

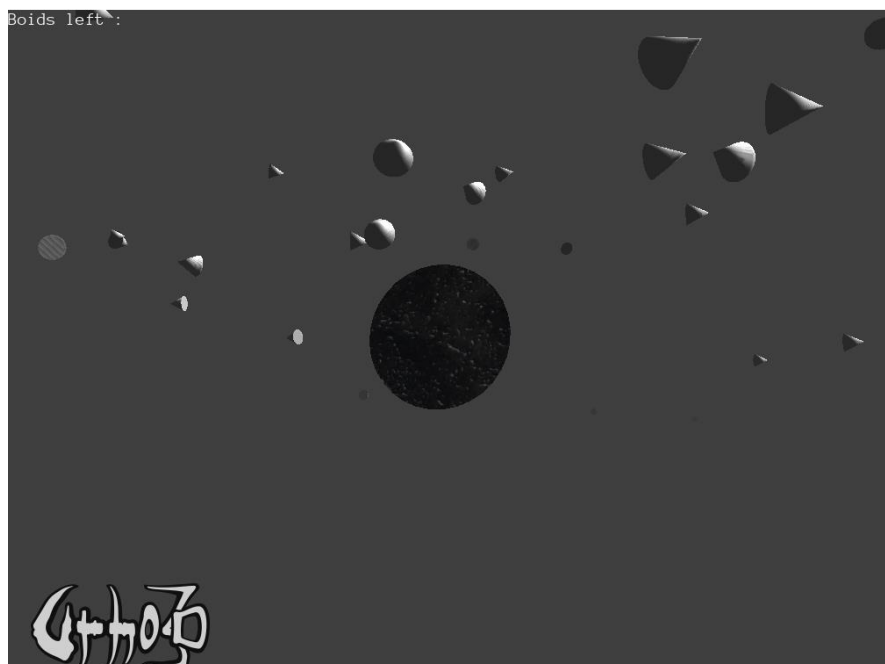
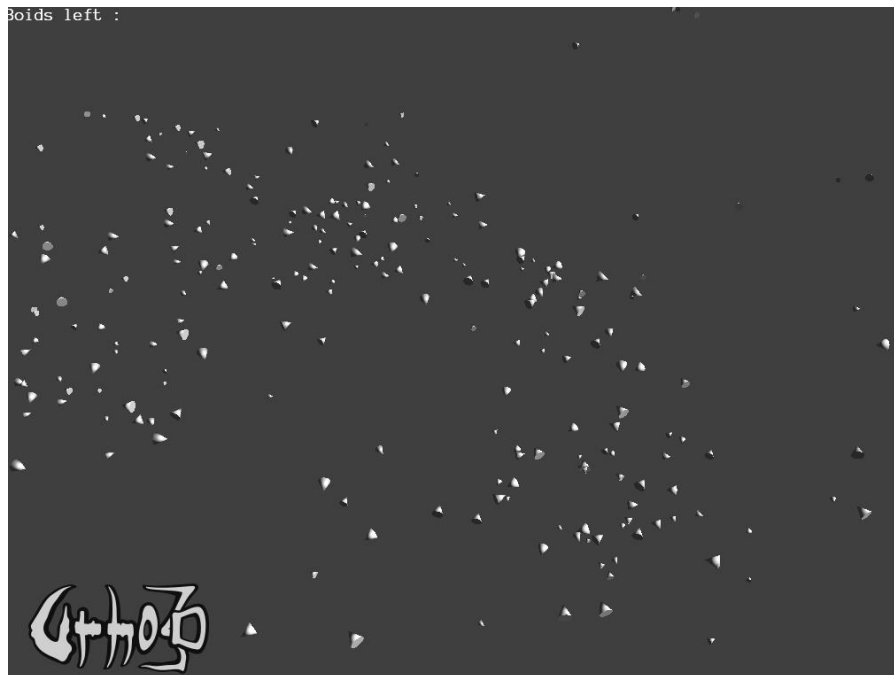
CGP3016M
Advanced Games Programming
Joe Martin – S15596040

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Game Description

The game I created, is a multiplayer space game using the Urho3D engine. The game allowed multiple players, all with their own ships, which can fire a bullet. The game has 300 other spaceships that fly around in swarms (boids). The objective of the game is to destroy as many ships as you can. You can do this be either flying into then, or by shooting them with your bullet. They will then be removed from the game. The players ship can move forward, turn, and move up and down. The direction of the ship will also turn to face the direction it is moving.



Analysis

50 boids, 193 frames:

Block	Cnt	Avg	Max	Frame	Total
RunFrame	193	5.184	9.718	5.184	1000.561
BeginFrame	193	0.052	0.078	0.052	10.091
FinishBackgroundResources	193	0.000	0.001	0.000	0.014
UpdateNetwork	193	0.018	0.047	0.018	3.560
UpdateInput	193	0.011	0.034	0.011	2.167
Update	193	3.145	6.870	3.145	607.020
UpdateScene	193	0.368	1.029	0.368	71.139
UpdatePhysics	193	0.347	1.011	0.347	67.057
StepSimulation	60	0.561	0.832	0.174	33.717
SendCollisionEvents	60	0.002	0.004	0.000	0.175
UpdateSmoothing	193	0.002	0.009	0.002	0.435
UpdateUI	193	0.028	0.077	0.028	5.552
PostUpdateNetwork	193	0.001	0.018	0.001	0.238
PrepareServerUpdate	31	0.000	0.001	0.000	0.010
SendServerUpdate	31	0.000	0.000	0.000	0.000
GetUIBatches	193	0.361	0.660	0.361	69.819
UpdateViews	193	0.468	4.317	0.468	90.463
UpdateDrawables	193	0.018	0.036	0.018	3.492
ReinsertToOctree	193	0.010	0.039	0.010	3.786
GetDrawables	193	0.107	0.253	0.107	20.668
ProcessLights	193	0.169	3.935	0.169	32.634
GetLightBatches	193	0.064	0.192	0.064	12.435
GetBaseBatches	193	0.012	0.022	0.012	2.358
Render	193	1.079	5.871	1.079	208.302
RenderViews	193	0.200	0.260	0.200	38.769
SortAndUpdateGeometry	193	0.045	0.078	0.045	8.920
PrepareInstancingBuffer	193	0.013	0.034	0.013	2.655
ExecuteRenderPath	193	0.108	0.167	0.108	20.942
ClearRenderTarget	193	0.007	0.021	0.007	1.415
RenderLights	193	0.095	0.146	0.095	18.370
RenderShadowMap	193	0.051	0.091	0.051	9.918
RenderUI	193	0.064	0.799	0.064	12.389
Present	193	0.799	5.614	0.799	154.353
ApplyFrameLimit	193	0.880	2.014	0.880	169.920
EndFrame	193	0.011	0.049	0.011	2.169

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

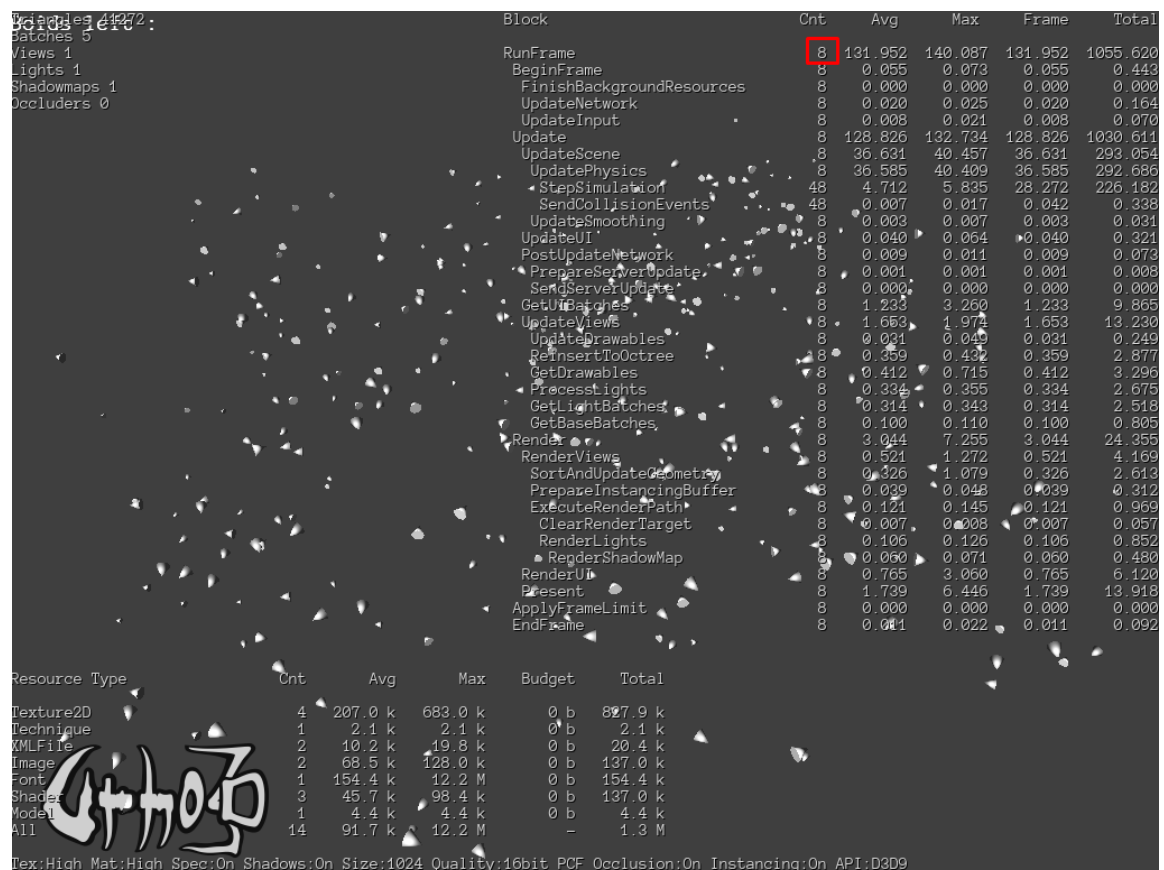
100 boids, 96 frames:

Block	Cnt	Avg	Max	Frame	Total
RunFrame	96	10.445	12.214	10.445	1002.789
BeginFrame	96	0.079	0.349	0.079	7.666
FinishBackgroundResources	96	0.000	0.011	0.000	0.016
UpdateNetwork	96	0.019	0.037	0.019	1.863
UpdateInput	96	0.037	0.298	0.037	3.646
Update	96	9.183	10.918	9.183	881.612
UpdateScene	96	1.130	2.363	1.130	108.492
UpdatePhysics	96	1.102	2.331	1.102	105.866
StepSimulation	60	1.190	1.872	0.744	71.459
SendCollisionEvents	60	0.004	0.025	0.002	0.252
UpdateSmoothing	96	0.002	0.012	0.002	0.224
UpdateUI	96	0.025	0.049	0.025	2.483
PostUpdateNetwork	96	0.002	0.016	0.002	0.227
PrepareServerUpdate	30	0.000	0.001	0.000	0.005
SendServerUpdate	30	0.000	0.000	0.000	0.000
GetUIBatches	96	0.960	1.760	0.960	92.165
UpdateViews	96	0.589	0.887	0.589	56.622
UpdateDrawables	96	0.021	0.041	0.021	2.056
ReinsertToOctree	96	0.049	0.145	0.049	4.795
GetDrawables	96	0.149	0.228	0.149	14.317
ProcessLights	96	0.162	0.382	0.162	15.600
GetLightBatches	96	0.098	0.136	0.098	9.413
GetBaseBatches	96	0.024	0.068	0.024	2.342
Render	96	1.158	1.679	1.158	111.169
RenderViews	96	0.233	0.414	0.233	22.399
SortAndUpdateGeometry	96	0.066	0.091	0.066	6.399
PrepareInstancingBuffer	96	0.021	0.031	0.021	2.092
ExecuteRenderPath	96	0.114	0.238	0.114	10.944
ClearRenderTarget	96	0.007	0.021	0.007	0.716
RenderLights	96	0.100	0.227	0.100	9.685
RenderShadowMap	96	0.055	0.110	0.055	5.399
RenderUI	96	0.175	0.350	0.175	16.848
Present	96	0.732	1.277	0.732	70.338
ApplyFrameLimit	96	0.000	0.000	0.000	0.000
EndFrame	96	0.010	0.022	0.010	1.026

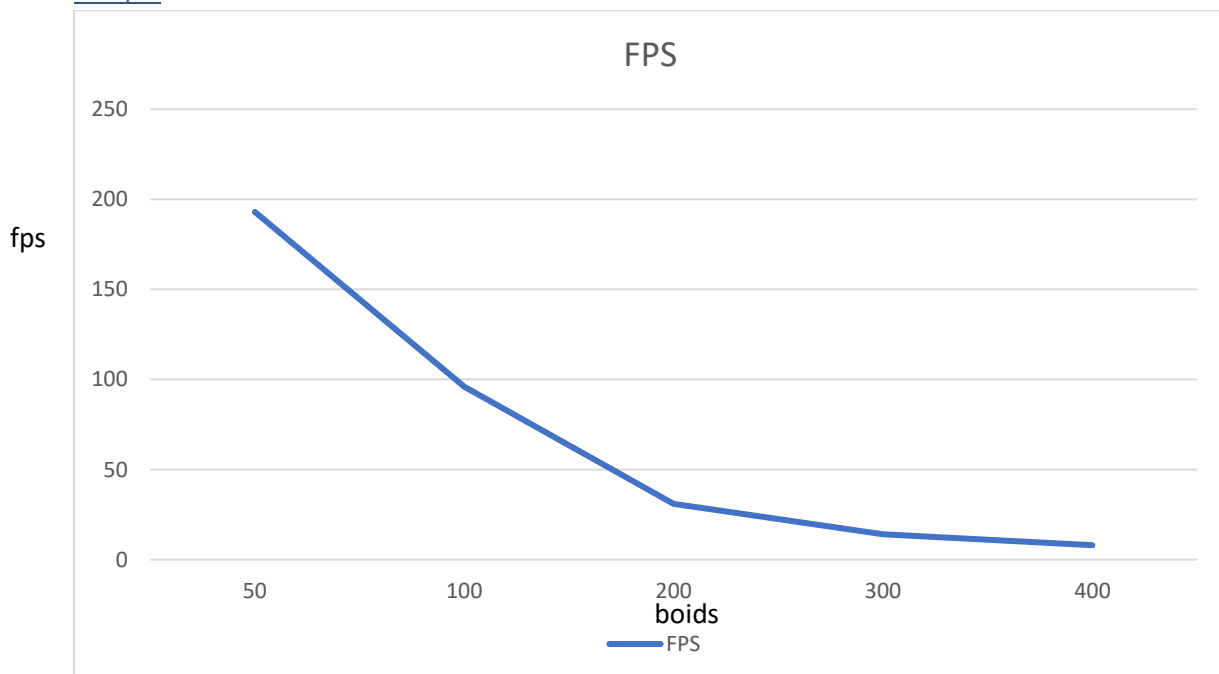
Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

400 boids, 8 frames:



Graph

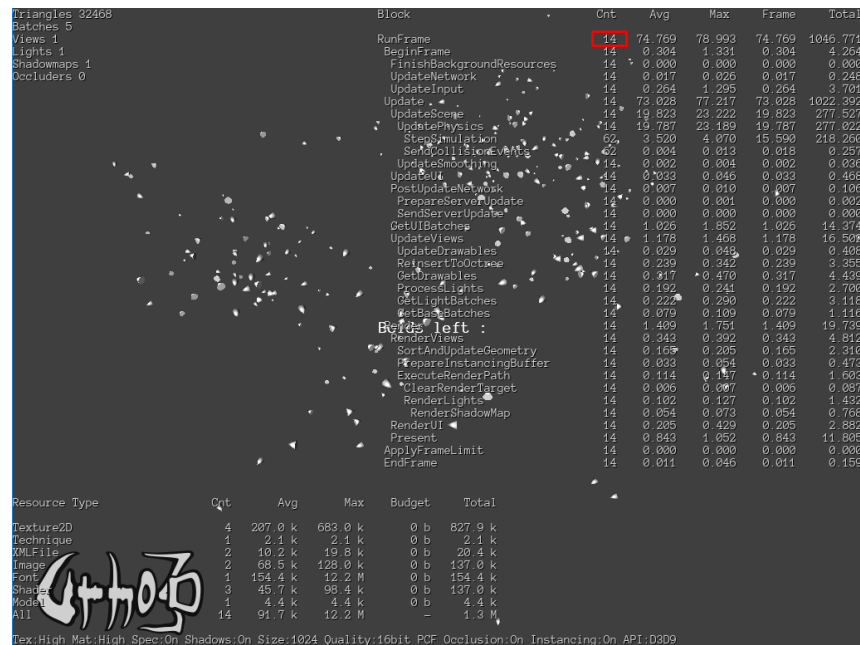


Optimisation

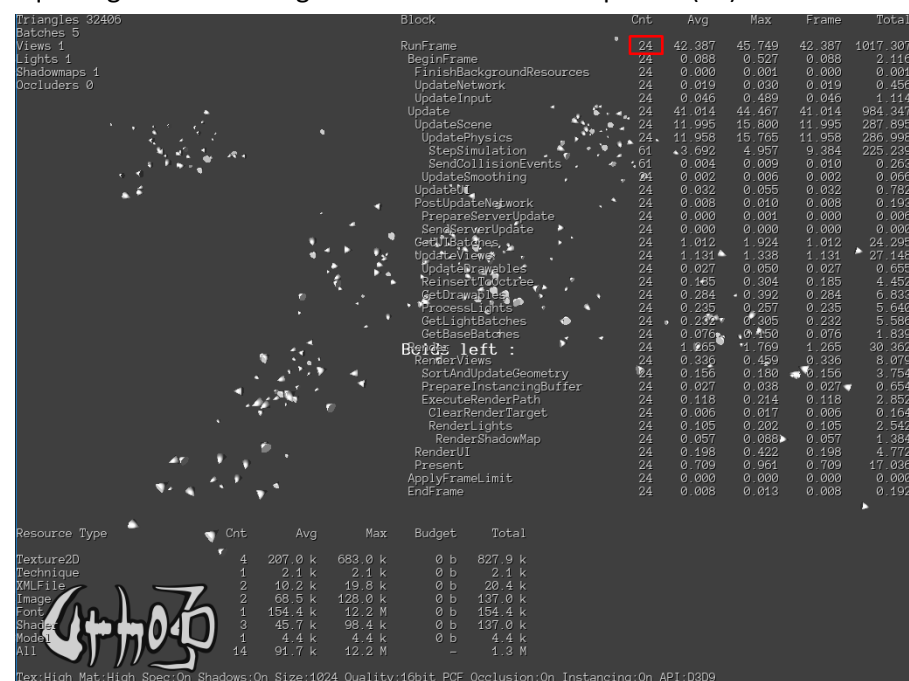
During this optimisation stage, I am going to carry out multiple experiments, using several different methods:

Boid Groups

The first method I will use, is Boid Splitting. This is when I take the boids and split them up into smaller groups. Initially, I have one big group of 300 boids. This means that all 300 boids are interacting with each other, applying forces, and searching for each other. This is very intensive and can cause low frames (14):



For another test, lets split this one big group of 300 into 2 smaller groups of 150 boids each, still equalling 300 boids altogether. The frame rate improves (24):



I am going to keep splitting the main group up to see how the frame rate will be affected.

3 groups of boids, 100 in each. Frame rate (32) :

Triangles	31662	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	32	31.779	34.644	31.779	1016.936
Views	1	BeginFrame	32	0.074	0.485	0.074	2.385
Lights	1	FinishBackgroundResources	32	0.000	0.001	0.000	0.004
Shadowmaps	1	UpdateNetwork	32	0.019	0.031	0.019	0.639
Occluders	0	UpdateInput	32	0.032	0.428	0.032	1.034
		Update	32	30.304	32.938	30.304	969.758
		UpdateScene	32	9.610	10.771	9.610	307.535
		UpdatePhysics	32	9.571	10.727	9.571	306.285
		StepSimulation	61	3.989	5.651	7.604	243.354
		SendCollisionEvents	61	0.004	0.009	0.008	0.273
		UpdateShadowing	32	0.003	0.004	0.003	0.101
		UpdateUI	32	0.029	0.055	0.029	0.955
		PostUpdateNetwork	32	0.008	0.018	0.008	0.276
		PrepareServerUpdate	31	0.000	0.011	0.000	0.023
		SendServerUpdate	31	0.000	0.000	0.000	0.000
		GetUIBatches	32	1.017	1.782	1.017	32.552
		UpdateViews	32	1.165	2.214	1.165	37.292
		UpdateDrawables	32	0.030	0.066	0.030	0.981
		ReinsertToOctree	32	0.186	0.403	0.186	5.968
		GetDrawables	32	0.298	0.536	0.298	9.548
		ProcessLights	32	0.262	1.283	0.262	8.414
		GetLightBatches	32	0.214	0.257	0.214	6.869
		GetBaseBatches	32	0.074	0.116	0.074	2.374
		Boids left :	32	1.375	1.735	1.375	44.027
		RenderViews	32	0.347	0.475	0.337	10.797
		SortAndUpdateGeometry	32	0.152	0.172	0.152	4.870
		PrepareInstancingBuffer	32	0.031	0.051	0.031	1.011
		ExecuteRenderPath	32	0.124	0.246	0.121	3.893
		ClearRenderTarget	32	0.007	0.030	0.007	0.222
		RenderLights	32	0.108	0.227	0.108	3.471
		RenderShadowMap	32	0.055	0.070	0.055	1.785
		RenderUI	32	0.237	0.401	0.237	7.602
		Present	32	0.782	1.079	0.782	25.050
		ApplyFrameLimit	32	0.000	0.000	0.000	0.000
		EndFrame	32	0.010	0.021	0.010	0.327

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

4 groups of boids, 75 in each. Frame rate (40) :

Triangles	34018	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	40	25.262	30.711	25.262	1010.496
Views	1	BeginFrame	40	0.055	0.184	0.055	2.228
Lights	1	FinishBackgroundResources	40	0.000	0.001	0.000	0.009
Shadowmaps	1	UpdateNetwork	40	0.021	0.038	0.021	0.848
Occluders	0	UpdateInput	40	0.006	0.015	0.006	0.277
		Update	40	23.781	28.796	23.781	951.263
		UpdateScene	40	7.455	10.310	7.455	298.208
		UpdatePhysics	40	7.421	10.278	7.421	296.842
		StepSimulation	61	3.885	4.807	5.925	237.006
		SendCollisionEvents	61	0.004	0.016	0.007	0.287
		UpdateShadowing	40	0.002	0.018	0.002	0.105
		UpdateUI	40	0.035	0.060	0.035	1.407
		PostUpdateNetwork	40	0.006	0.021	0.006	0.246
		PrepareServerUpdate	30	0.000	0.001	0.000	0.005
		SendServerUpdate	30	0.000	0.000	0.000	0.000
		GetUIBatches	40	1.002	3.209	1.002	40.085
		UpdateViews	40	1.106	1.383	1.106	44.252
		UpdateDrawables	40	0.025	0.048	0.025	1.032
		ReinsertToOctree	40	0.144	0.221	0.144	5.778
		GetDrawables	40	0.261	0.445	0.261	10.440
		ProcessLights	40	0.278	0.472	0.278	11.127
		GetLightBatches	40	0.238	0.262	0.233	9.334
		GetBaseBatches	40	0.072	0.108	0.072	2.915
		Boids left :	40	1.400	1.927	1.400	56.029
		RenderViews	40	0.347	0.443	0.347	13.906
		SortAndUpdateGeometry	40	0.164	0.234	0.164	6.573
		PrepareInstancingBuffer	40	0.030	0.051	0.030	1.209
		ExecuteRenderPath	40	0.119	0.214	0.119	4.772
		ClearRenderTarget	40	0.006	0.009	0.006	0.254
		RenderLights	40	0.106	0.197	0.106	4.271
		RenderShadowMap	40	0.059	0.092	0.059	2.367
		RenderUI	40	0.229	0.711	0.229	9.189
		Present	40	0.806	1.235	0.806	32.255
		ApplyFrameLimit	40	0.000	0.000	0.000	0.000
		EndFrame	40	0.010	0.038	0.010	0.430

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

5 groups of boids, 60 in each. Frame rate (45) :

Triangles	29200	Block	Cnt	Avg	Max	Frame	Total
Batches	4						
Views	1	RunFrame	45	22.638	29.344	22.638	1018.743
Lights	1	BeginFrame	45	0.162	1.657	0.162	7.322
Shadowmaps	0	FinishBackgroundResources	45	0.000	0.001	0.000	0.003
Occluders	0	UpdateNetwork	45	0.020	0.038	0.020	0.907
		UpdateInput	45	0.118	1.608	0.118	5.250
		Update	45	21.203	27.664	21.203	954.141
		UpdateScene	45	7.279	12.932	7.279	327.598
		UpdatePhysics	45	7.242	12.944	7.242	325.914
		StepSimulation	61	4.286	6.314	5.811	261.503
		SendCollisionEvents	61	0.005	0.013	0.007	0.319
		UpdateSmoothing	45	0.003	0.019	0.003	0.157
		UpdateUI	45	0.027	0.055	0.027	1.223
		PostUpdateNetwork	45	0.005	0.018	0.005	0.262
		PrepareServerUpdate	31	0.000	0.002	0.000	0.011
		SendServerUpdate	31	0.000	0.000	0.000	0.000
		GetUIBatches	45	0.969	2.108	0.969	43.644
		UpdateViews	45	0.908	1.084	0.908	40.899
		UpdateDrawables	45	0.027	0.076	0.027	1.237
		ReinsertToOctree	45	0.162	0.304	0.162	7.300
		GetDrawables	45	0.273	0.344	0.273	12.294
		ProcessLights	45	0.095	0.171	0.095	4.317
		GetLightBatches	45	0.188	0.234	0.188	8.478
		GetBaseBatches	45	0.065	0.100	0.065	2.955
		RenderViews	45	1.248	1.565	1.248	56.199
		SortAndUpdateGeometry	45	0.277	0.441	0.277	12.492
		PrepareInstancingBuffer	45	0.132	0.158	0.132	5.980
		ExecuteRenderPath	45	0.029	0.115	0.029	1.328
		ClearRenderTarget	45	0.077	0.190	0.077	3.487
		RenderLights	45	0.007	0.021	0.007	0.317
		RenderUI	45	0.063	0.143	0.063	2.866
		Present	45	0.215	0.330	0.215	9.680
		ApplyFrameLimit	45	0.737	0.963	0.737	33.197
		EndFrame	45	0.000	0.000	0.000	0.000
			45	0.009	0.020	0.009	0.420

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

6 groups of boids, 50 in each. Frame rate (51) :

Triangles	34204	Block	Cnt	Avg	Max	Frame	Total
Batches	5						
Views	1	RunFrame	51	19.618	25.256	19.618	1000.536
Lights	1	BeginFrame	51	0.049	0.114	0.049	2.514
Shadowmaps	1	FinishBackgroundResources	51	0.000	0.002	0.000	0.008
Occluders	0	UpdateNetwork	51	0.020	0.044	0.020	1.032
		UpdateInput	51	0.007	0.024	0.007	0.357
		Update	51	18.234	23.404	18.234	929.934
		UpdateScene	51	6.106	11.493	6.106	311.446
		UpdatePhysics	51	6.069	11.459	6.069	309.565
		StepSimulation	60	4.080	5.419	4.801	244.855
		SendCollisionEvents	60	0.005	0.035	0.006	0.312
		UpdateSmoothing	51	0.002	0.011	0.002	0.152
		UpdateUI	51	0.025	0.037	0.025	1.319
		PostUpdateNetwork	51	0.004	0.011	0.004	0.237
		PrepareServerUpdate	30	0.000	0.001	0.000	0.006
		SendServerUpdate	30	0.000	0.000	0.000	0.000
		GetUIBatches	51	0.995	1.771	0.995	50.756
		UpdateViews	51	1.157	2.485	1.157	59.019
		UpdateDrawables	51	0.027	0.052	0.027	1.388
		ReinsertToOctree	51	0.149	0.294	0.149	7.604
		GetDrawables	51	0.293	0.349	0.293	14.962
		ProcessLights	51	0.278	0.578	0.278	14.225
		GetLightBatches	51	0.239	0.382	0.239	12.227
		GetBaseBatches	51	0.072	0.149	0.072	3.721
		RenderViews	51	1.343	1.820	1.343	68.978
		SortAndUpdateGeometry	51	0.346	0.594	0.346	17.696
		PrepareInstancingBuffer	51	0.156	0.262	0.156	7.986
		ExecuteRenderPath	51	0.024	0.121	0.024	1.230
		ClearRenderTarget	51	0.122	0.220	0.122	6.246
		RenderLights	51	0.007	0.024	0.007	0.360
		RenderShadowMap	51	0.108	0.199	0.108	5.532
		RenderUI	51	0.061	0.133	0.061	3.145
		Present	51	0.217	0.451	0.217	11.103
		ApplyFrameLimit	51	0.727	1.055	0.727	37.118
		EndFrame	51	0.000	0.000	0.000	0.000
			51	0.009	0.025	0.009	0.462

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

During these tests, you can see the gradual increase of the frame rate. During the test, I allowed around 10 seconds before checking and taking the screenshot of the framerate, this was to give the boids time to interact with each other, and this would be the most intensive part of the game, so it is good to test it at its most strained time.

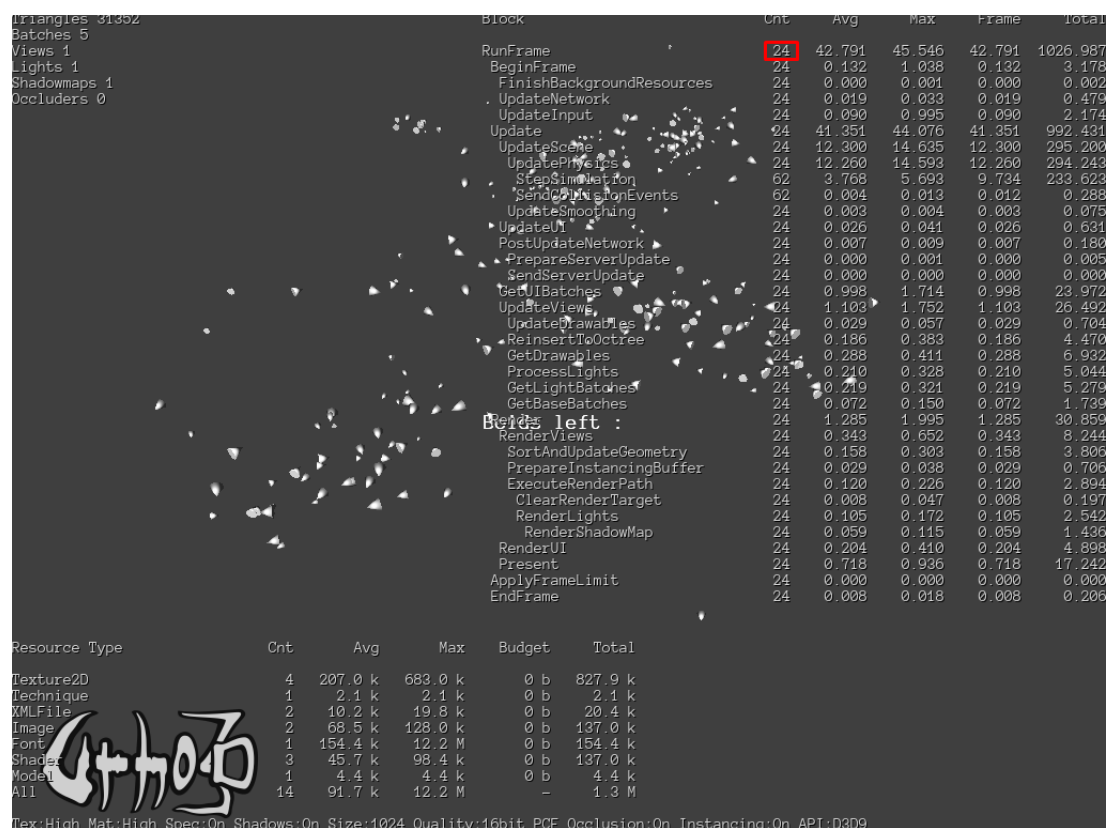
Boid splitting was a very good way to improve the frame rate of the game. Having 300 boids with the optimisation caused the frame rate to increase from 14 to 51. This is a very good result, but it must also be noted, that these individual boid groups do not interact with each other. Meaning, yes, we have a greatly improved frame rate, but the boids are actually interacting with the environment less. Meaning their behaviour will be slightly altered. Some boids will fly away not seeing its neighbours etc.

To conclude, this method is very good at improving the frame rate of the game, and it is very easy to implement, however, it can have a big effect on the boids behaviour.

Limiting the Neighbours

In this method to try and improve optimisation, I am going to be counting the number of neighbours that each boid checks. I am going to get the total number of boids (300) and I am going to gradually make the game check for less and less neighbours to see how it affects the performance. The initial frame rate again, as seen in the above method, is 14. I have also made it, so it is only one group of boids, 300 in size, ignoring the previous method.

Checking for 1/2 of neighbours, frame rate (24) :



Checking for 1/3 of neighbours, frame rate (33) :

Triangles	33212	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	33	30.508	35.250	30.508	1006.776
Views	1	BeginFrame	33	0.081	0.347	0.081	2.703
Lights	1	FinishBackgroundResources	33	0.000	0.010	0.000	0.012
Shadowmaps	1	UpdateNetwork	33	0.019	0.040	0.019	0.645
Occluders	0	UpdateInput	33	0.030	0.283	0.030	1.288
		Update	33	29.100	33.404	29.109	960.593
		UpdateScene	33	8.711	11.676	8.711	287.482
		UpdatePhysics	33	8.673	11.618	8.673	286.221
		StepSimulation	60	3.736	4.670	6.793	224.208
		SendCollisionEvents	60	0.005	0.020	0.009	0.308
		UpdateSmoothing	33	0.003	0.015	0.003	0.121
		UpdateUI	33	0.034	0.050	0.034	1.126
		PostUpdateNetwork	33	0.007	0.013	0.007	0.253
		PrepareServerUpdate	31	0.000	0.001	0.000	0.012
		SendServerUpdate	31	0.000	0.000	0.000	0.000
		GetUIBatches	33	1.028	3.381	1.028	33.932
		UpdateViews	33	1.062	1.278	1.062	35.076
		UpdateDrawables	33	0.027	0.053	0.027	0.901
		ReinsertToOctree	33	0.160	0.285	0.169	5.583
		GetDrawables	33	0.249	0.351	0.249	8.218
		ProcessLights	33	0.219	0.291	0.219	7.243
		GetLightBatches	33	0.227	0.250	0.227	7.500
		GetBaseBatches	33	0.076	0.102	0.076	2.534
		RenderViews	33	1.294	1.757	1.294	42.702
		SortAndUpdateGeometry	33	0.336	0.432	0.336	11.110
		PrepareInstancingBuffer	33	0.159	0.235	0.159	5.250
		ExecuteRenderPath	33	0.030	0.062	0.030	1.011
		ClearRenderTarget	33	0.115	0.176	0.115	3.822
		RenderLights	33	0.005	0.012	0.006	0.211
		RenderShadowMap	33	0.102	0.155	0.102	3.384
		RenderUI	33	0.057	0.100	0.057	1.895
		Present	33	0.217	0.653	0.217	7.161
		ApplyFrameLimit	33	0.722	1.050	0.722	23.850
		EndFrame	33	0.009	0.045	0.009	0.325

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

Checking for 1/4 of neighbours, frame rate (39) :

Triangles	31600	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	39	25.732	31.099	25.732	1003.573
Views	1	BeginFrame	39	0.045	0.080	0.045	1.793
Lights	1	FinishBackgroundResources	39	0.000	0.001	0.000	0.002
Shadowmaps	1	UpdateNetwork	39	0.018	0.027	0.018	0.733
Occluders	0	UpdateInput	39	0.006	0.023	0.006	0.243
		Update	39	24.301	28.074	24.301	947.776
		UpdateScene	39	7.967	11.235	7.967	310.715
		UpdatePhysics	39	7.929	11.155	7.929	309.252
		StepSimulation	60	4.114	4.975	6.329	246.847
		SendCollisionEvents	60	0.005	0.011	0.007	0.305
		UpdateSmoothing	39	0.003	0.009	0.003	0.121
		UpdateUI	39	0.036	0.099	0.036	1.419
		PostUpdateNetwork	39	0.006	0.022	0.006	0.262
		PrepareServerUpdate	30	0.000	0.001	0.000	0.017
		SendServerUpdate	30	0.000	0.002	0.000	0.002
		GetUIBatches	39	1.013	3.226	1.013	39.527
		UpdateViews	39	1.026	1.328	1.026	40.031
		UpdateDrawables	39	0.029	0.058	0.029	1.151
		ReinsertToOctree	39	0.161	0.233	0.161	6.305
		GetDrawables	39	0.252	0.415	0.252	9.864
		ProcessLights	39	0.204	0.360	0.204	7.961
		GetLightBatches	39	0.219	0.283	0.219	8.571
		GetBaseBatches	39	0.068	0.096	0.068	2.650
		RenderViews	39	1.361	4.040	1.361	53.101
		SortAndUpdateGeometry	39	0.342	0.535	0.342	13.379
		PrepareInstancingBuffer	39	0.159	0.250	0.159	6.206
		ExecuteRenderPath	39	0.031	0.057	0.031	1.214
		ClearRenderTarget	39	0.118	0.165	0.118	4.613
		RenderLights	39	0.006	0.008	0.006	0.243
		RenderShadowMap	39	0.106	0.149	0.106	4.134
		RenderUI	39	0.059	0.088	0.059	2.308
		Present	39	0.217	0.704	0.217	8.500
		ApplyFrameLimit	39	0.784	3.425	0.784	30.586
		EndFrame	39	0.009	0.023	0.009	0.378

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

Checking for 1/5 of neighbours, frame rate (46) :

Triangles	31972	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	46	22.065	27.959	22.065	1015.017
Views	1	BeginFrame	46	0.050	0.122	0.050	2.333
Lights	1	FinishBackgroundResources	46	0.000	0.002	0.000	0.010
Shadowmaps	1	UpdateNetwork	46	0.020	0.053	0.020	0.951
Occluders	0	UpdateInput	46	0.007	0.036	0.007	0.341
		Update	46	20.622	26.308	20.622	948.626
		UpdateScene	46	6.886	12.231	6.886	316.765
		UpdatePhysics	46	6.852	12.181	6.852	315.194
		StepSimulation	61	4.102	5.639	5.440	250.279
		SendCollisionEvents	61	0.005	0.014	0.007	0.326
		UpdateSmoothing	46	0.003	0.013	0.003	0.155
		UpdateUI	46	0.036	0.065	0.036	1.672
		PostUpdateNetwork	46	0.005	0.021	0.005	0.264
		PrepareServerUpdate	30	0.000	0.001	0.000	0.005
		SendServerUpdate	30	0.000	0.000	0.000	0.000
		GetUIBatches	46	1.000	2.444	1.000	46.022
		UpdateViews	46	1.068	1.832	1.068	49.136
		UpdateDrawables	46	0.030	0.150	0.030	1.410
		ReinsertToOctree	46	0.152	0.399	0.152	7.036
		GetDrawables	46	0.289	0.903	0.289	13.306
		ProcessLights	46	0.211	0.814	0.211	9.747
		GetLightBatches	46	0.221	0.374	0.221	10.175
		GetBaseBatches	46	0.069	0.098	0.069	3.190
		RenderViews	46	1.370	2.983	1.370	63.039
		SortAndUpdateGeometry	46	0.352	0.800	0.352	16.235
		PrepareInstancingBuffer	46	0.150	0.186	0.150	6.939
		ExecuteRenderPath	46	0.029	0.047	0.029	1.358
		ClearRenderTarget	46	0.135	0.480	0.135	6.217
		RenderLights	46	0.009	0.089	0.009	0.414
		RenderShadowMap	46	0.118	0.367	0.118	5.464
		RenderUI	46	0.065	0.262	0.065	3.026
		Present	46	0.220	0.500	0.220	10.156
		ApplyFrameLimit	46	0.779	2.499	0.779	35.854
		EndFrame	46	0.000	0.000	0.000	0.000
			46	0.009	0.023	0.009	0.422

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

Checking for 1/6 of neighbours, frame rate (56) :

Triangles	30856	Block	Cnt	Avg	Max	Frame	Total
Batches	5	RunFrame	56	17.845	25.747	17.845	990.368
Views	1	BeginFrame	56	0.065	0.387	0.065	3.642
Lights	1	FinishBackgroundResources	56	0.000	0.002	0.000	0.002
Shadowmaps	1	UpdateNetwork	56	0.022	0.148	0.022	1.274
Occluders	0	UpdateInput	56	0.020	0.238	0.020	1.131
		Update	56	16.495	22.824	16.495	923.724
		UpdateScene	56	5.676	11.026	5.676	317.898
		UpdatePhysics	56	5.639	10.979	5.639	315.838
		StepSimulation	60	4.190	5.767	4.489	251.422
		SendCollisionEvents	60	0.005	0.024	0.006	0.336
		UpdateSmoothing	56	0.003	0.014	0.003	0.206
		UpdateUI	56	0.033	0.053	0.033	1.852
		PostUpdateNetwork	56	0.004	0.012	0.004	0.255
		PrepareServerUpdate	30	0.000	0.001	0.000	0.019
		SendServerUpdate	30	0.000	0.000	0.000	0.000
		GetUIBatches	56	0.204	0.686	0.204	11.470
		UpdateViews	56	0.859	1.135	0.859	48.155
		UpdateDrawables	56	0.022	0.043	0.022	1.263
		ReinsertToOctree	56	0.124	0.296	0.124	6.950
		GetDrawables	56	0.252	0.360	0.252	14.134
		ProcessLights	56	0.108	0.208	0.108	6.057
		GetLightBatches	56	0.199	0.322	0.199	11.166
		GetBaseBatches	56	0.067	0.132	0.067	3.806
		RenderViews	56	1.260	8.551	1.260	70.579
		SortAndUpdateGeometry	56	0.142	0.182	0.142	7.999
		PrepareInstancingBuffer	56	0.027	0.047	0.027	1.556
		ExecuteRenderPath	56	0.083	0.168	0.083	4.656
		ClearRenderTarget	56	0.007	0.036	0.007	0.406
		RenderLights	56	0.009	0.143	0.009	3.876
		RenderShadowMap	56	0.059	0.086	0.059	3.537
		RenderUI	56	0.098	1.644	0.098	5.518
		Present	56	0.851	6.575	0.851	47.685
		ApplyFrameLimit	56	0.000	0.000	0.000	0.000
		EndFrame	56	0.041	0.027	0.011	0.676

Resource Type	Cnt	Avg	Max	Budget	Total
Texture2D	4	207.0 k	683.0 k	0 b	827.9 k
Technique	1	2.1 k	2.1 k	0 b	2.1 k
XMLFile	2	10.2 k	19.8 k	0 b	20.4 k
Image	2	68.5 k	128.0 k	0 b	137.0 k
Font	1	154.4 k	12.2 M	0 b	154.4 k
Shader	3	45.7 k	98.4 k	0 b	137.0 k
Model	1	4.4 k	4.4 k	0 b	4.4 k
All	14	91.7 k	12.2 M	-	1.3 M

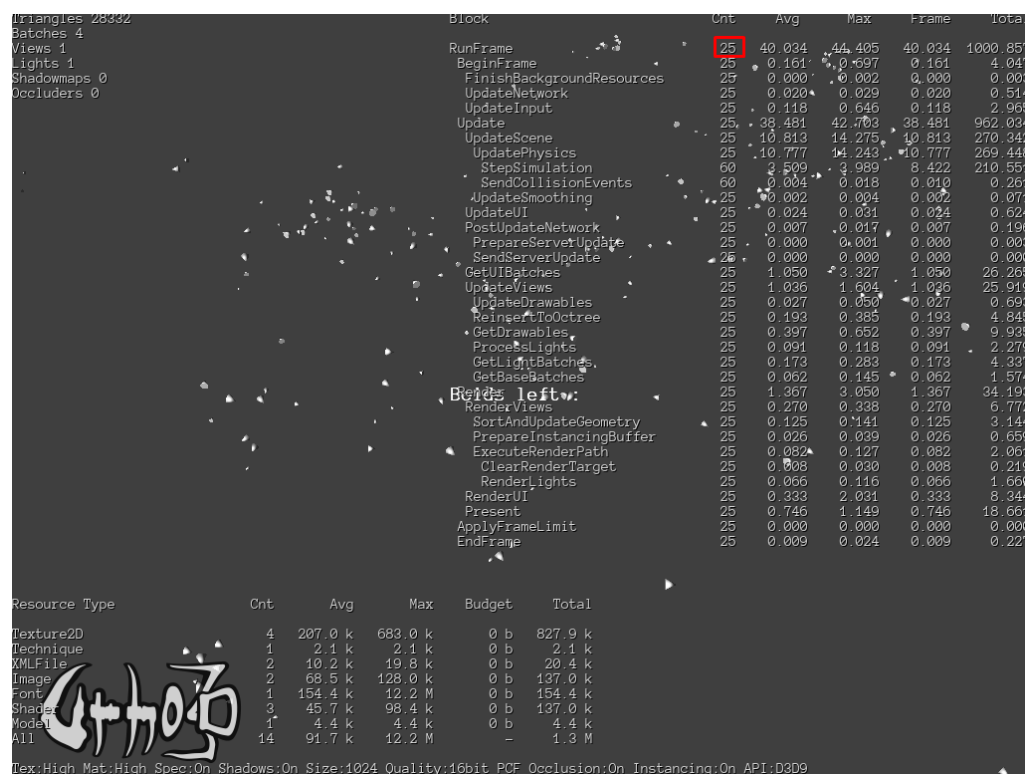
Tex:High Mat:High Spec:On Shadows:On Size:1024 Quality:16bit PCF Occlusion:On Instancing:On API:D3D9

From these tests, once again, I saw an improvement in frame rate. As with the first method, as the frame rate gets better, this is because the boids are interacting with each other less. In the first method all of the boids interacting with each other in the same group, which is a positive, but the groups didn't interact. With this method, all of the boids are in the same group and are interactable, however, they cannot interact with all of the members in the group. This again will lose some of the behaviour of the boids and did mean that some of the boids did fly away alone, but you can tell a slight difference in the behaviours. In this method, I think they were better. As they can see the neighbours, and they're all in the same group, I think they stuck together more, and less flew away. Compared to the previous method were the group members might have been too far away from each other to interact, and therefore they got lost.

Boid Splitting

In this method, I only used one group of boids, 300 in size, and I updated the first half in one update loops, and then I updated the second half of the group in the next loops and repeated this.

Again, the initial frame rate is 14. When I used the method described about, the frame rate is (25) :



This method did show that the frame rate improves, however, it didn't show a big change on 300 boids. It also did affect the behaviour a little, as the boids were interacting less, they often got more spread from each other, and some even lost their neighbours completely. This was the worst method used.

Video

<https://youtu.be/VFnq1CcB9dg>