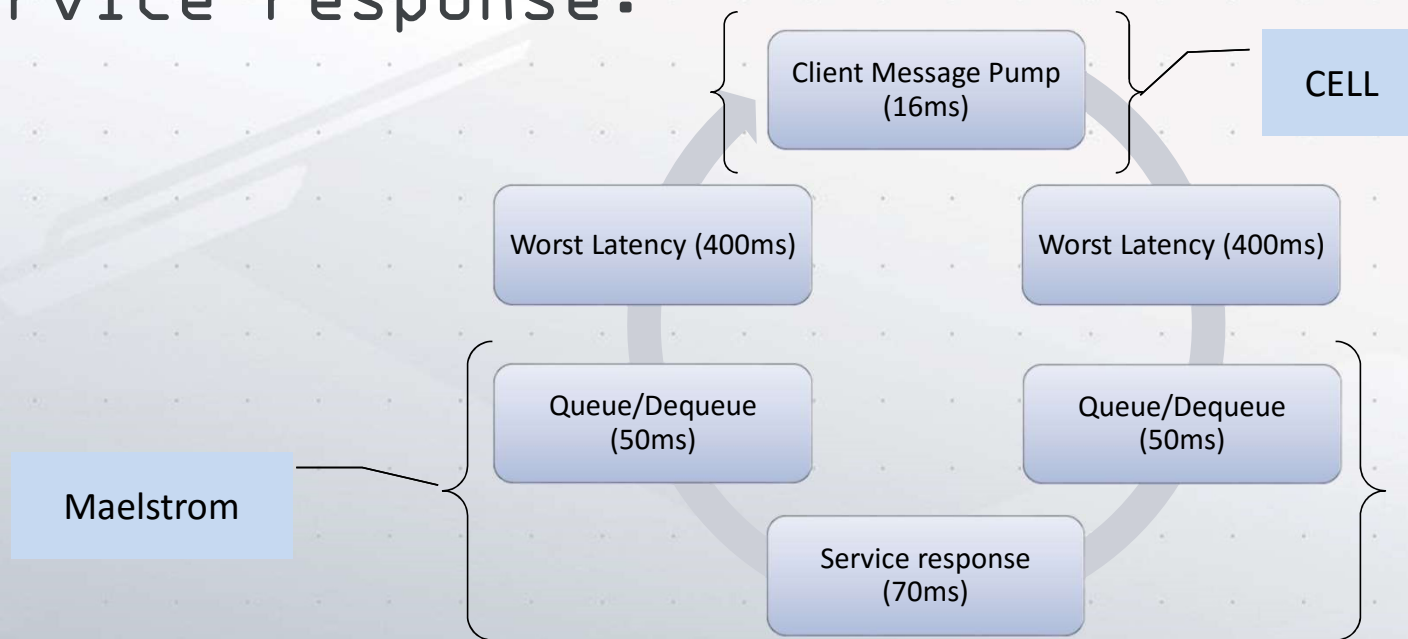
    void initializeCustomLoadoutSlot(int slotIndex);
};
COMPILE_CHECK_SIZE(s_custom_loadout_slot, 20);
```

"GAMING INTELLIGENCE"

- The methods and technologies that gather, store, report, and analyze game data to help people to understand and improve the game.

AIMING HIGHER

Reliably transmit telemetry in real-time, enabling subsecond service response.



AIMING HIGHER

1. Sequential
2. Contextual
3. Compatible

AIMING HIGHER

1. Sequential
2. Contextual
3. Compatible

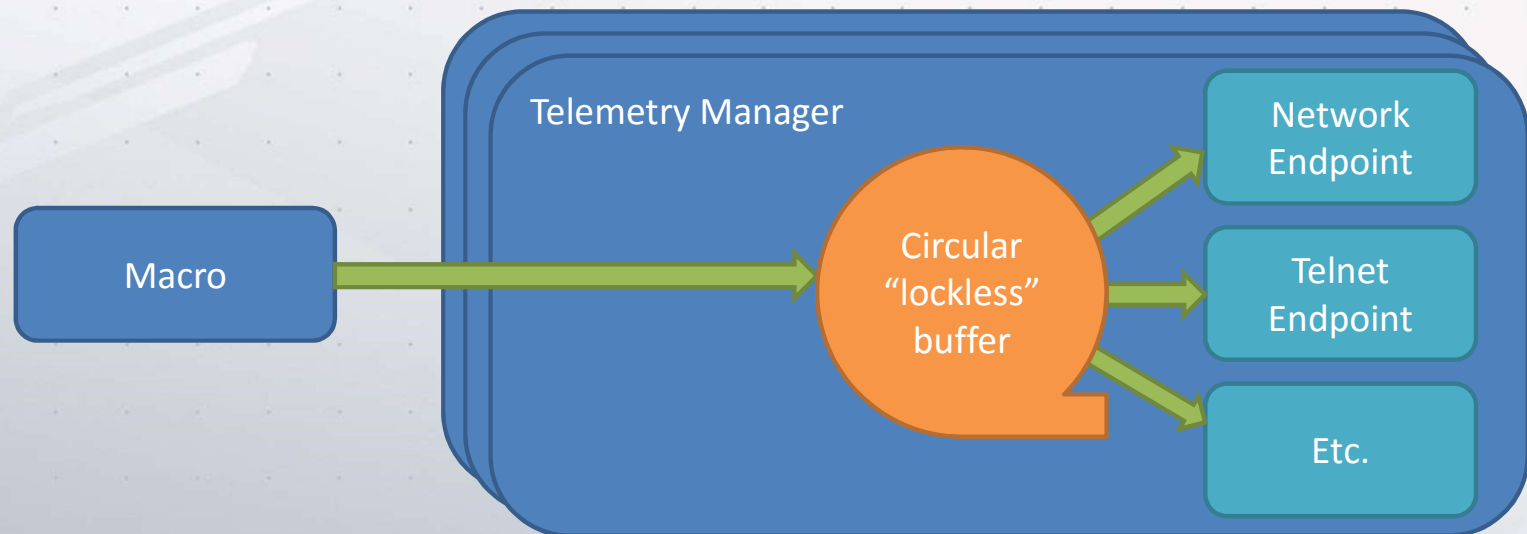
AIMING HIGHER

1. Sequential
2. Contextual
3. Compatible

AIMING HIGHER: CELL AND MAELSTROM

Common Event Logging Library (CELL)

- Telemetry Manager
- C++ Macro/Function (15-30 μ s)



CELL AND MAELSTROM

Common Event Logging Library (CELL)

- Telemetry Manager
- C++ Macro/Function (15-30 μ s)
- Build-time preprocessor
 - Global Schemastore
 - “Ever Growing Schema”: Forwards & Backwards Compatible
 - BOND serialization (typical events ~120 bytes)

CELL AND MAELSTROM

Maelstrom

- Ingestion Service
- BOND wrappers
- Azure Event Hub

MAELSTROM CONSUMERS

- Common API for consuming event streams.
- Orleans (distributed virtual actors)
 - Stats
 - Storage
- Librarian (Session/Blob Indexer)
- Telemetry Event Viewer [TEV]

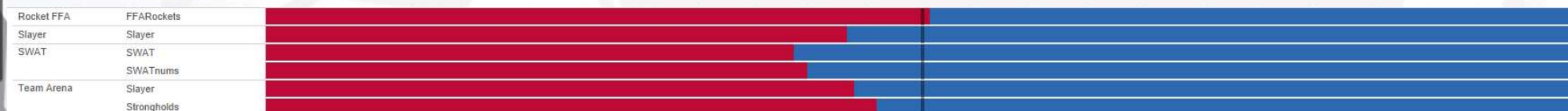
HADOOP / HIVE

- Hadoop/HIVE
 - Custom Java BOND SerDe reads raw BLOB, stores into ORC
 - Regular jobs run hourly for BI reports.
 - Ad-Hoc reports in HQL/Tableau/R

GOTCHAS

- Client implementation took time
- Statistics Event: Nonsequential
- Hibernation makes for very long sessions
- Stream Querying deferred to post-launch
- Schema Store caused problem during iteration

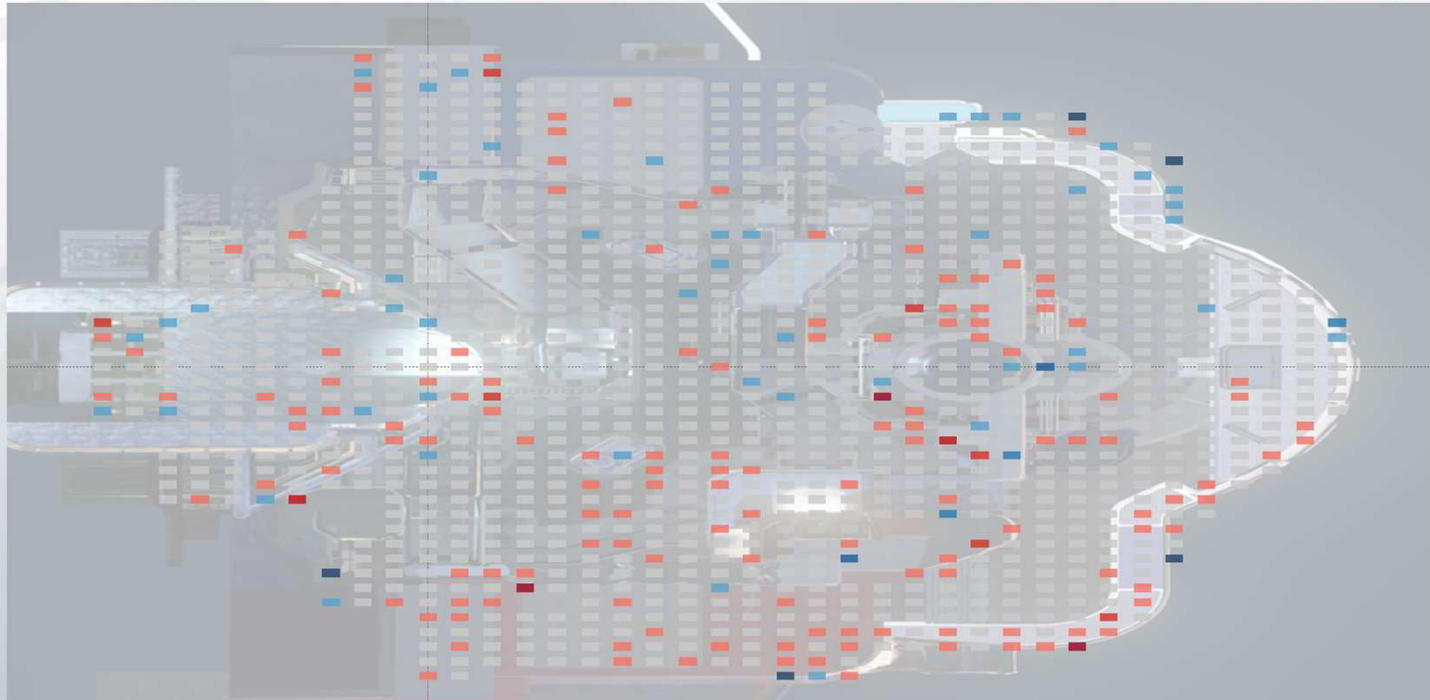
RESULTS: MAP BALANCE



Acropolis Remix	Rocket FFA	FFARockets	47.57%	54.55%	50.00%	56.84%	
	Slayer	Slayer	56.95%	55.00%	55.17%	55.40%	55.84%
	SWAT	SWAT	56.45%	60.92%	59.57%	60.29%	58.07%
		SWATnums	57.17%	60.36%	58.86%	57.97%	60.37%
	Team Arena	Slayer	58.17%	55.80%	55.34%	52.88%	53.01%
		Strongholds	53.88%	53.66%	51.58%	55.88%	53.82%

Playlistname	Gamevariantname	BlueTeamMMRDeltaBinned / Team Color																					
		-2 Blue	-1 Blue	-0.9 Blue	-0.8 Blue	-0.7 Blue	-0.6 Blue	-0.5 Blue	-0.4 Blue	-0.3 Blue	-0.2 Blue	-0.1 Blue	0 Blue	0.1 Blue	0.2 Blue	0.3 Blue	0.4 Blue	0.5 Blue	0.6 Blue	0.7 Blue	0.8 Blue	0.9 Blue	1 Blue
Rocket FFA	FFARockets				44.44%	36.36%	39.47%	44.44%	45.78%	44.44%	44.86%	49.82%	50.77%	51.27%	50.89%	43.97%	48.94%	58.82%	55.26%	44.44%			
Slayer	Slayer		4.76%	7.97%	6.57%	14.71%	18.05%	26.82%	29.46%	42.66%	45.84%	50.62%	55.62%	62.99%	66.35%	70.21%	77.89%	81.74%	90.79%	91.19%	92.42%	97.33%	97.30%
SWAT	SWAT			6.90%	21.43%	35.80%	35.83%	38.13%	35.90%	46.97%	51.01%	55.16%	59.19%	66.54%	69.40%	73.20%	81.55%	84.67%	88.97%	92.31%	94.92%	82.14%	
	SWATnums			17.86%	23.26%	18.48%	25.42%	37.43%	33.49%	45.71%	52.31%	54.81%	58.95%	63.28%	69.42%	70.00%	78.24%	83.33%	89.83%	87.84%	84.62%	83.72%	
Team Arena	Slayer			5.00%	10.59%	12.59%	15.47%	26.97%	28.36%	41.16%	45.19%	49.57%	55.20%	64.01%	65.28%	65.32%	83.09%	76.67%	91.01%	93.29%	96.77%	100.00%	
	Strongholds			13.16%	14.77%	13.68%	24.20%	31.98%	30.46%	43.81%	42.88%	47.32%	53.66%	59.48%	59.88%	60.04%	79.51%	77.22%	82.80%	86.81%	88.06%	97.26%	

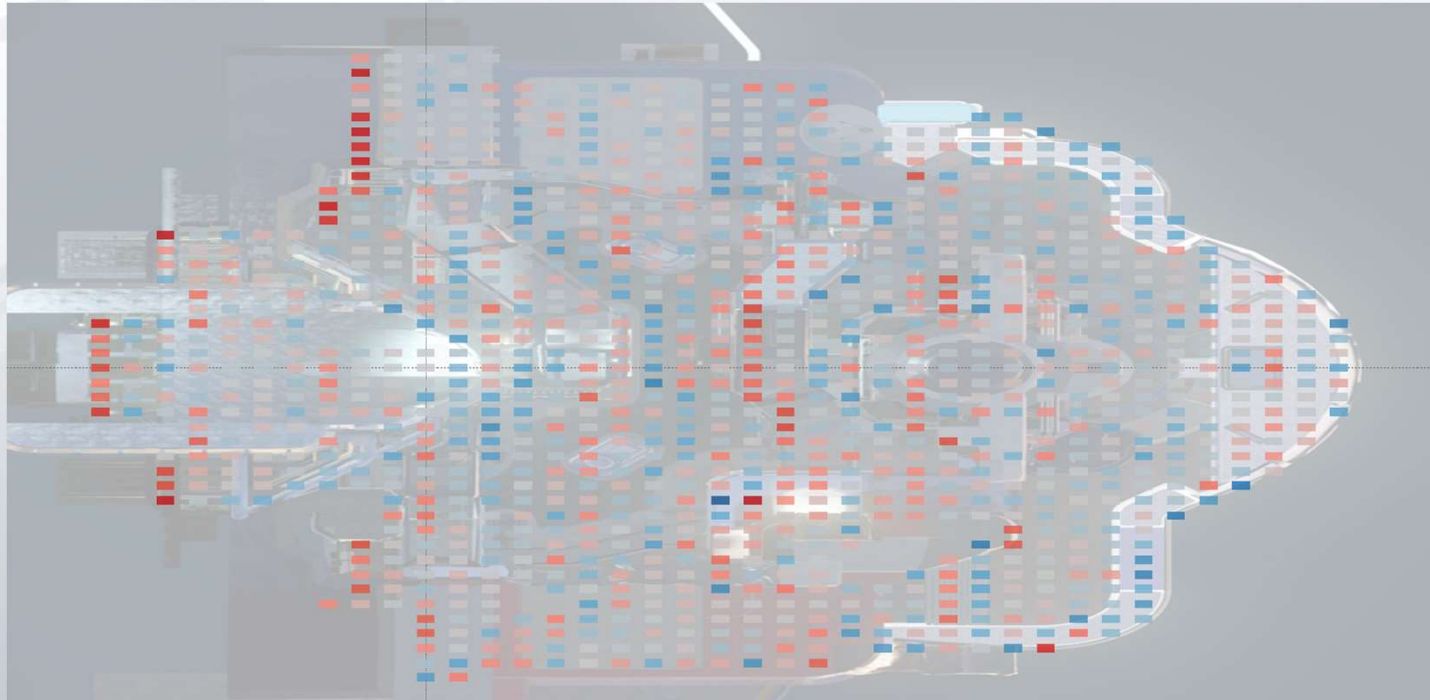
RESULTS: DEATHS

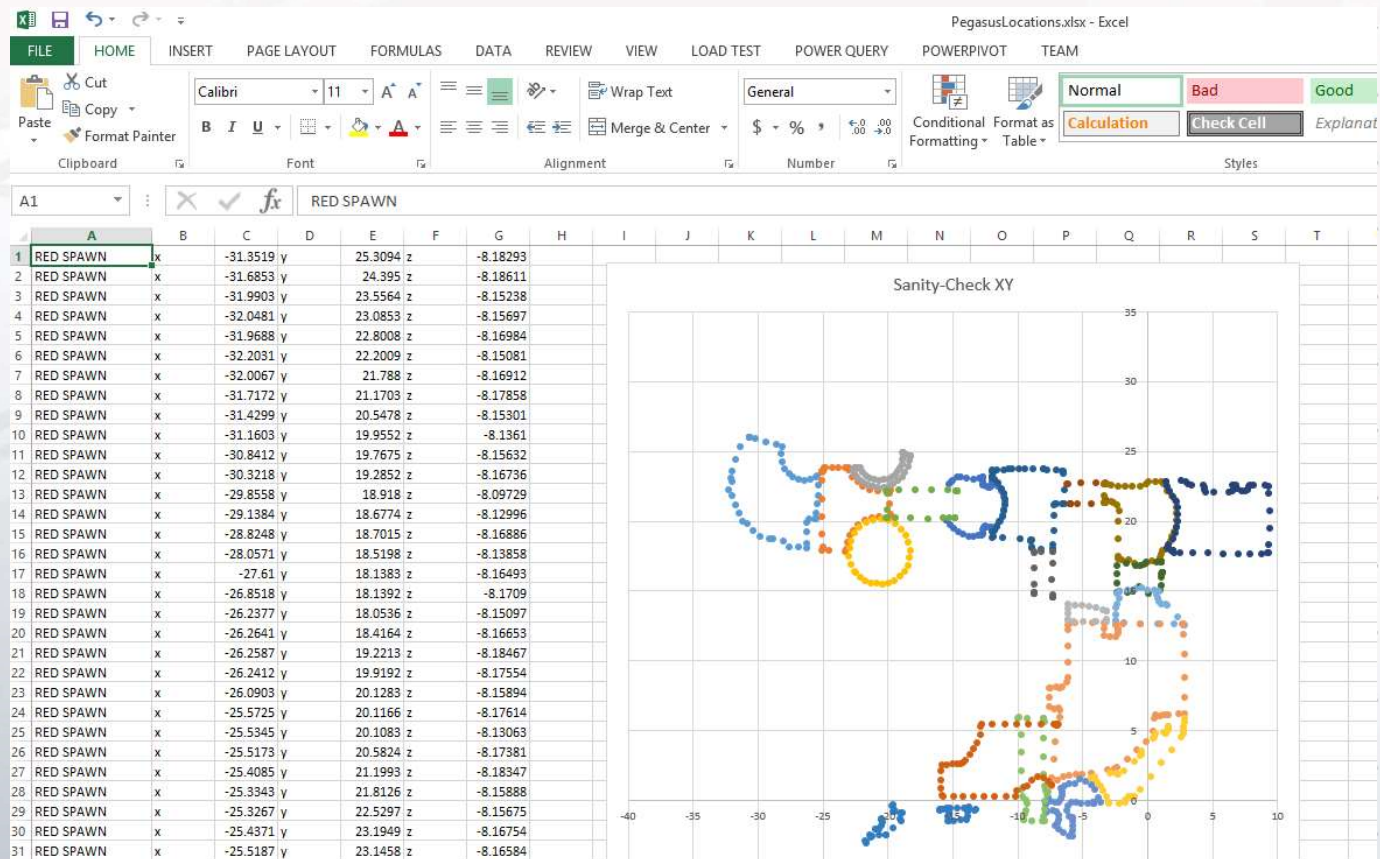


RESULTS: TRAVERSAL

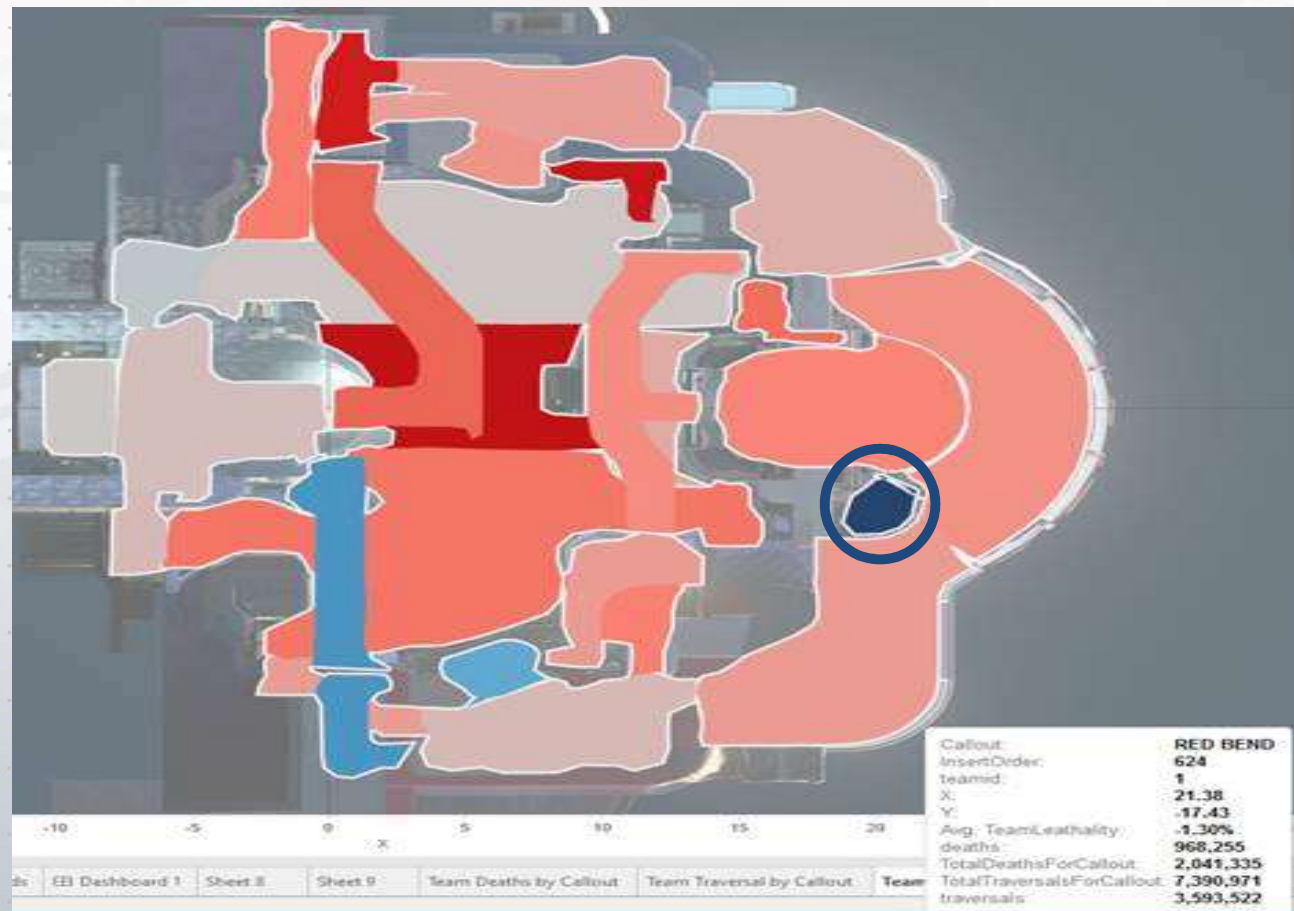


RESULTS: LETHALITY





RESULTS: HEATMAPS



RESULTS: HEATMAPS



RESULTS: MAP BALANCE

Year of Da..	Week of D..	Team Color	Gamevariantname SWATnums
2015	Week 44	Blue	53%
	Week 45	Blue	53%
	Week 46	Blue	54%
	Week 47	Blue	54%
	Week 48	Blue	54%
	Week 49	Blue	54%
	Week 50	Blue	54%
	Week 51	Blue	54%
	Week 52	Blue	53%
	Week 53	Blue	53%
2016	Week 1	Blue	53%
	Week 2	Blue	53%
	Week 3	Blue	53%
	Week 4	Blue	53%
	Week 5	Blue	51%
	Week 6	Blue	50%
	Week 7	Blue	50%
	Week 8	Blue	50%
	Week 9	Blue	50%
	Week 10	Blue	50%
	Week 11	Blue	50%

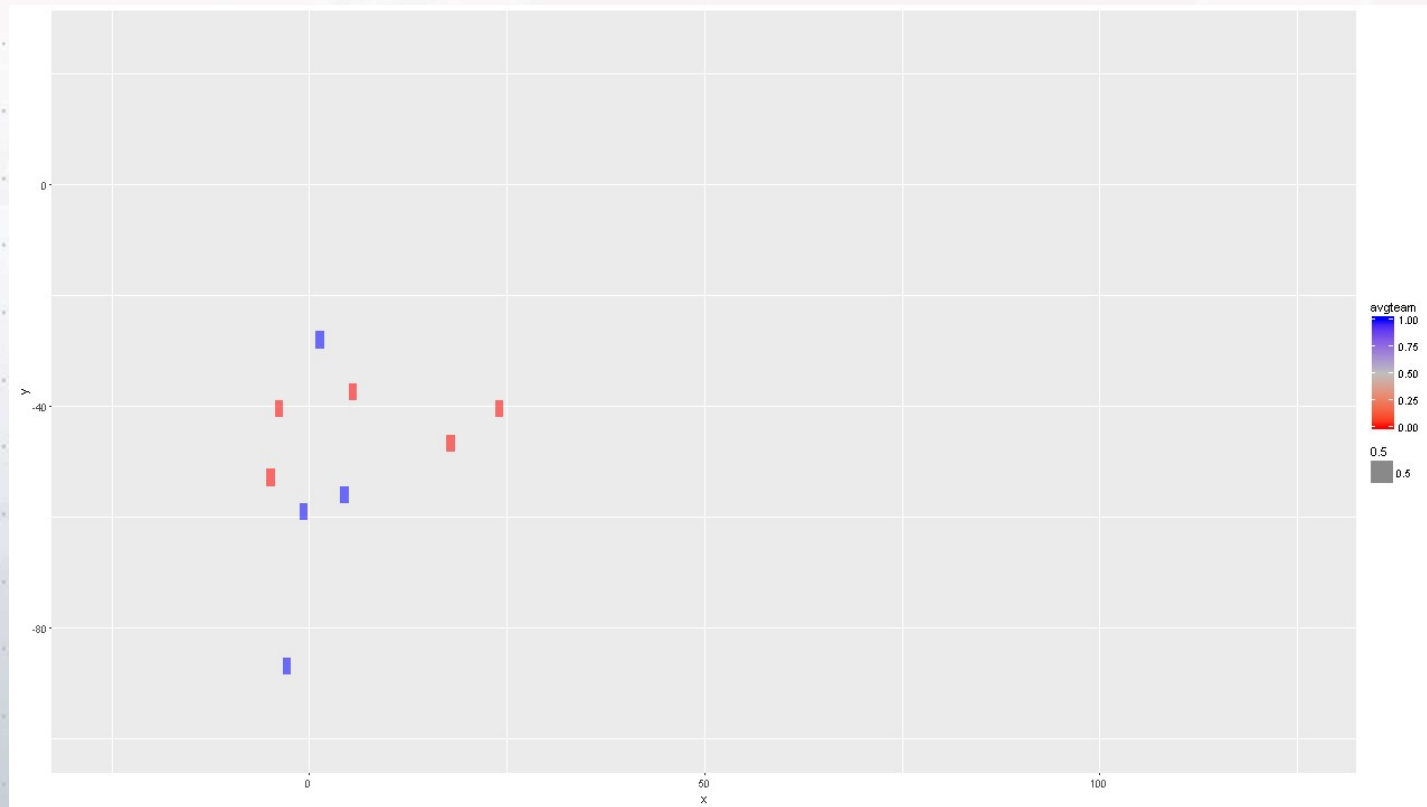
Year of Da..	Week of D..	Team Color	Gamevariantname SWATnums
2015	Week 45	Blue	52%
	Week 46	Blue	53%
	Week 47	Blue	53%
	Week 48	Blue	53%
	Week 49	Blue	53%
	Week 50	Blue	53%
	Week 51	Blue	53%
	Week 52	Blue	52%
	Week 53	Blue	52%
2016	Week 1	Blue	53%
	Week 2	Blue	51%
	Week 3	Blue	53%
	Week 4	Blue	51%
	Week 5	Blue	50%
	Week 6	Blue	50%
	Week 7	Blue	50%
	Week 8	Blue	49%
	Week 9	Blue	50%
	Week 10	Blue	48%
	Week 11	Blue	49%

RESULTS: ANIMATED HEATMAPS



RESULTS: ANIMATED HEATMAPS

RESULTS: ANIMATED HEATMAPS





RESULTS: ANIMATED HEATMAPS



RESULTS: ANIMATED HEATMAPS



THANK YOU!
(AND PLEASE FILL OUT THE SURVEY)

TOMM @ MICROSOFT.COM

GAME DEVELOPERS CONFERENCE March 14–18, 2016 · Expo: March 16–18, 2016 #GDC16

