Rainbow Six Siege: Quest for Performance

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Technical Architect
Ubisoft Montreal

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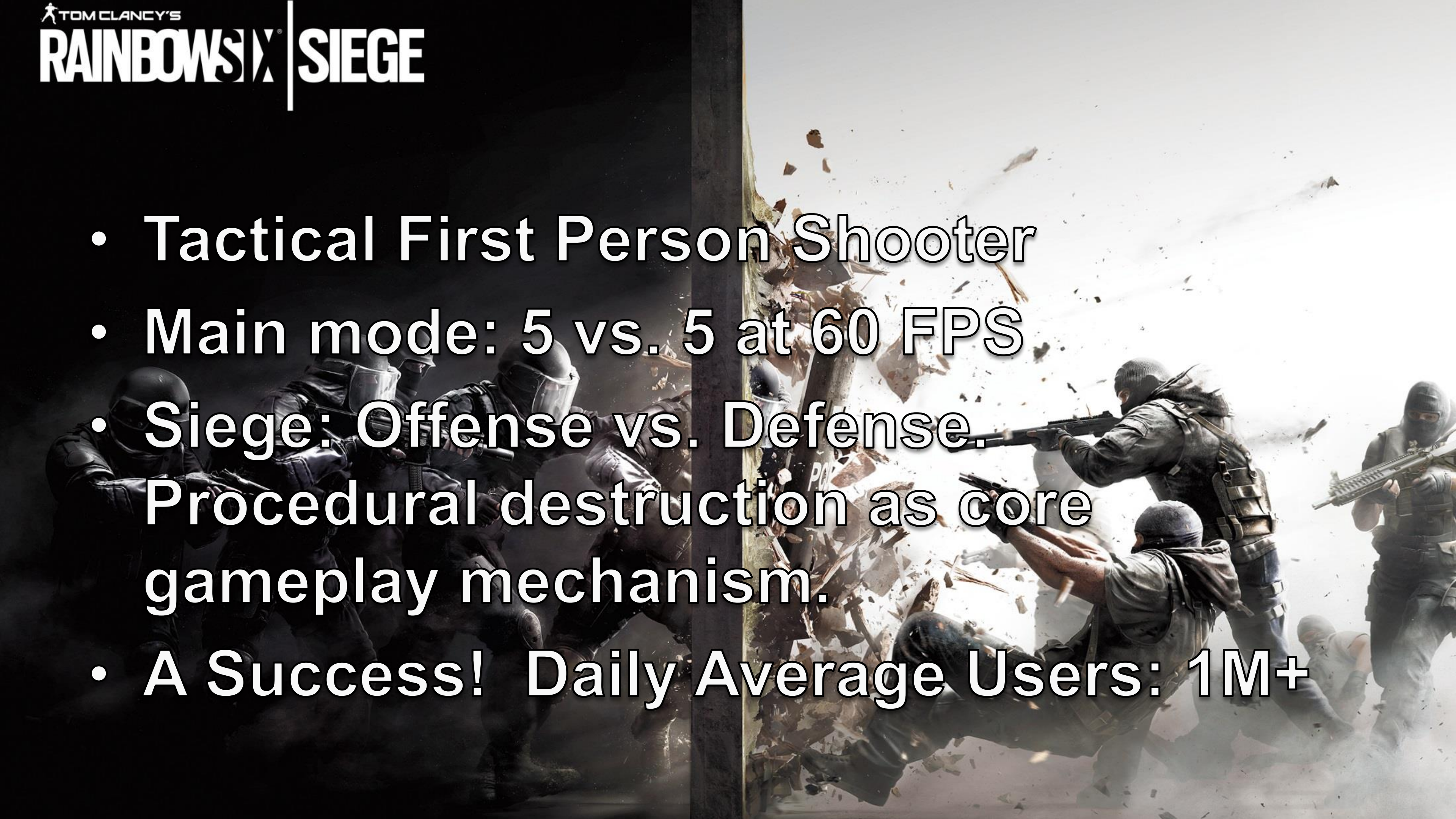
TOM CLANCY'S RAINBOW SIX | SIEGE



- Tactical First Person Shooter
- Main mode: 5 vs. 5 at 60 FPS
- Siege: Offense vs. Defense. Procedural destruction as core gameplay mechanism.
- A Success! Daily Average Users: 1M+

This Talk is NOT About

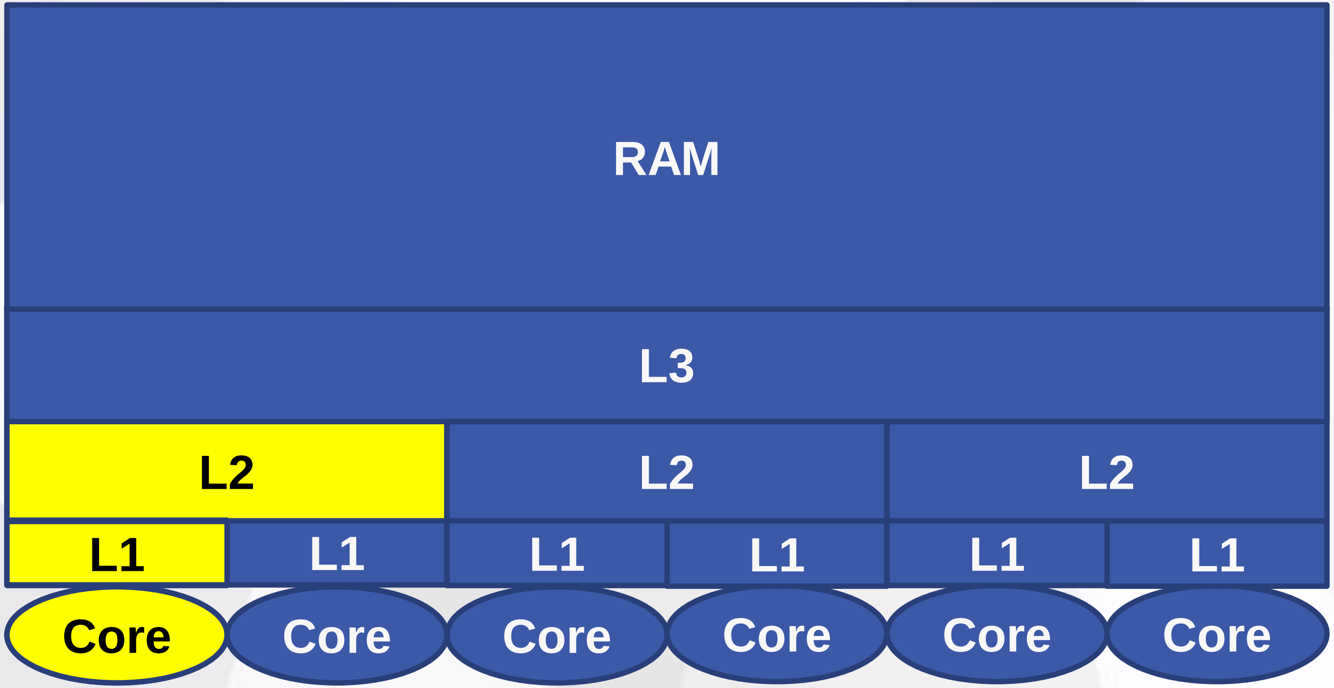
- Checkerboard rendering (see Jalal El Mansouri GDC talk)
- Optimizations in specific systems
- Task scheduling strategies
- Compilation flags, LTO, etc.

Outline

- Situation and workflow overview
- Reduce memory allocation cost
- Reduce memory allocation number
- Lock-free solutions
- Q&A

Situation and Workflow Overview

Cache



RAM

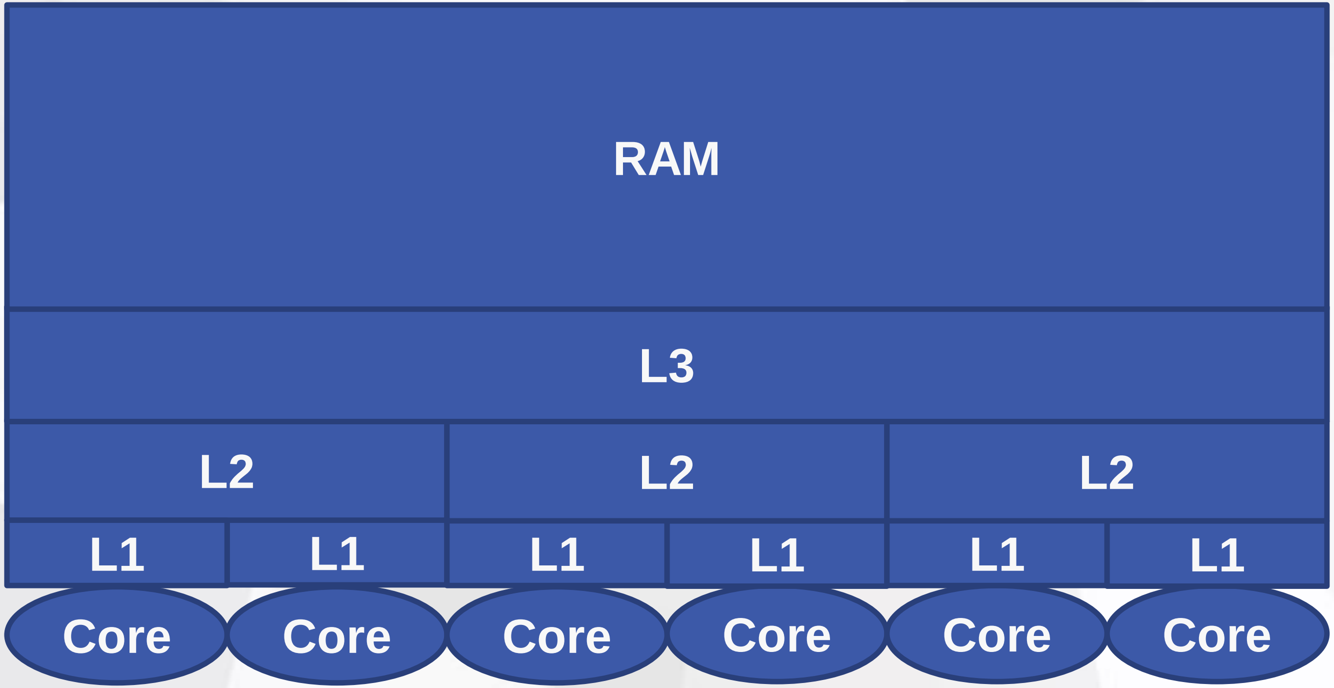
L3

L2 L2 L2

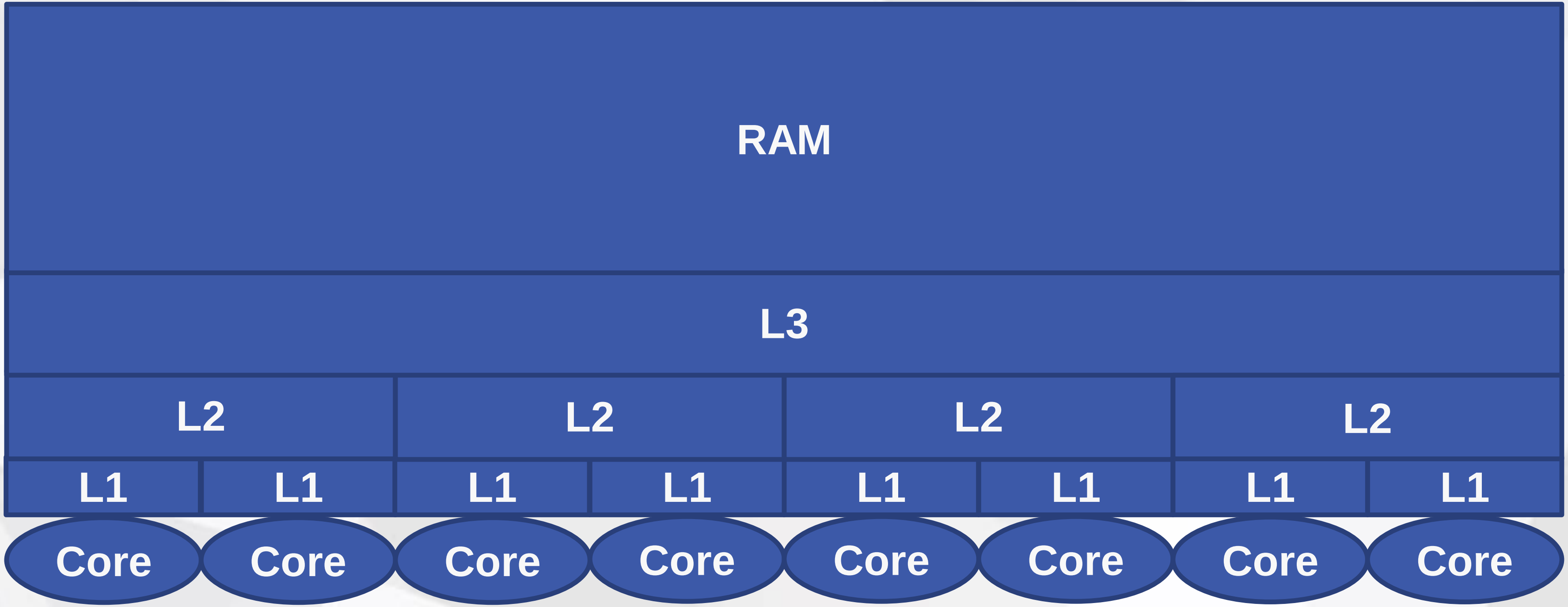
L1 L1 L1 L1 L1 L1

Core Core Core Core Core Core

Cache



Console Reality



RAM

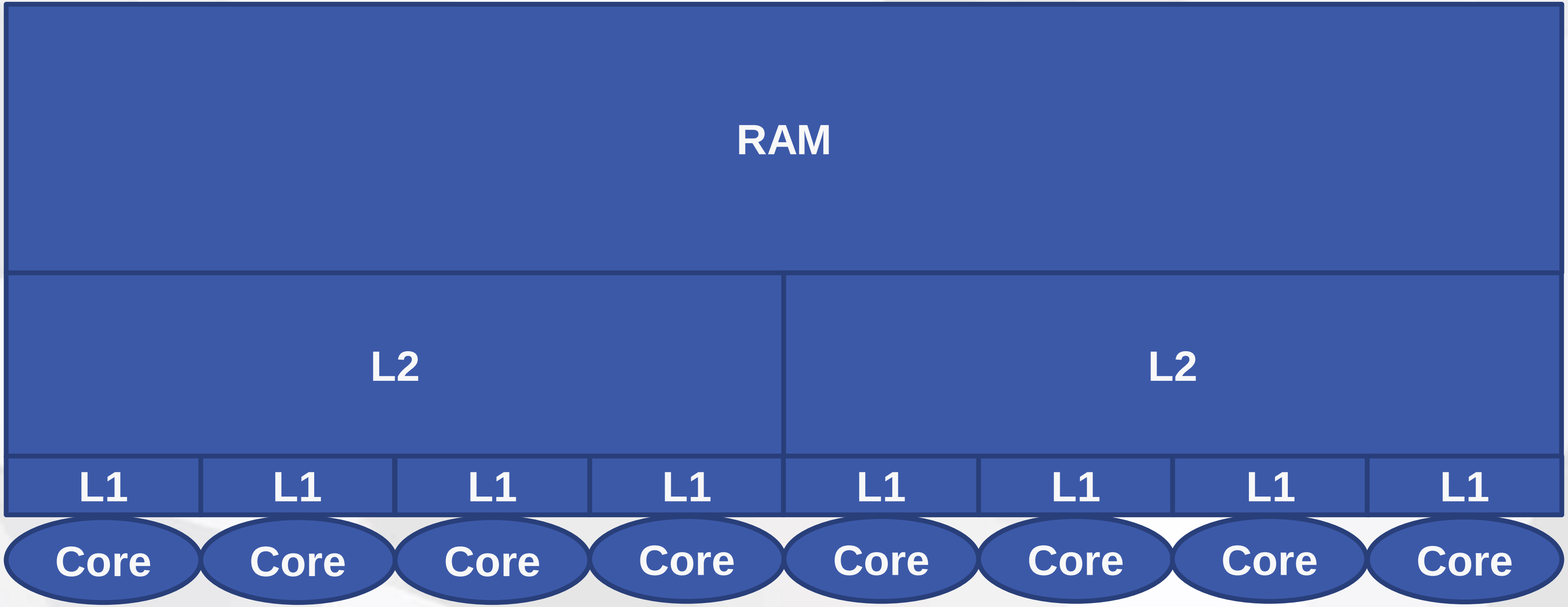
L3

L2 L2 L2 L2

L1 L1 L1 L1 L1 L1 L1 L1

Core Core Core Core Core Core Core Core

Console Reality



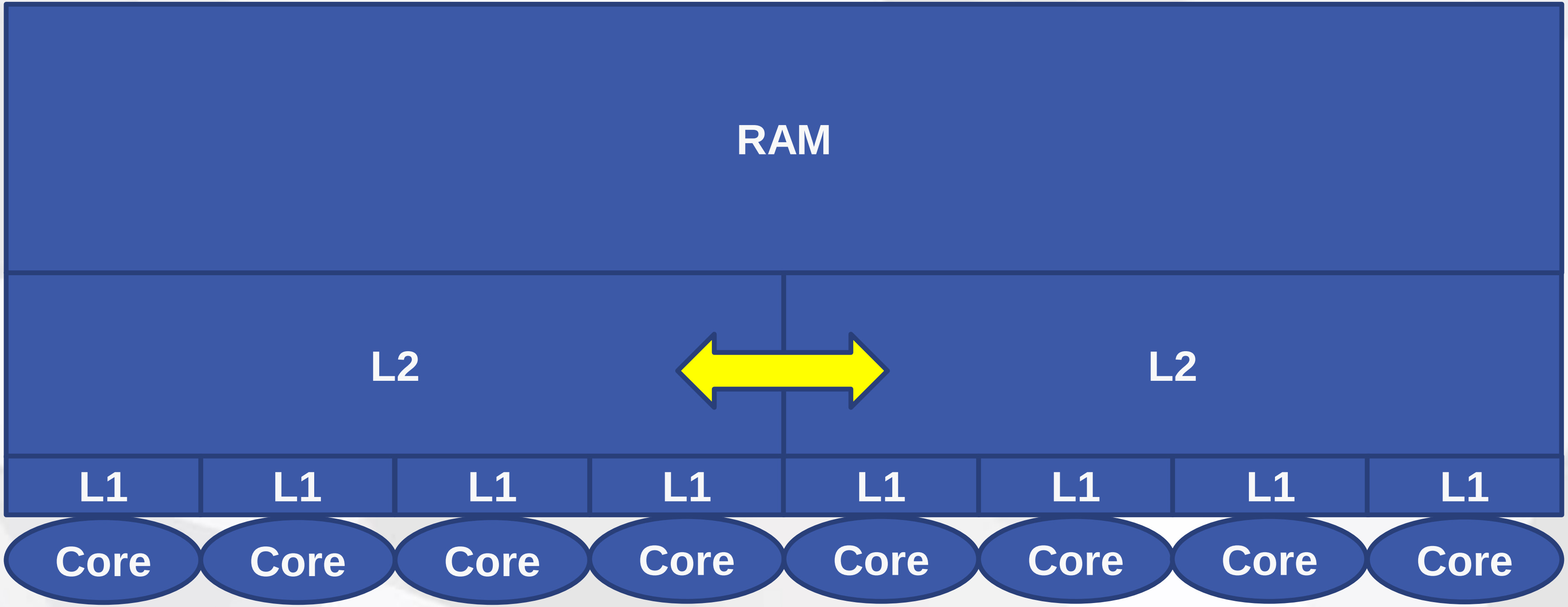
RAM

L2 L2

L1 L1 L1 L1 L1 L1 L1 L1

Core Core Core Core Core Core Core Core

Console Reality


RAM

L2

L2

L1

L1

L1

L1

L1

L1

L1

L1

Core

Core

Core

Core

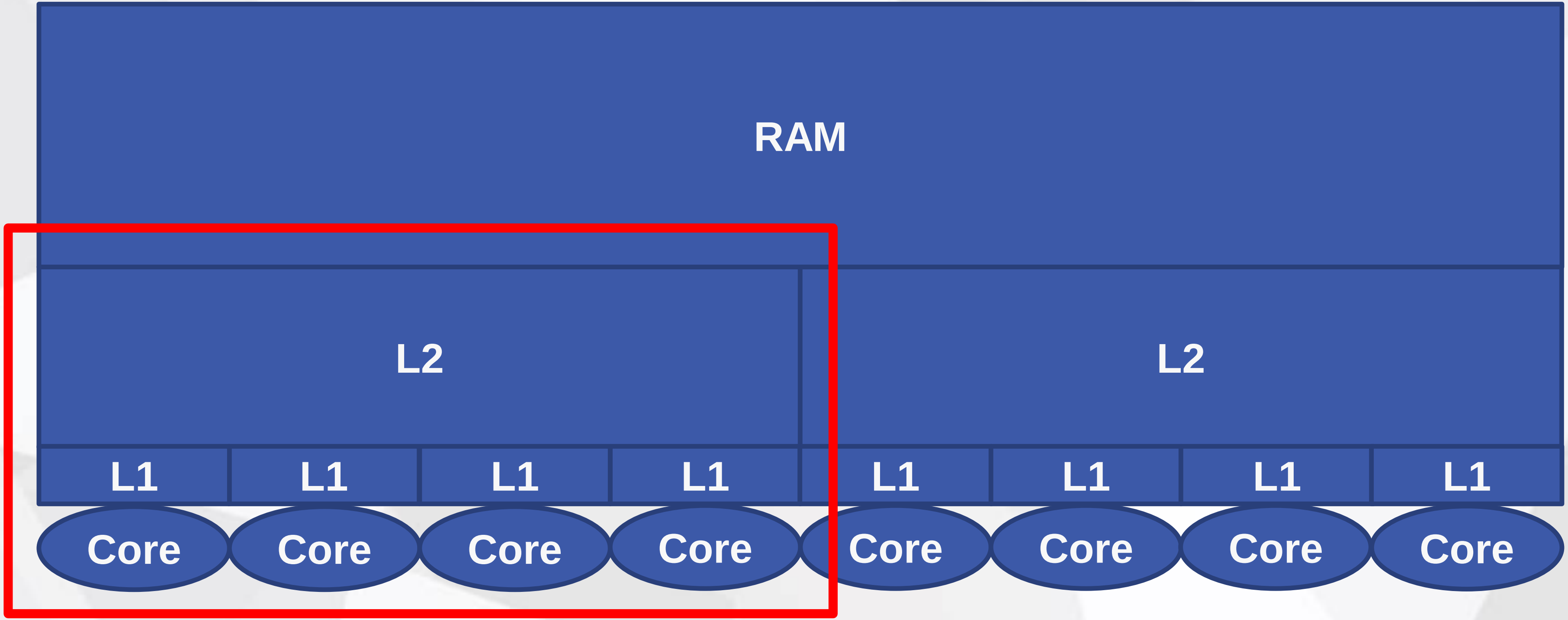
Core

Core

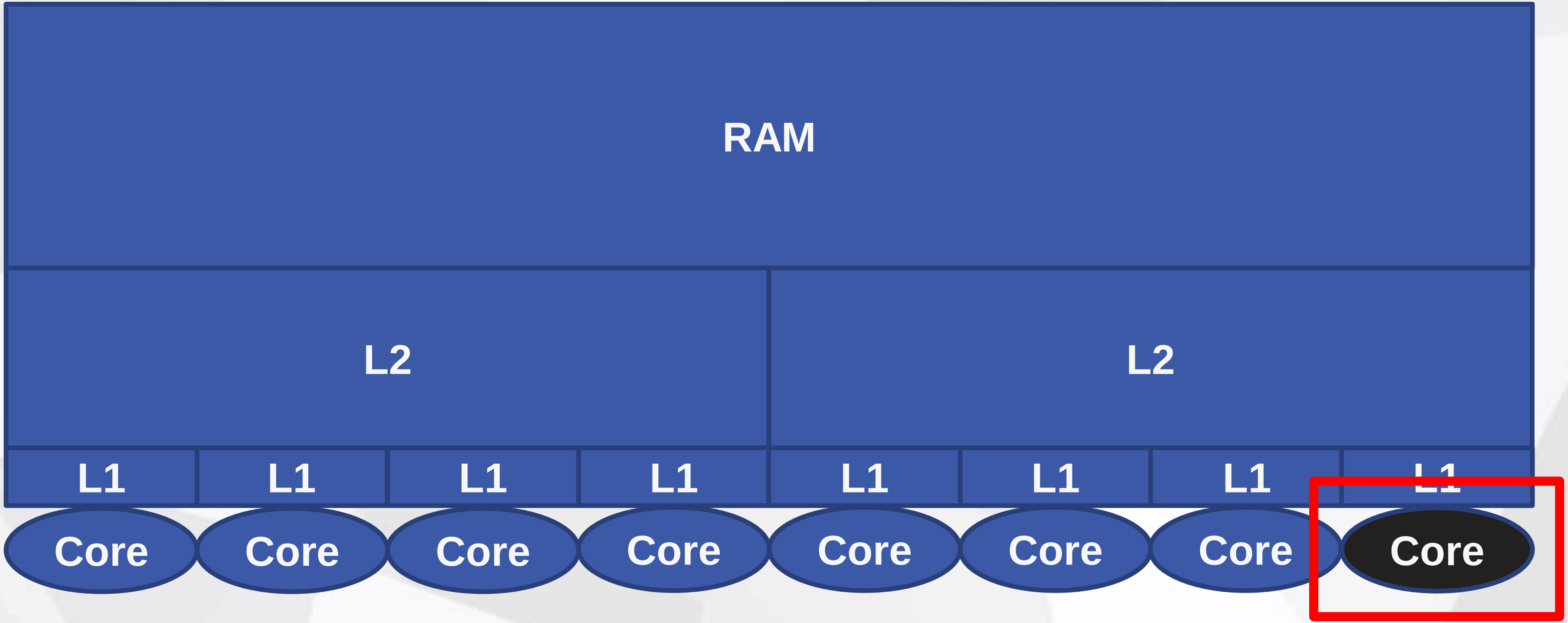
Core

Core

Console Reality



Console Reality



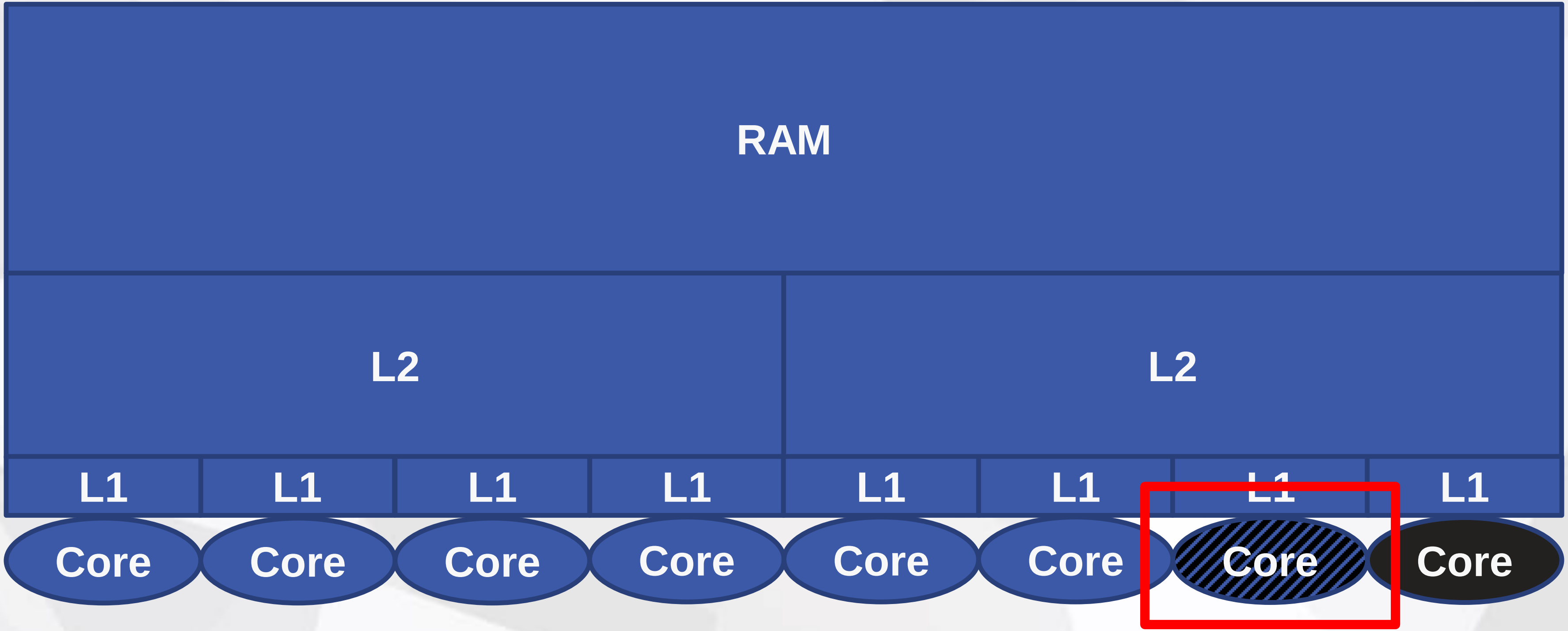
RAM

L2 L2

L1 L1 L1 L1 L1 L1 L1 L1

Core Core Core Core Core Core Core Core

Console Reality



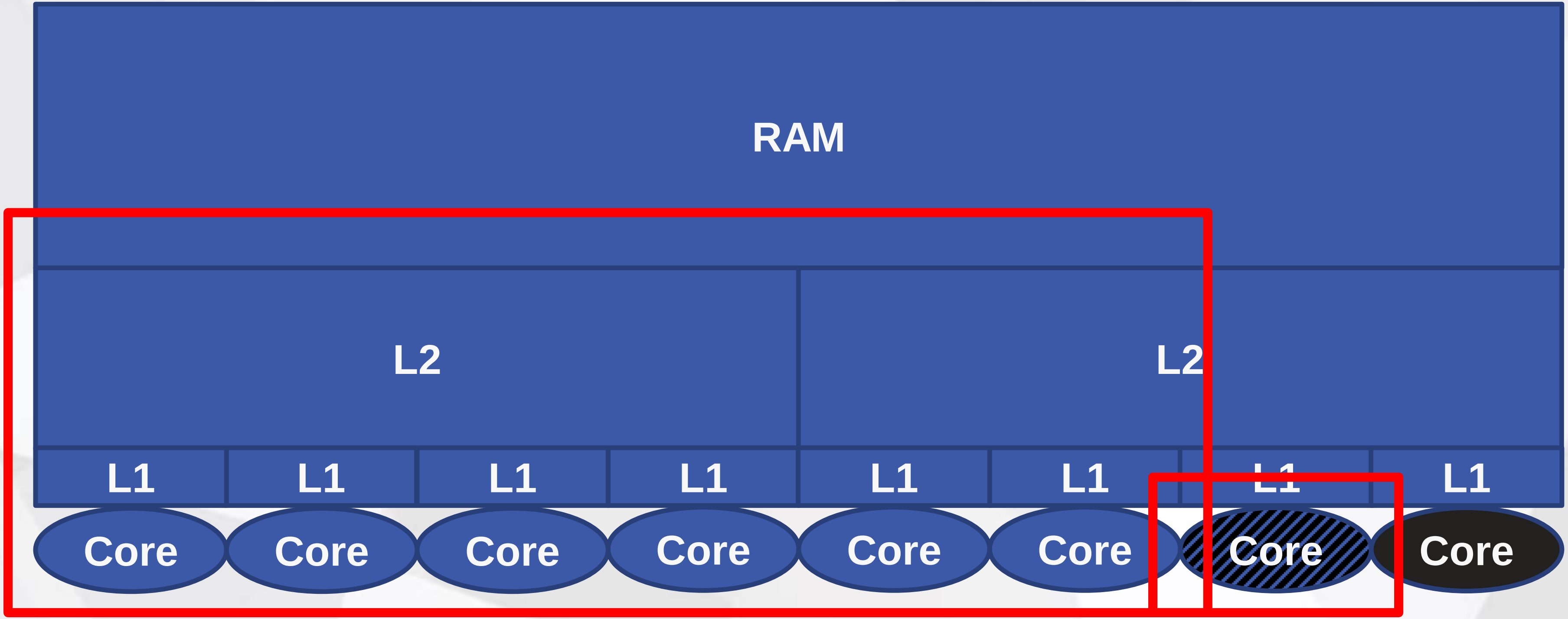
RAM

L2 L2

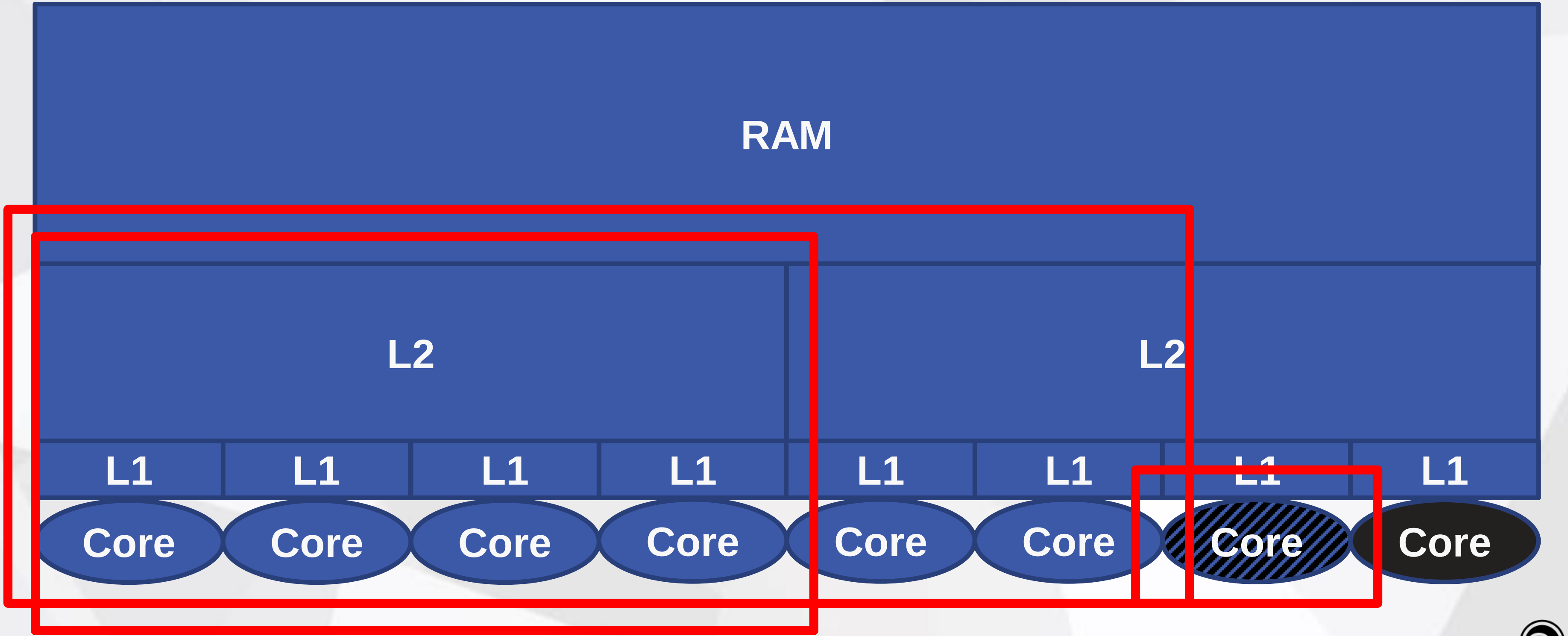
L1 L1 L1 L1 L1 L1 L1 L1

Core Core Core Core Core Core Core Core

Console Reality



Console Reality



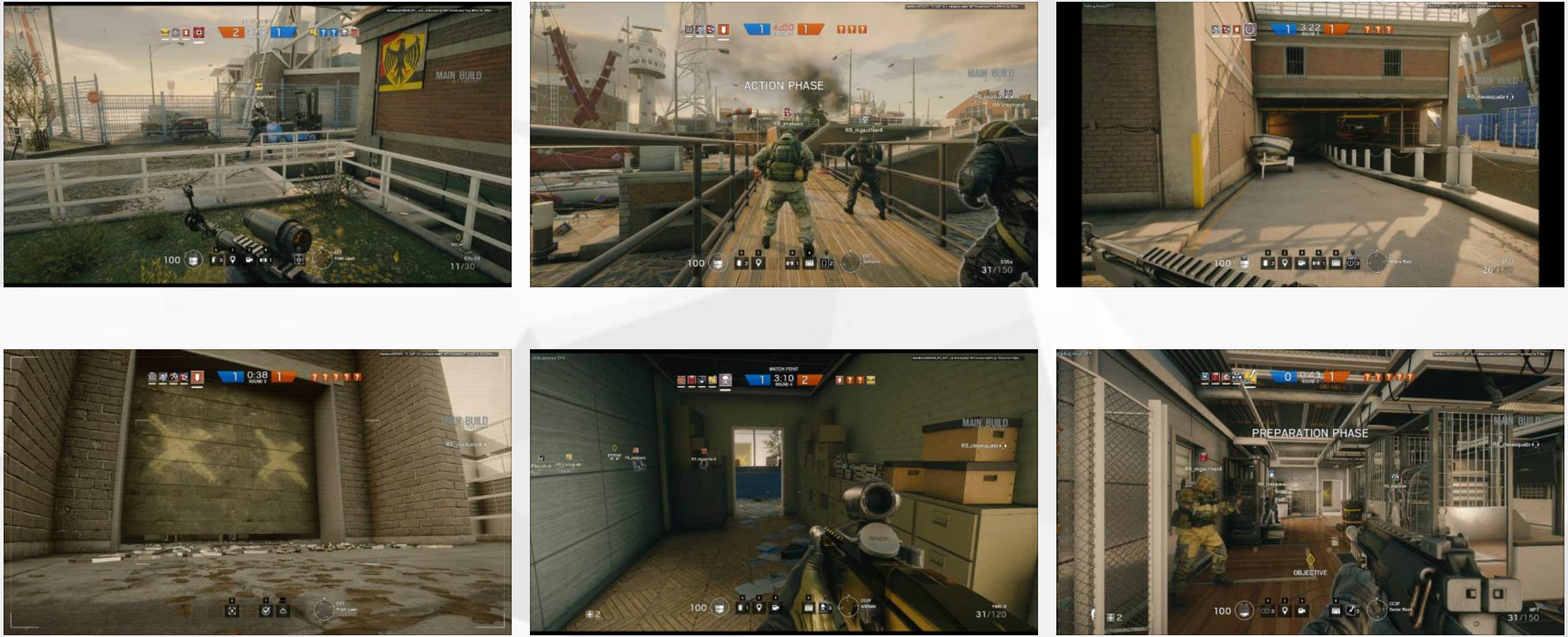
Targets

- Debug (/Ob1)
- Release (asserts and debug tools)
- Profile
- Final

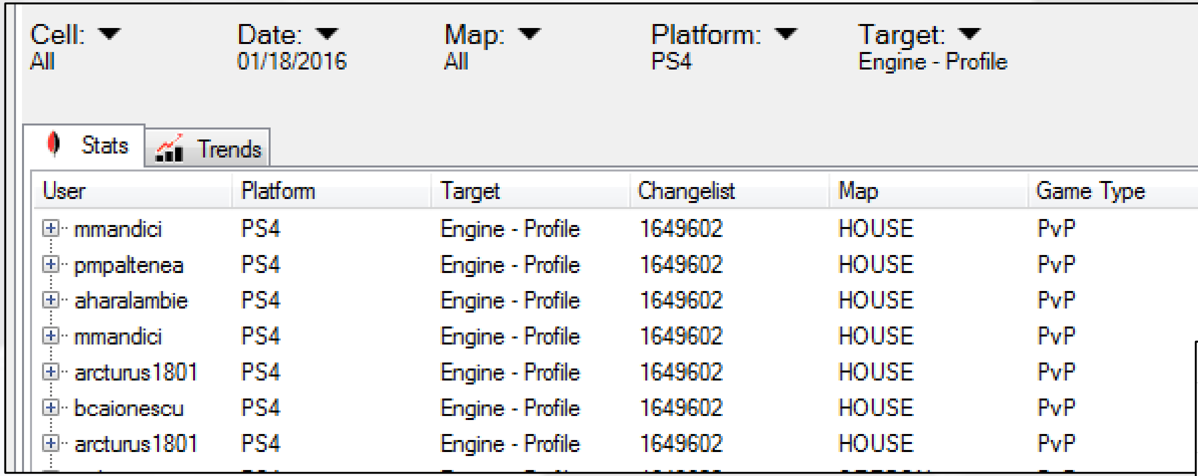
Unified Telemetry

- Single channel for all telemetry data
- Universal timestamping across different processes and machines
- Can be both local or on server

Profiling Workflow



Profiling Workflow



Cell: All

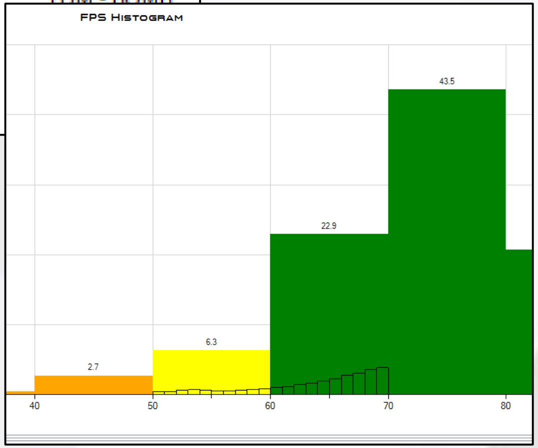
Date: 01/18/2016

Map: All

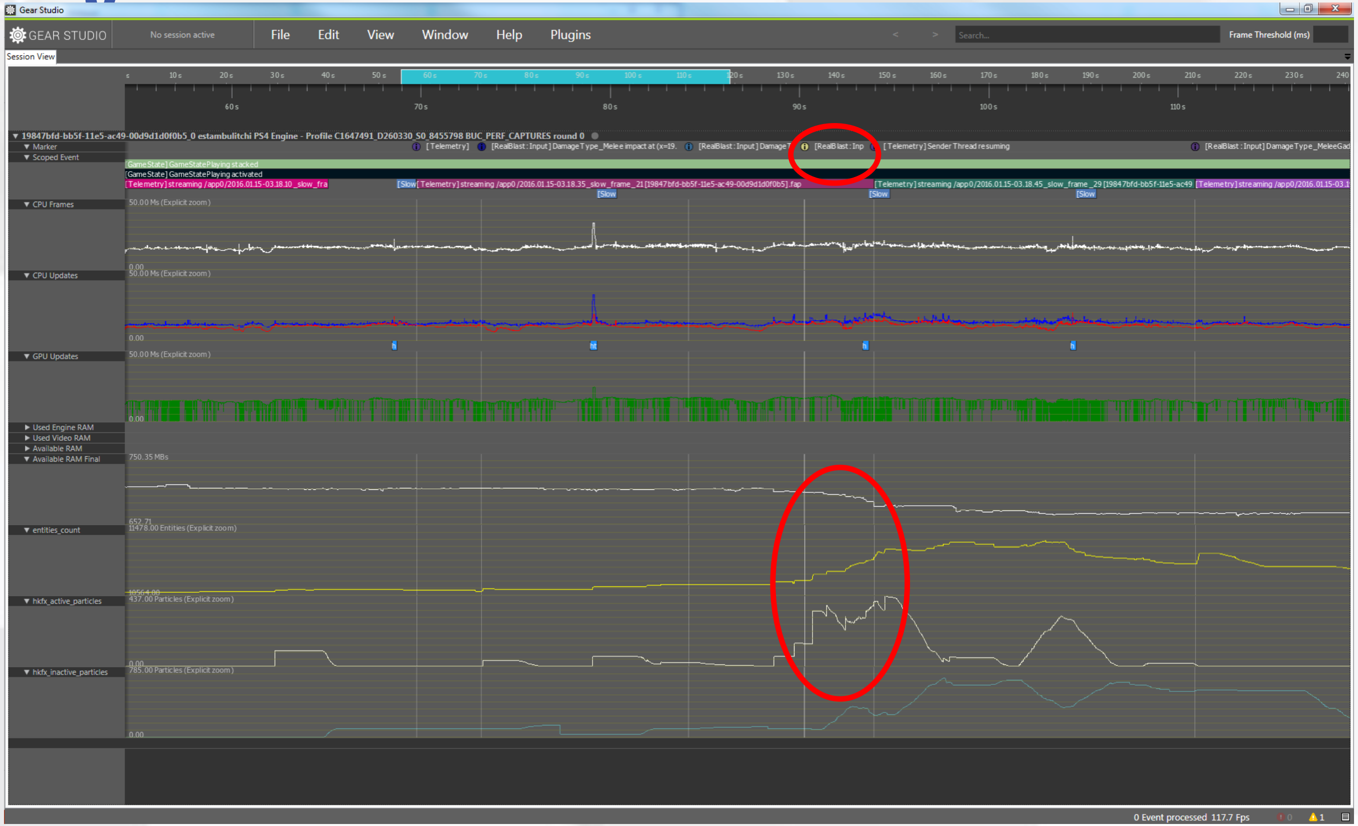
Platform: PS4

Target: Engine - Profile

User	Platform	Target	Changelist	Map	Game Type	Game Mode
mmandici	PS4	Engine - Profile	1649602	HOUSE	PvP	TDM - BOMB
pmpaltenea	PS4	Engine - Profile	1649602	HOUSE	PvP	TDM - BOMB
aharalambie	PS4	Engine - Profile	1649602	HOUSE	PvP	TDM - BOMB
mmandici	PS4	Engine - Profile	1649602	HOUSE	PvP	TDM - BOMB
arcturus1801	PS4	Engine - Profile	1649602	HOUSE	PvP	
bcaionescu	PS4	Engine - Profile	1649602	HOUSE	PvP	
arcturus1801	PS4	Engine - Profile	1649602	HOUSE	PvP	



Profiling Workflow



19847bfd-bb5f-11e5-ac49-00d9d1d0f0b5_0 estambulitchi PS4 Engine - Profile C1647491_D260330_S0_8455798 BUC_PERF_CAPTURES round 0

[Telemetry] [RealBlast : Input] DamageType_Melee impact at (x=19. [RealBlast : Input] DamageT [RealBlast : Inp [Telemetry] Sender Thread resuming [RealBlast : Input] DamageType_MeleeGad

[GameState] GameStatePlaying stacked

[GameState] GameStatePlaying activated

[Telemetry] streaming /app0/2016.01.15-03.18.10 _slow_fra [Slow [Telemetry] streaming /app0/2016.01.15-03.18.35_slow_frame_21 [19847bfd-bb5f-11e5-ac49-00d9d1d0f0b5].fap [Telemetry] streaming /app0/2016.01.15-03.18.45_slow_frame_29 [19847bfd-bb5f-11e5-ac49 [Telemetry] streaming /app0/2016.01.15-03.1

[Slow [Slow [Slow

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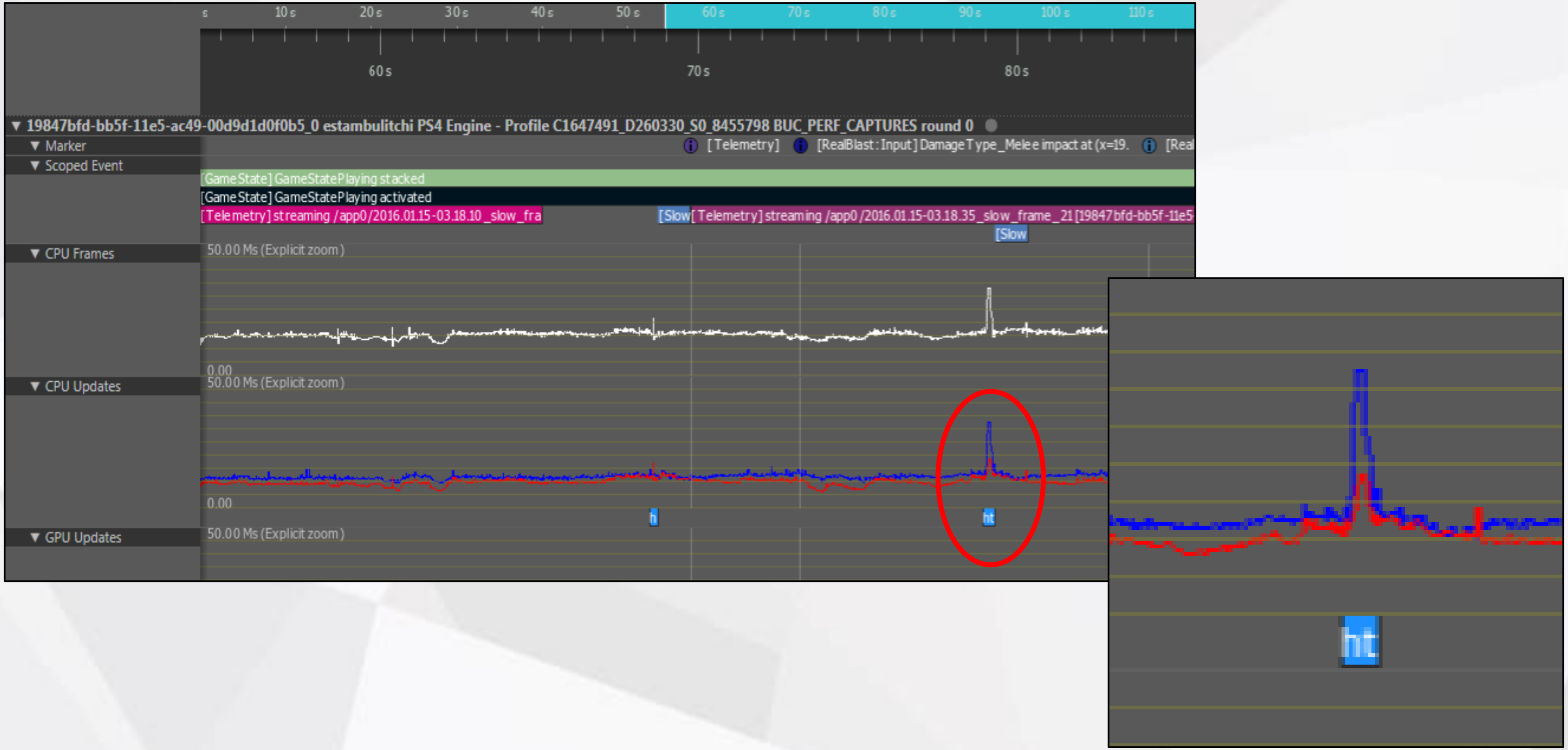
Profiling Workflow



▼ 19847bfd-bb5f-11e5-ac49-00d9d1d0f0b5_0 estambulitchi PS4 Engine - Profile C1647491_D260330_S0_8455798 BUC_PERF_CAPTURES round 0

[Telemetry] [RealBlast : Input] DamageType_Melee impact at (x=19. [Real

[GameState] GameStatePlaying stacked

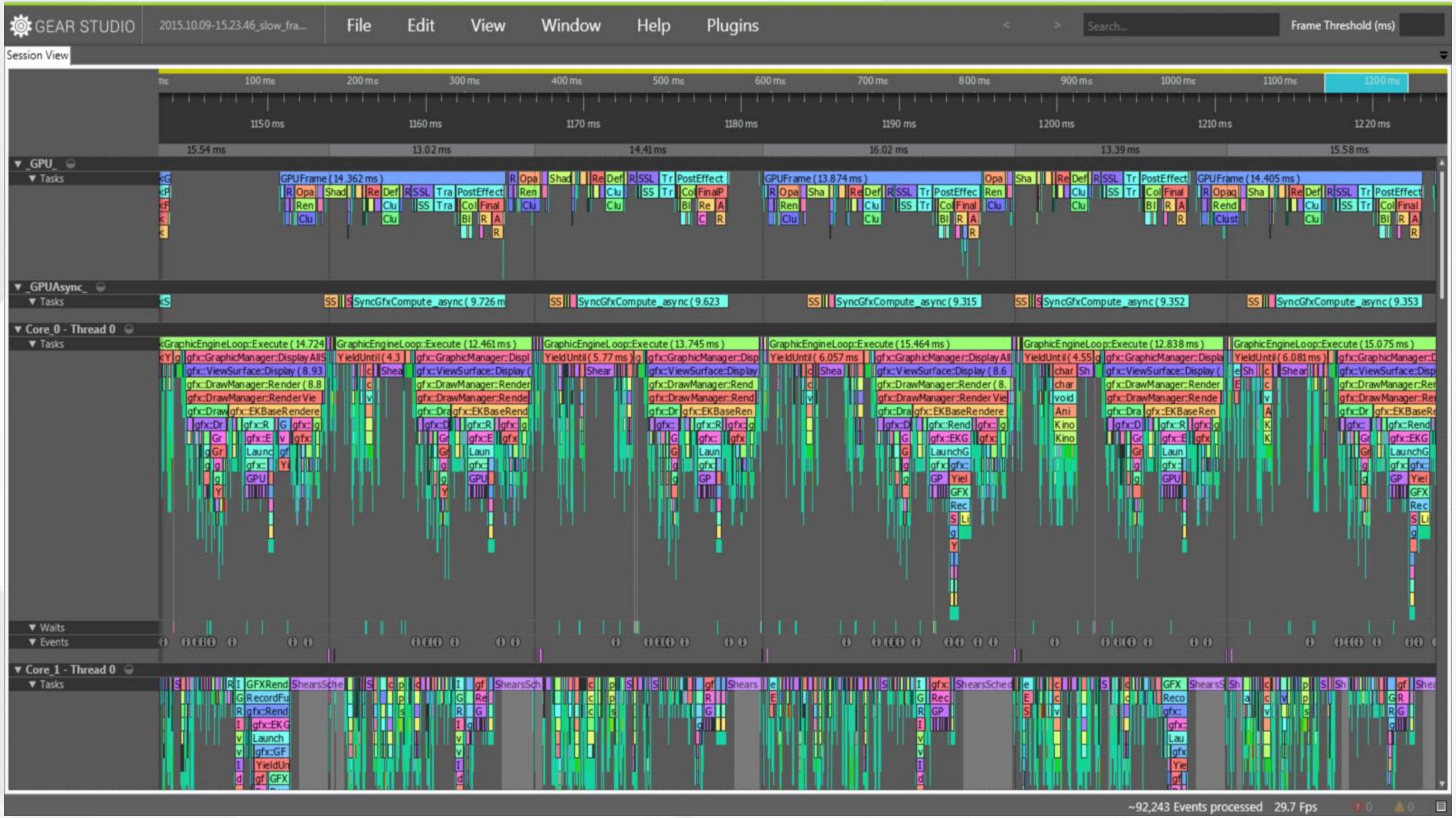
[GameState] GameStatePlaying activated

[Telemetry] streaming /app0/2016.01.15-03.18.10 _slow_fra

[Slow[Telemetry] streaming /app0/2016.01.15-03.18.35 _slow_frame_21 [19847bfd-bb5f-11e5

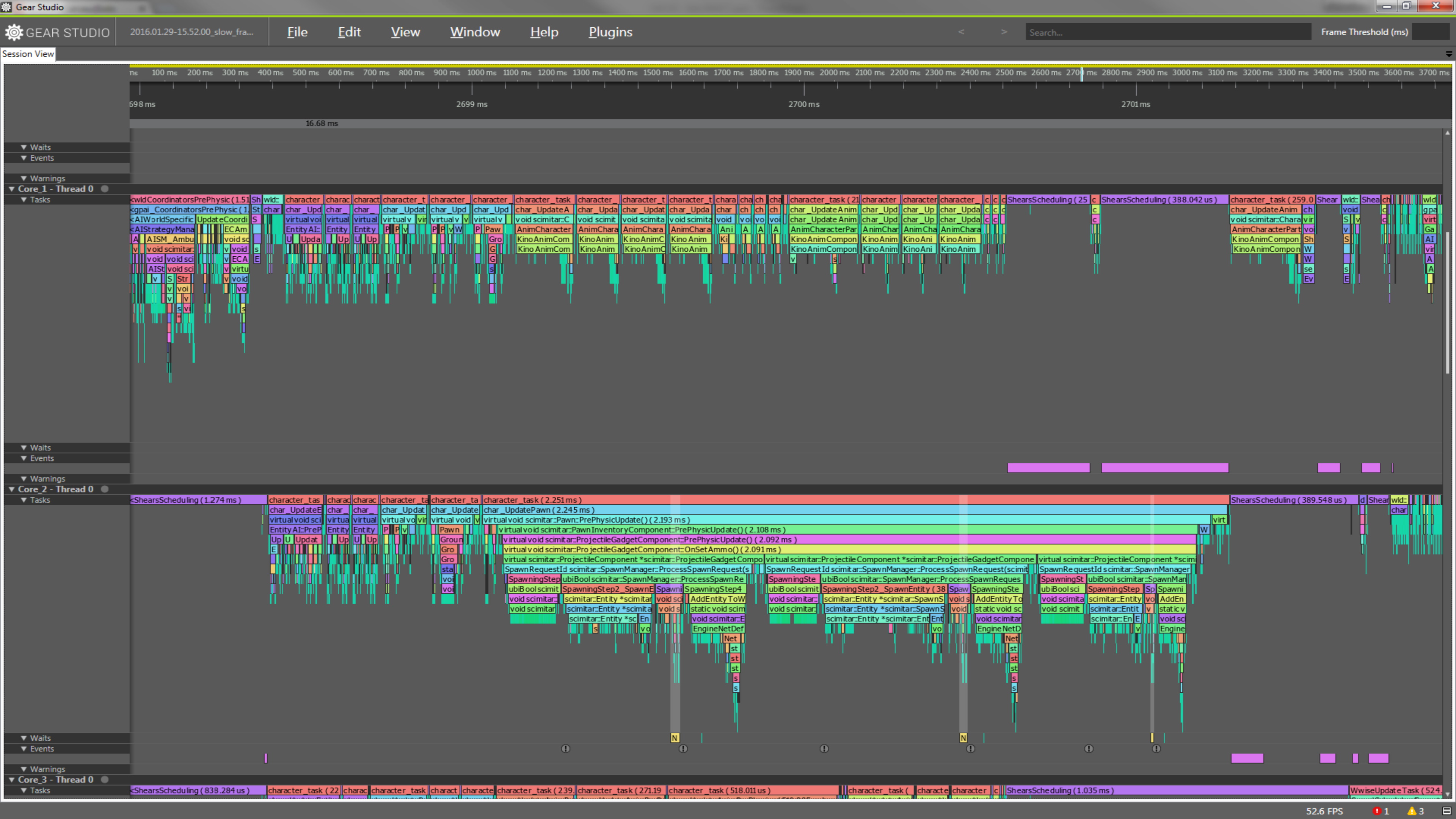
[Slow

Profiling Workflow



Profiling with Tags

```
void Foo()
{
    ubiProfile(Foo);
    for(int i = 0; i < 10; ++i) {
        ubiProfileEvent(Processing);
    }
}
```


Gear Studio
GEAR STUDIO
2016.01.29-15.52.00_slow_fra...
File
Edit
View
Window
Help
Plugins
Search...
Frame Threshold (ms)
Session View
698 ms
2699 ms
2700 ms
2701 ms
16.68 ms
Waits
Events
Warnings
Core_1 - Thread 0
Tasks
<wldCoordinatorsPrePhysic (1.51
<gpai_CoordinatorsPrePhysic (1.
<AIWorldSpecific
<AIStrategyMana
AISM_Ambu
character_task
char_UpdateAnim
AnimCharacterPar
KinoAnimCompon
ShearsScheduling (25
ShearsScheduling (388.042 us)
character_task (259.0
void scimitar::Chara
AnimCharacterPart
Core_2 - Thread 0
<ShearsScheduling (1.274 ms)
character_task (2.251 ms)
char_UpdatePawn (2.245 ms)
virtual void scimitar::Pawn::PrePhysicUpdate() (2.193 ms)
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (2.108 ms)
virtual void scimitar::ProjectileGadgetComponent::PrePhysicUpdate() (2.092 ms)
virtual void scimitar::ProjectileGadgetComponent::OnSetAmmo() (2.091 ms)
virtual scimitar::ProjectileComponent *scimitar::ProjectileGadgetCompo
SpawnRequestId scimitar::SpawnManager::ProcessSpawnRequest(s
ubiBool scimitar::SpawnManager::ProcessSpawnRe
SpawningStep2_SpawnEntity (38
scimitar::Entity *scimitar::SpawnS
AddEntityToW
static void scim
EngineNetDef
ShearsScheduling (389.548 us)
Core_3 - Thread 0
<ShearsScheduling (838.284 us)
character_task (239.
character_task (271.19
character_task (518.011 us)
ShearsScheduling (1.035 ms)
WwiseUpdateTask (524.
52.6 FPS
1
3

Profiling with Tags

- Allows printf() style tags

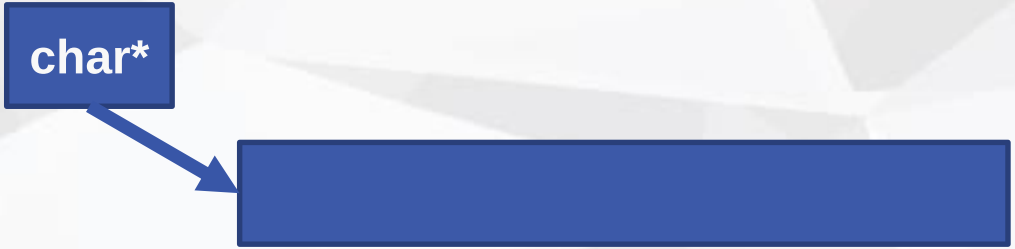
```
ubiProfileFormat("Processing asset: %s", assetName);
```

Profiling with Tags

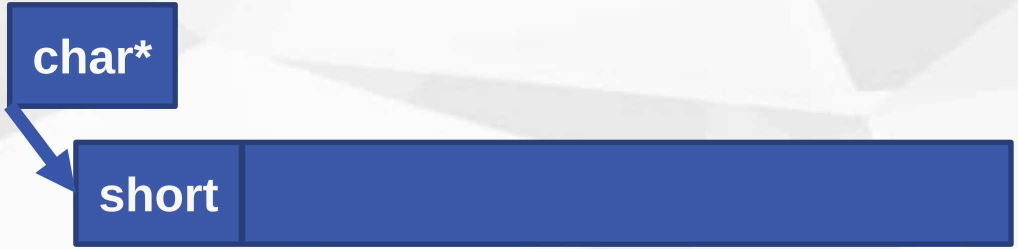
- Low cpu overhead (< 200 cycles on PC)
- Low memory usage (< 8 bytes on average)
- Context switches
- Deadlock snapshot
- Low frequency counters (graphs)

Improving Performance => Measurements

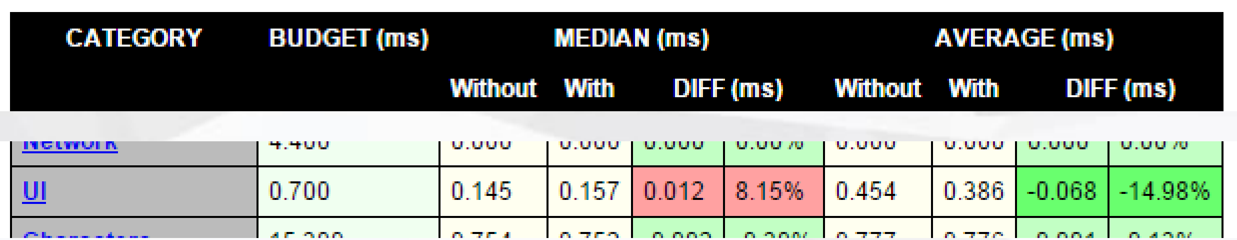
scimitar::SimpleString



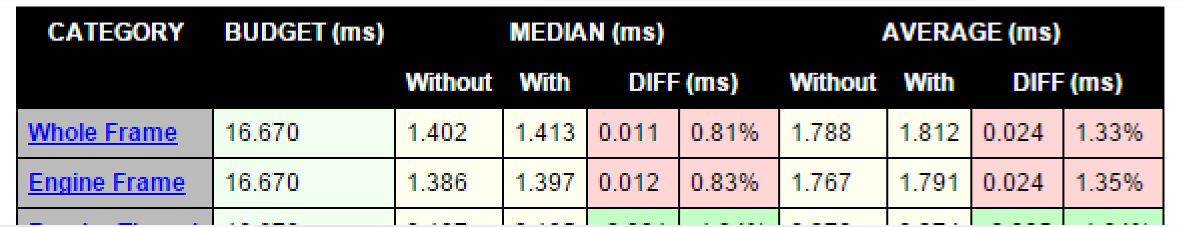
scimitar::SimpleString



scimitar::SimpleString



CATEGORY	BUDGET (ms)	MEDIAN (ms)				AVERAGE (ms)			
		Without	With	DIFF (ms)		Without	With	DIFF (ms)	
Network	4.400	0.000	0.000	0.000	0.00%	0.000	0.000	0.000	0.00%
UI	0.700	0.145	0.157	0.012	8.15%	0.454	0.386	-0.068	-14.98%

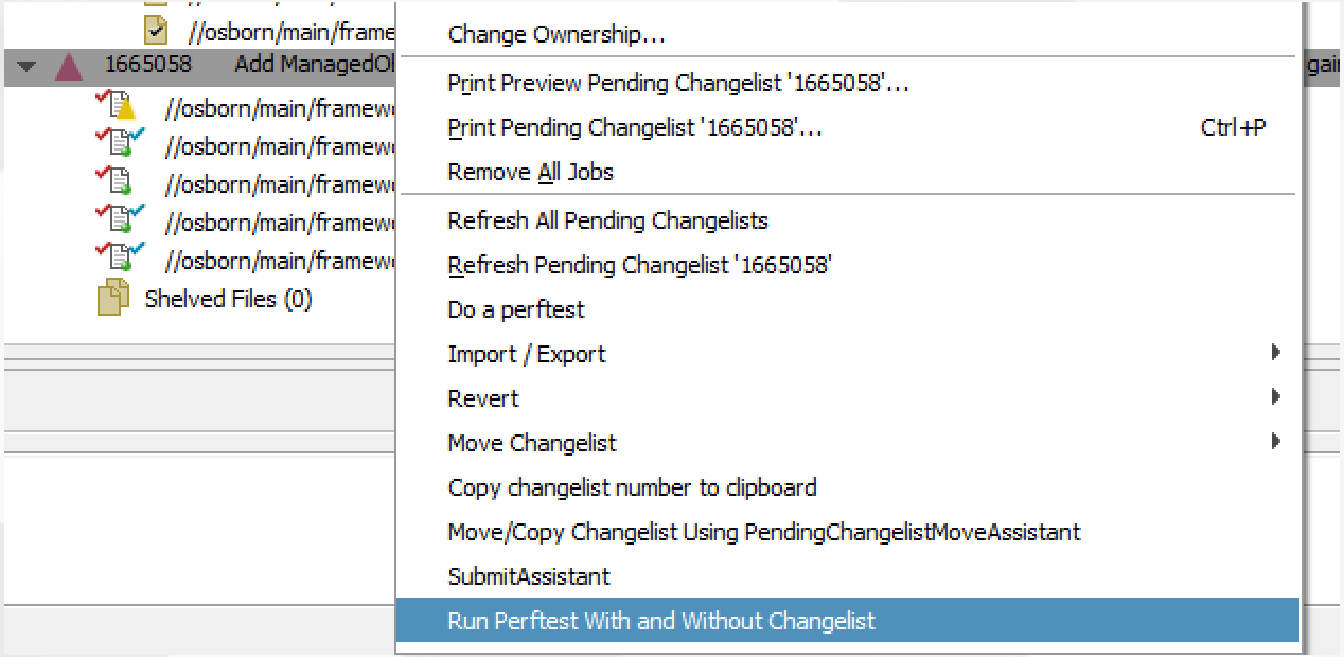


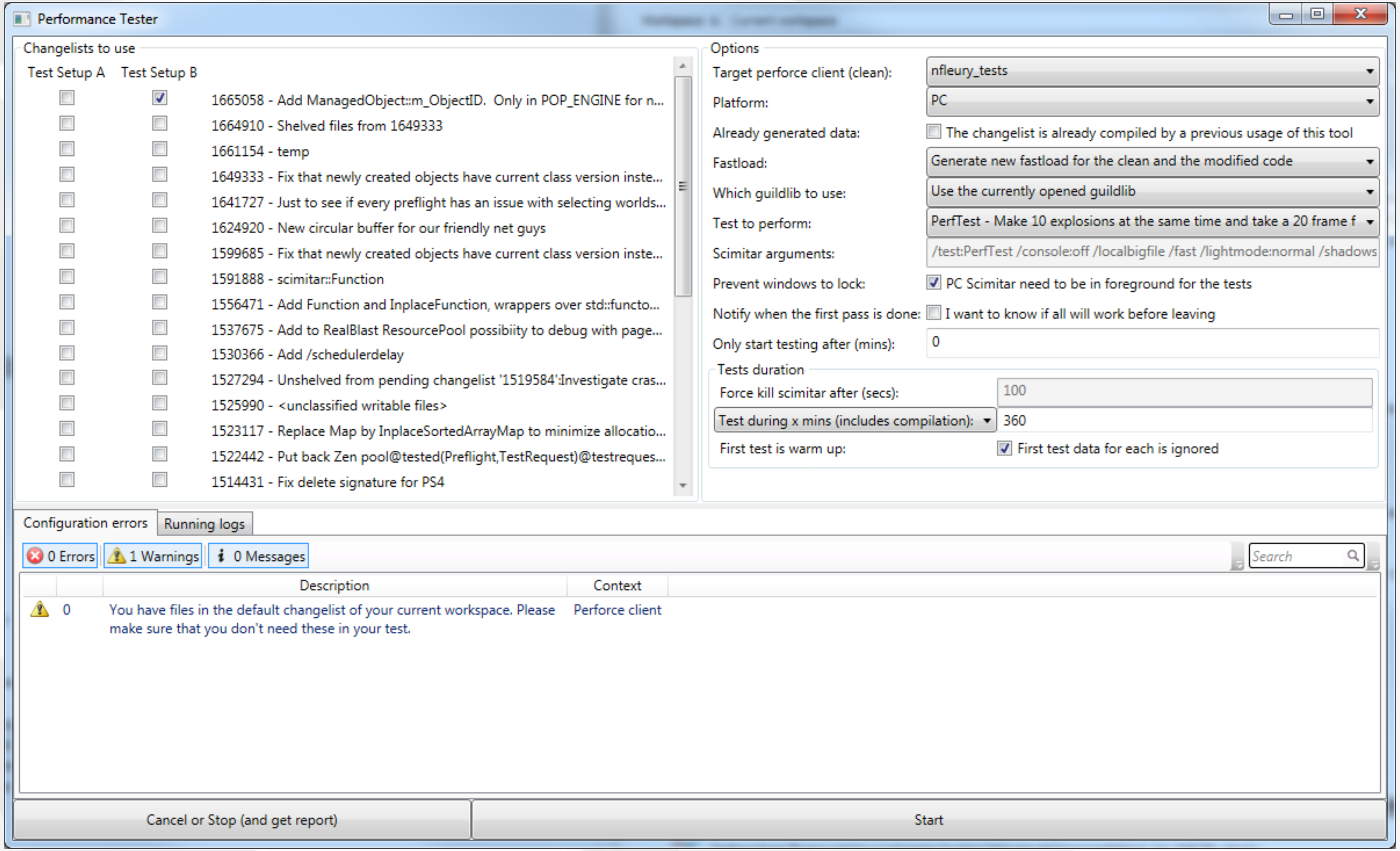
CATEGORY	BUDGET (ms)	MEDIAN (ms)				AVERAGE (ms)			
		Without	With	DIFF (ms)		Without	With	DIFF (ms)	
Whole Frame	16.670	1.402	1.413	0.011	0.81%	1.788	1.812	0.024	1.33%
Engine Frame	16.670	1.386	1.397	0.012	0.83%	1.767	1.791	0.024	1.35%

InplaceString Example

```
const char* Func()
{
    InplaceString<256> str;
    ...
    return StringFormat("%s", str.GetBuffer());
}
```

Performance Tester


//osborn/main/frame
1665058
Add ManagedOl
gai
//osborn/main/framew
//osborn/main/framew
//osborn/main/framew
//osborn/main/framew
//osborn/main/framew
Shelved Files (0)
Change Ownership...
Print Preview Pending Changelist '1665058'...
Print Pending Changelist '1665058'...
Ctrl+P
Remove All Jobs
Refresh All Pending Changelists
Refresh Pending Changelist '1665058'
Do a perftest
Import / Export
Revert
Move Changelist
Copy changelist number to clipboard
Move/Copy Changelist Using PendingChangelistMoveAssistant
SubmitAssistant
Run Perftest With and Without Changelist



Performance Tester

Changelists to use

Test Setup A	Test Setup B	
□	☑	1665058 - Add ManagedObject::m_ObjectID. Only in POP_ENGINE for n...
□	□	1664910 - Shelved files from 1649333
□	□	1661154 - temp
□	□	1649333 - Fix that newly created objects have current class version inste...
□	□	1641727 - Just to see if every preflight has an issue with selecting worlds...
□	□	1624920 - New circular buffer for our friendly net guys
□	□	1599685 - Fix that newly created objects have current class version inste...
□	□	1591888 - scimitar::Function
□	□	1556471 - Add Function and InplaceFunction, wrappers over std::functo...
□	□	1537675 - Add to RealBlast ResourcePool possibiity to debug with page...
□	□	1530366 - Add /schedulerdelay
□	□	1527294 - Unshelved from pending changelist '1519584':Investigate cras...
□	□	1525990 - <unclassified writable files>
□	□	1523117 - Replace Map by InplaceSortedArrayMap to minimize allocatio...
□	□	1522442 - Put back Zen pool@tested(Preflight,TestRequest)@testreques...
□	□	1514431 - Fix delete signature for PS4

Options

Target perforce client (clean): nfleury_tests

Platform: PC

Already generated data: □ The changelist is already compiled by a previous usage of this tool

Fastload: Generate new fastload for the clean and the modified code

Which guildlib to use: Use the currently opened guildlib

Test to perform: PerfTest - Make 10 explosions at the same time and take a 20 frame f

Scimitar arguments: /test:PerfTest /console:off /localbigfile /fast /lightmode:normal /shadows

Prevent windows to lock: ☑ PC Scimitar need to be in foreground for the tests

Notify when the first pass is done: □ I want to know if all will work before leaving

Only start testing after (mins): 0

Tests duration

Force kill scimitar after (secs): 100

Test during x mins (includes compilation): 360

First test is warm up: ☑ First test data for each is ignored

		Description	Context
⚠	0	You have files in the default changelist of your current workspace. Please make sure that you don't need these in your test.	Perforce client

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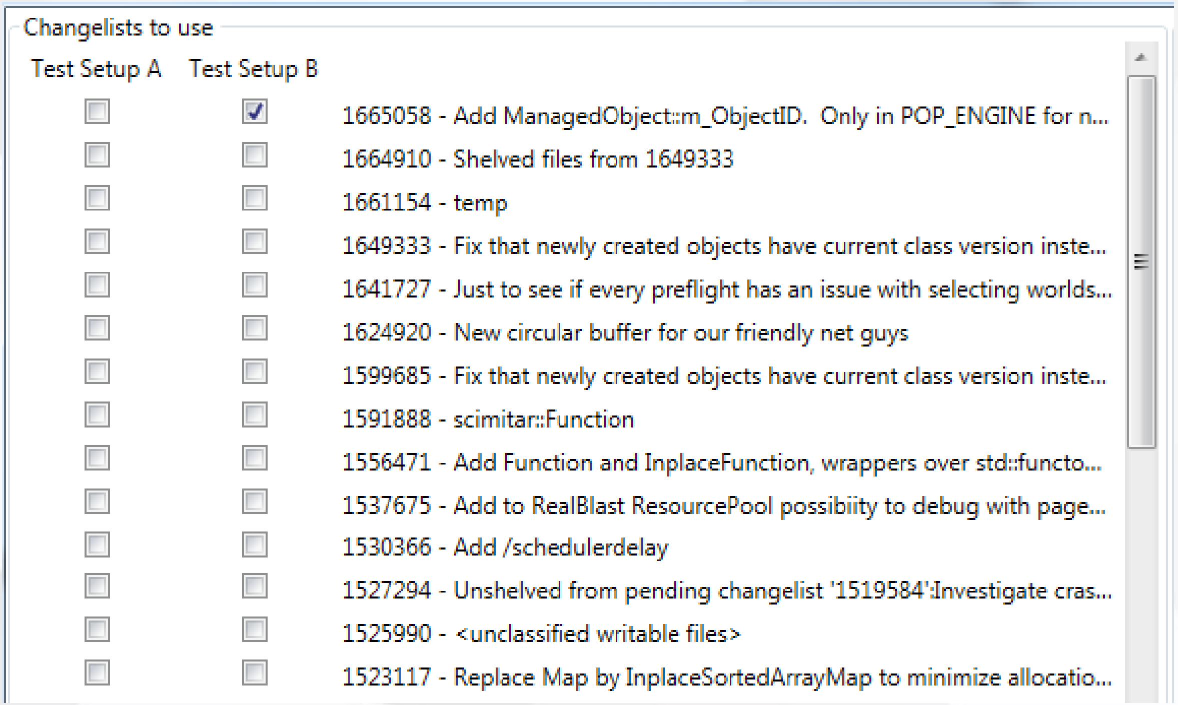
Performance Tester



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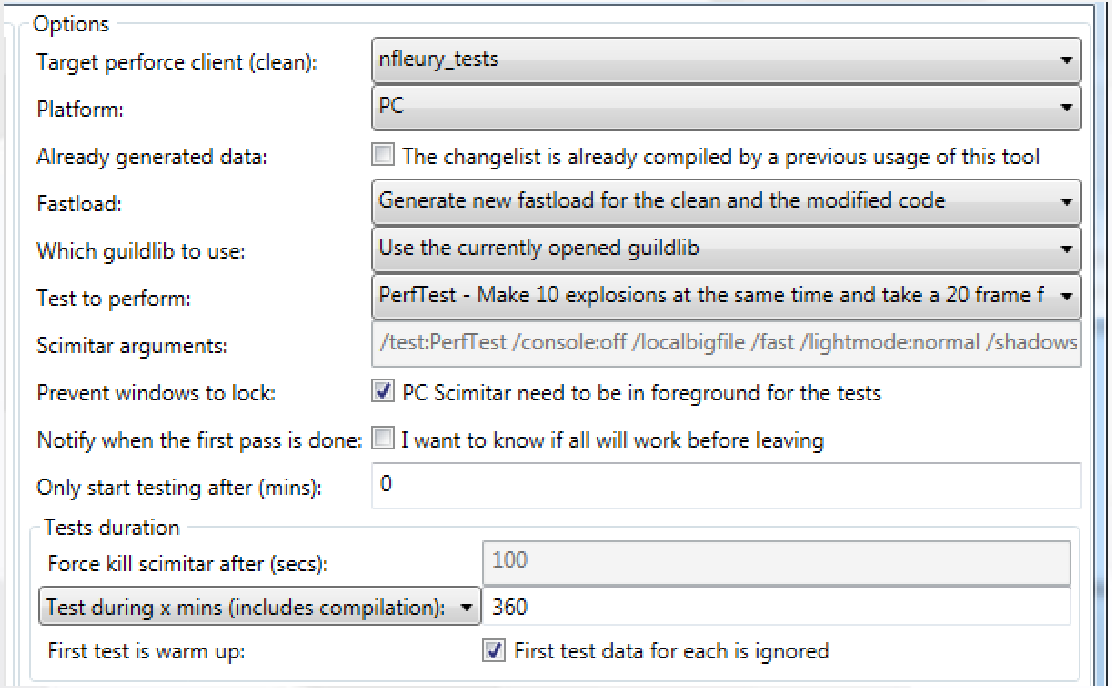
Performance Tester



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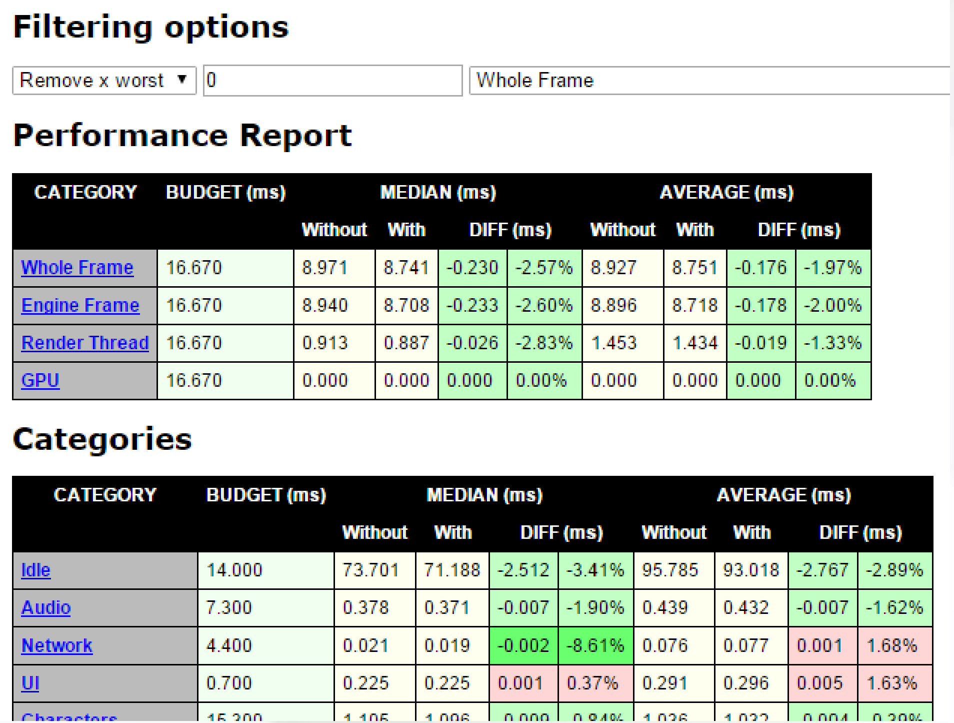
Notify when the first pass is done:	□ I want to know if all will work before leaving
Only start testing after (mins):	0

Tests duration

Force kill scimitar after (secs):	100
Test during x mins (includes compilation):	360
First test is warm up:	☑ First test data for each is ignored

Performance Tester



Filtering options

Remove x worst ▾ | 0 | Whole Frame

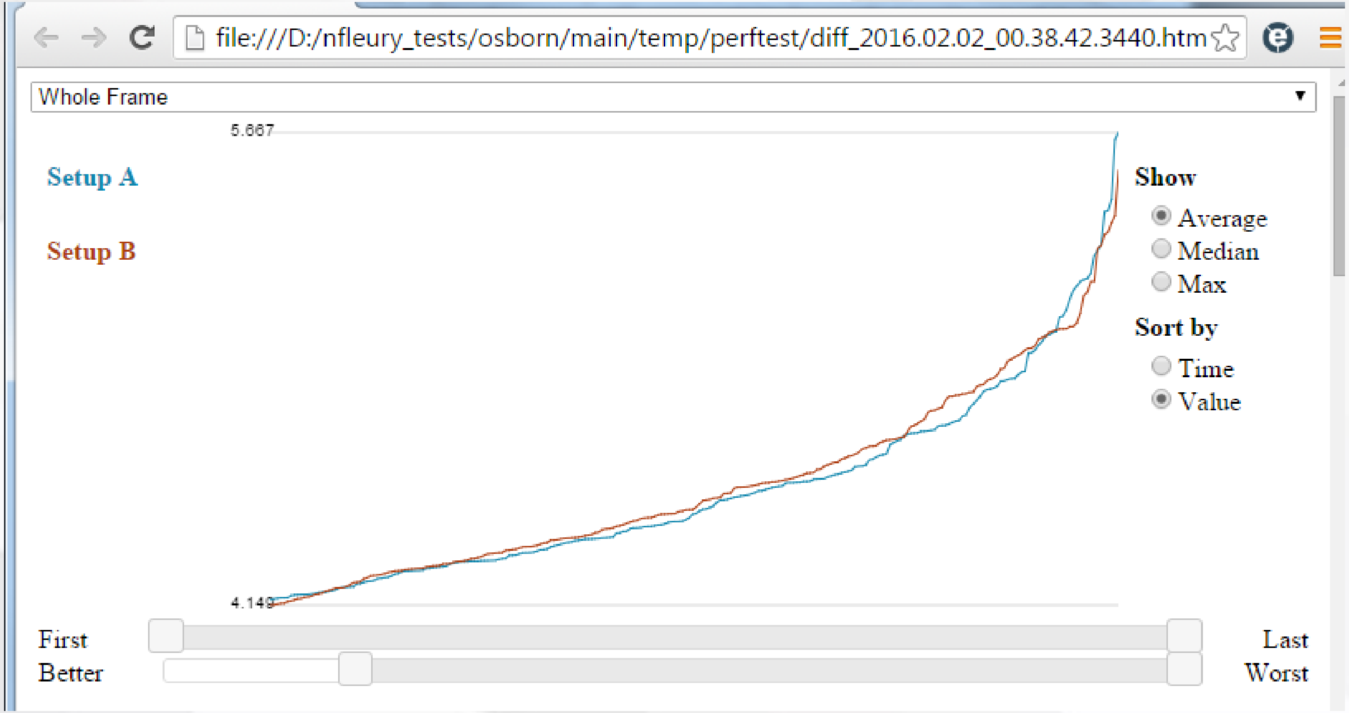
Performance Report

CATEGORY	BUDGET (ms)	MEDIAN (ms)				AVERAGE (ms)			
		Without	With	DIFF (ms)		Without	With	DIFF (ms)	
Whole Frame	16.670	8.971	8.741	-0.230	-2.57%	8.927	8.751	-0.176	-1.97%
Engine Frame	16.670	8.940	8.708	-0.233	-2.60%	8.896	8.718	-0.178	-2.00%
Render Thread	16.670	0.913	0.887	-0.026	-2.83%	1.453	1.434	-0.019	-1.33%
GPU	16.670	0.000	0.000	0.000	0.00%	0.000	0.000	0.000	0.00%

Categories

CATEGORY	BUDGET (ms)	MEDIAN (ms)				AVERAGE (ms)			
		Without	With	DIFF (ms)		Without	With	DIFF (ms)	
Idle	14.000	73.701	71.188	-2.512	-3.41%	95.785	93.018	-2.767	-2.89%
Audio	7.300	0.378	0.371	-0.007	-1.90%	0.439	0.432	-0.007	-1.62%
Network	4.400	0.021	0.019	-0.002	-8.61%	0.076	0.077	0.001	1.68%
UI	0.700	0.225	0.225	0.001	0.37%	0.291	0.296	0.005	1.63%
Characters	15.300	1.105	1.096	-0.009	-0.84%	1.036	1.032	-0.004	-0.39%

Performance Tester



file:///D:/nfleury_tests/osborn/main/temp/perftest/diff_2016.02.02_00.38.42.3440.htm

Whole Frame ▾

Show

● Average
○ Median
○ Max

Sort by

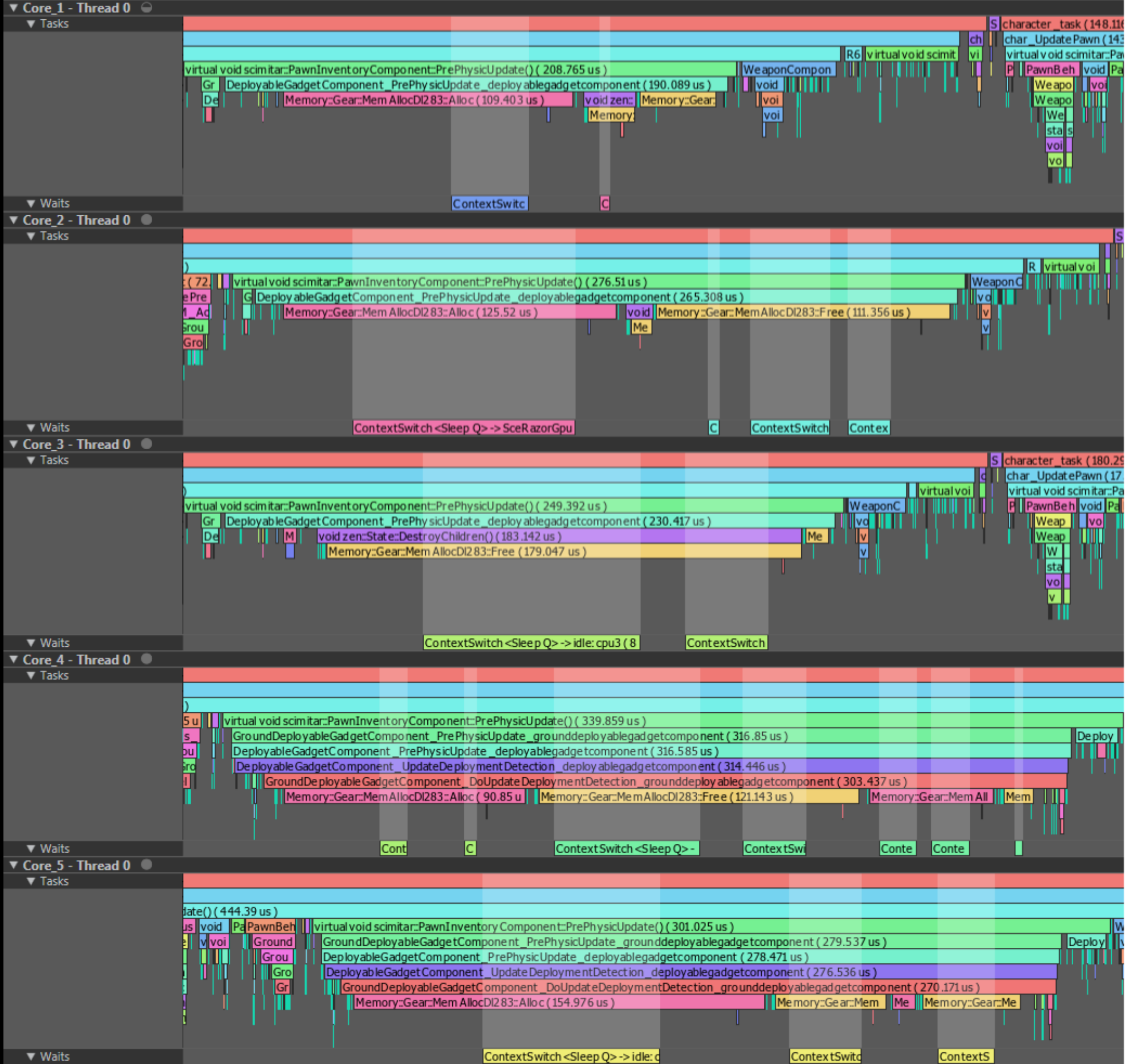
○ Time
● Value

Performance Tester

Advantages

- Eases iteration on performance improvements
- Prevents bad or unworthy optimizations

Reduce Memory Allocation Cost


▼ Core_1 - Thread 0
▼ Tasks
character_task (148.11
char_UpdatePawn (14
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (208.765 us)
WeaponCompon
DeployableGadgetComponent_PrePhysicUpdate_deployablegadgetcomponent (190.089 us)
Memory::Gear::MemAllocDl283::Alloc (109.403 us)
void zen::
Memory::Gear:
PawnBeh
▼ Waits
ContextSwitc
▼ Core_2 - Thread 0
▼ Tasks
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (276.51 us)
WeaponC
DeployableGadgetComponent_PrePhysicUpdate_deployablegadgetcomponent (265.308 us)
Memory::Gear::MemAllocDl283::Alloc (125.52 us)
Memory::Gear::MemAllocDl283::Free (111.356 us)
▼ Waits
ContextSwitch <Sleep Q> -> SceRazorGpu
ContextSwitch
Contex
▼ Core_3 - Thread 0
▼ Tasks
character_task (180.2
char_UpdatePawn (17
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (249.392 us)
WeaponC
DeployableGadgetComponent_PrePhysicUpdate_deployablegadgetcomponent (230.417 us)
void zen::State::DestroyChildren() (183.142 us)
Memory::Gear::MemAllocDl283::Free (179.047 us)
PawnBeh
▼ Waits
ContextSwitch <Sleep Q> -> idle: cpu3 (8
ContextSwitch
▼ Core_4 - Thread 0
▼ Tasks
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (339.859 us)
GroundDeployableGadgetComponent_PrePhysicUpdate_grounddeployablegadgetcomponent (316.85 us)
DeployableGadgetComponent_PrePhysicUpdate_deployablegadgetcomponent (316.585 us)
DeployableGadgetComponent_UpdateDeploymentDetection_deployablegadgetcomponent (314.446 us)
GroundDeployableGadgetComponent_DoUpdateDeploymentDetection_grounddeployablegadgetcomponent (303.437 us)
Memory::Gear::MemAllocDl283::Alloc (90.85 u
Memory::Gear::MemAllocDl283::Free (121.143 us)
Memory::Gear::MemAll
▼ Waits
ContextSwitch <Sleep Q> -
ContextSwi
▼ Core_5 - Thread 0
▼ Tasks
date() (444.39 us)
virtual void scimitar::PawnInventoryComponent::PrePhysicUpdate() (301.025 us)
GroundDeployableGadgetComponent_PrePhysicUpdate_grounddeployablegadgetcomponent (279.537 us)
DeployableGadgetComponent_PrePhysicUpdate_deployablegadgetcomponent (278.471 us)
DeployableGadgetComponent_UpdateDeploymentDetection_deployablegadgetcomponent (276.536 us)
GroundDeployableGadgetComponent_DoUpdateDeploymentDetection_grounddeployablegadgetcomponent (270.171 us)
Memory::Gear::MemAllocDl283::Alloc (154.976 us)
Memory::Gear::Mem
▼ Waits
ContextSwitch <Sleep Q> -> idle: c
ContextSwitc
ContextS

Memory Situation

- Inheriting from old generation setup (X360, PS3)
- Sizes 8-12-16-…-64 have each a dedicated allocator. 72-80-96-128-144 as well.
- Bunch of other different allocators
- Tried to replace almost everything by jemalloc: worse results.

Memory

- Made fixed size allocators lock-free (wait-free)
- Lock-free correspondence between page and allocator
- Simplified code layers: allocator choice function in .h to even maximize inlining

Task Allocator

```
void MyTask::Execute() {
    Array<...> myArray;
    populate(myArray);
    process(myArray);
}
-> myArray.~Array();
```

Array on the stack
==
temp buffer on the heap

Task Allocator

```
void WorkerThread::ProcessTasks() {
    TaskAllocator allocator(128KB);
    while(1) {
        Task* newTask = GetNextTask();
        newTask->Execute();
        allocator.Reset();
    }
}
```

Task Allocator

```
void Array::Grow(std::size_t size)
{
    Allocator* allocator = DefaultAllocator;
    if(IsOnStack(this))
        allocator = g_TLSTaskAllocator;
    m_Buf = allocator->Realloc(m_Buf, size);
}
```

Task Allocator

```
thread_local const void* Memory::m_StackStart = nullptr;

// Called when creating a thread
void Memory::SetStackStart(const void* stackStart)
{
    m_StackStart = stackStart;
}
```

Task Allocator

```
bool IsOnStack(const void* ptr)
{
  unsigned char stackEnd;
  if (ptr >= (&stackEnd + ptrdiff_t(1<<20)) ||
      ptr <= &stackEnd)
  {
    // avoid TLS access for cases likely not on stack
    // (not 1Meg from top of stack)
    return false;
  }
  return ptr < m_StackStart;  // thread-local
```

Task Allocator

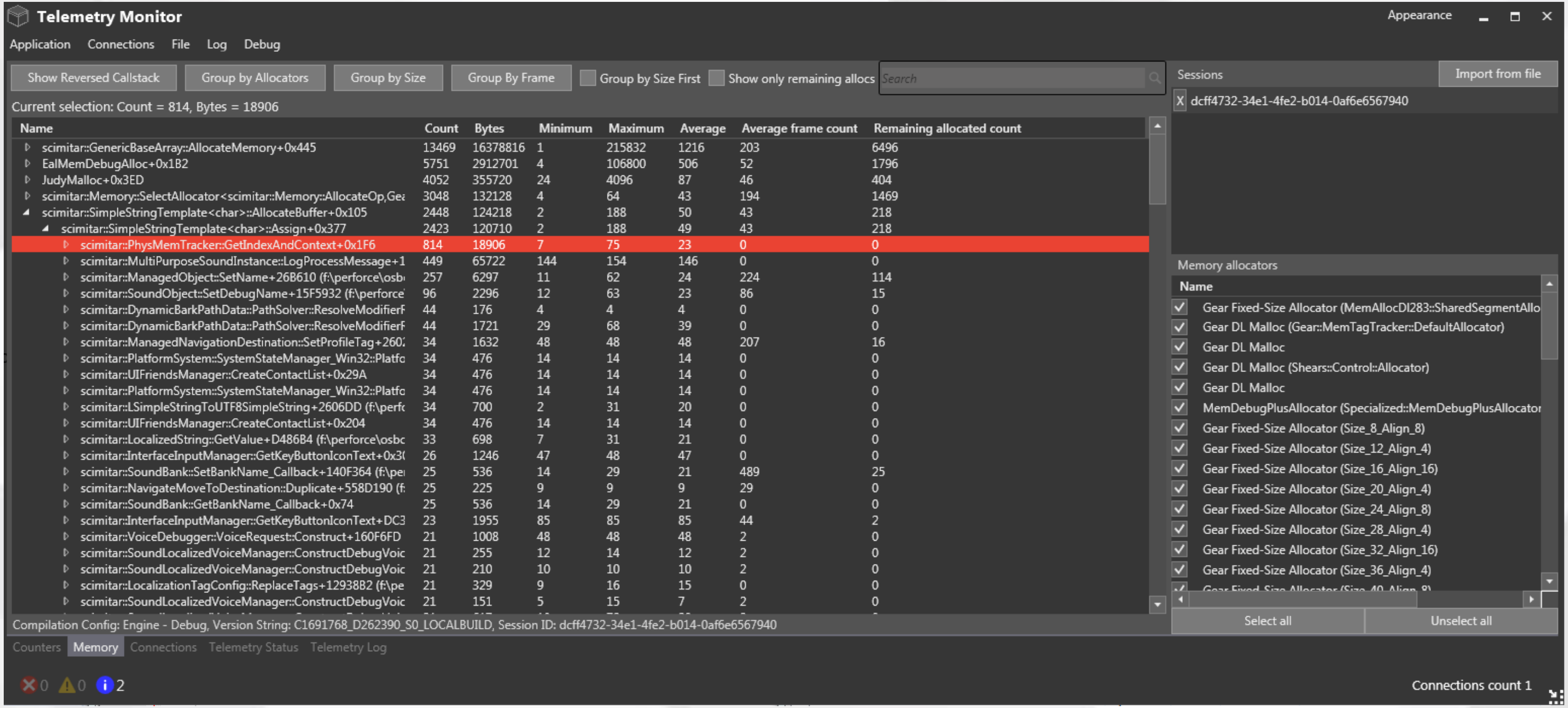
```
bool IsOnStack(const void* ptr)
{
  unsigned char stackEnd;
  if (ptr >= (&stackEnd + ptrdiff_t(1<<20)) ||
      ptr <= &stackEnd)
  {
    // avoid TLS access for cases likely not on stack
    // (not 1Meg from top of stack)
    return false;
  }
  return ptr < m_StackStart;  // thread-local
```

Task Allocator

- Cache friendly, same memory reused by each task since reset at end of task
- Fast allocation: 1 TLS access + pointer increment
- Free is no-op
- No contention

Reduce Memory Allocation Number

Memory Allocations



□ Group by Size First □ Show only remaining allocs

Current selection: Count = 814, Bytes = 18906

Name	Count	Bytes	Minimum	Maximum	Average	Average frame count	Remaining allocated count
▷ scimitar::GenericBaseArray::AllocateMemory+0x445	13469	16378816	1	215832	1216	203	6496
▷ EalMemDebugAlloc+0x1B2	5751	2912701	4	106800	506	52	1796
▷ JudyMalloc+0x3ED	4052	355720	24	4096	87	46	404
▷ scimitar::Memory::SelectAllocator<scimitar::Memory::AllocateOp,Gea	3048	132128	4	64	43	194	1469
◢ scimitar::SimpleStringTemplate<char>::AllocateBuffer+0x105	2448	124218	2	188	50	43	218
◢ scimitar::SimpleStringTemplate<char>::Assign+0x377	2423	120710	2	188	49	43	218
▷ scimitar::PhysMemTracker::GetIndexAndContext+0x1F6	814	18906	7	75	23	0	0
▷ scimitar::MultiPurposeSoundInstance::LogProcessMessage+1	449	65722	144	154	146	0	0
▷ scimitar::ManagedObject::SetName+26B610 (f:\perforce\osb	257	6297	11	62	24	224	114
▷ scimitar::SoundObject::SetDebugName+15F5932 (f:\perforce	96	2296	12	63	23	86	15
▷ scimitar::DynamicBarkPathData::PathSolver::ResolveModifierF	44	176	4	4	4	0	0
▷ scimitar::DynamicBarkPathData::PathSolver::ResolveModifierF	44	1721	29	68	39	0	0
▷ scimitar::ManagedNavigationDestination::SetProfileTag+260	34	1632	48	48	48	207	16
▷ scimitar::PlatformSystem::SystemStateManager_Win32::Platfo	34	476	14	14	14	0	0
▷ scimitar::UIFriendsManager::CreateContactList+0x29A	34	476	14	14	14	0	0
▷ scimitar::PlatformSystem::SystemStateManager_Win32::Platfo	34	476	14	14	14	0	0
▷ scimitar::LSimpleStringToUTF8SimpleString+2606DD (f:\perf	34	700	2	31	20	0	0
▷ scimitar::UIFriendsManager::CreateContactList+0x204	34	476	14	14	14	0	0
▷ scimitar::LocalizedString::GetValue+D486B4 (f:\perforce\osbc	33	698	7	31	21	0	0
▷ scimitar::InterfaceInputManager::GetKeyButtonIconText+0x3(	26	1246	47	48	47	0	0
▷ scimitar::SoundBank::SetBankName_Callback+140F364 (f:\pe	25	536	14	29	21	489	25
▷ scimitar::NavigateMoveToDestination::Duplicate+558D190 (f:	25	225	9	9	9	29	0
▷ scimitar::SoundBank::GetBankName_Callback+0x74	25	536	14	29	21	0	0
▷ scimitar::InterfaceInputManager::GetKeyButtonIconText+DC3	23	1955	85	85	85	44	2
▷ scimitar::VoiceDebugger::VoiceRequest::Construct+160F6FD	21	1008	48	48	48	2	0
▷ scimitar::SoundLocalizedVoiceManager::ConstructDebugVoic	21	255	12	14	12	2	0
▷ scimitar::SoundLocalizedVoiceManager::ConstructDebugVoic	21	210	10	10	10	2	0
▷ scimitar::LocalizationTagConfig::ReplaceTags+12938B2 (f:\pe	21	329	9	16	15	0	0
▷ scimitar::SoundLocalizedVoiceManager::ConstructDebugVoic	21	151	5	15	7	2	0

Compilation Config: Engine - Debug, Version String: C1691768_D262390_S0_LOCALBUILD, Session ID: dcff4732-34e1-4fe2-b014-0af6e6567940

Sessions

X dcff4732-34e1-4fe2-b014-0af6e6567940

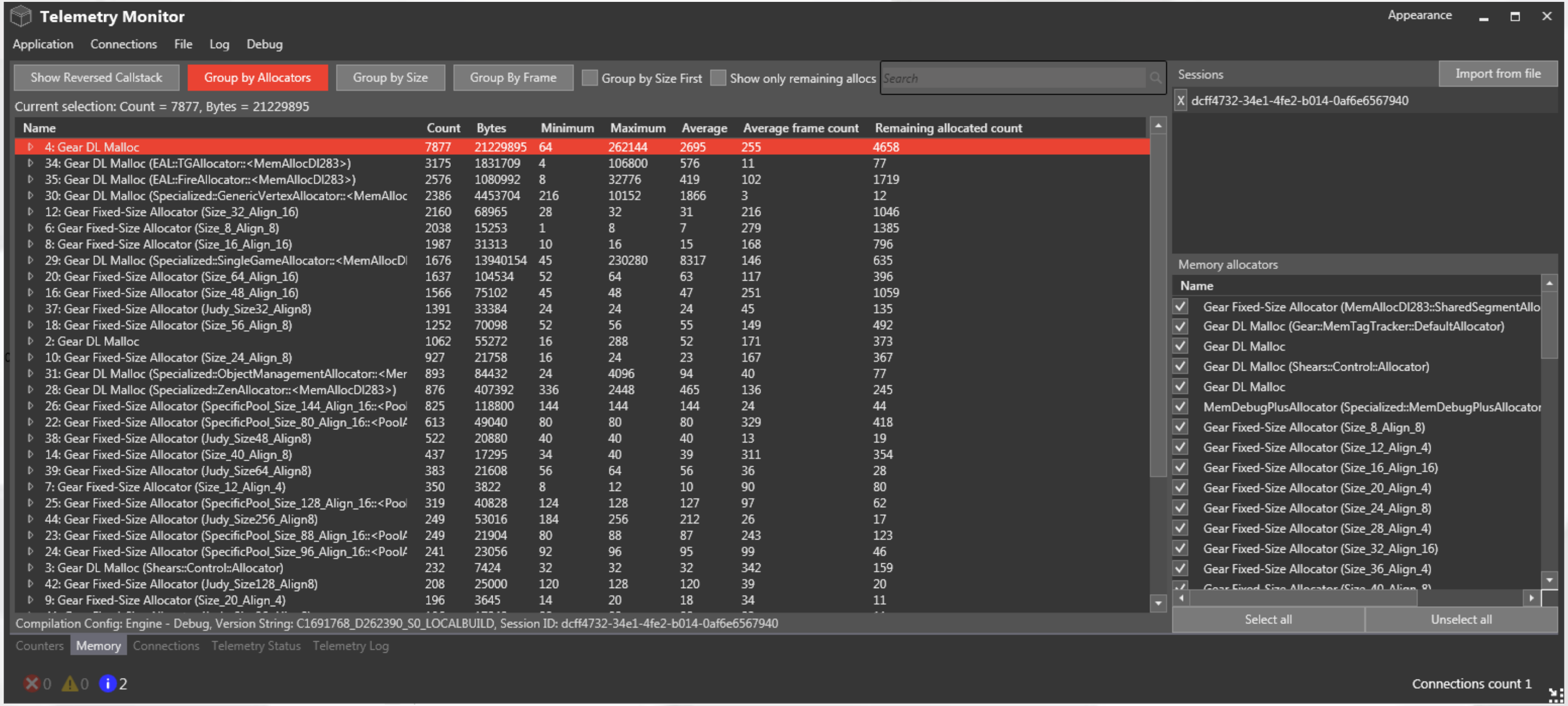
Memory allocators

Name

- ☑ Gear Fixed-Size Allocator (MemAllocDI283::SharedSegmentAllo
- ☑ Gear DL Malloc (Gear::MemTagTracker::DefaultAllocator)
- ☑ Gear DL Malloc
- ☑ Gear DL Malloc (Shears::Control::Allocator)
- ☑ Gear DL Malloc
- ☑ MemDebugPlusAllocator (Specialized::MemDebugPlusAllocator
- ☑ Gear Fixed-Size Allocator (Size_8_Align_8)
- ☑ Gear Fixed-Size Allocator (Size_12_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_16_Align_16)
- ☑ Gear Fixed-Size Allocator (Size_20_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_24_Align_8)
- ☑ Gear Fixed-Size Allocator (Size_28_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_32_Align_16)
- ☑ Gear Fixed-Size Allocator (Size_36_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_40_Align_8)

Connections count 1

Memory Allocations



Current selection: Count = 7877, Bytes = 21229895

Name	Count	Bytes	Minimum	Maximum	Average	Average frame count	Remaining allocated count
4: Gear DL Malloc	7877	21229895	64	262144	2695	255	4658
34: Gear DL Malloc (EAL::TGAllocator::<MemAllocDl283>)	3175	1831709	4	106800	576	11	77
35: Gear DL Malloc (EAL::FireAllocator::<MemAllocDl283>)	2576	1080992	8	32776	419	102	1719
30: Gear DL Malloc (Specialized::GenericVertexAllocator::<MemAlloc	2386	4453704	216	10152	1866	3	12
12: Gear Fixed-Size Allocator (Size_32_Align_16)	2160	68965	28	32	31	216	1046
6: Gear Fixed-Size Allocator (Size_8_Align_8)	2038	15253	1	8	7	279	1385
8: Gear Fixed-Size Allocator (Size_16_Align_16)	1987	31313	10	16	15	168	796
29: Gear DL Malloc (Specialized::SingleGameAllocator::<MemAllocDl	1676	13940154	45	230280	8317	146	635
20: Gear Fixed-Size Allocator (Size_64_Align_16)	1637	104534	52	64	63	117	396
16: Gear Fixed-Size Allocator (Size_48_Align_16)	1566	75102	45	48	47	251	1059
37: Gear Fixed-Size Allocator (Judy_Size32_Align8)	1391	33384	24	24	24	45	135
18: Gear Fixed-Size Allocator (Size_56_Align_8)	1252	70098	52	56	55	149	492
2: Gear DL Malloc	1062	55272	16	288	52	171	373
10: Gear Fixed-Size Allocator (Size_24_Align_8)	927	21758	16	24	23	167	367
31: Gear DL Malloc (Specialized::ObjectManagementAllocator::<Mer	893	84432	24	4096	94	40	77
28: Gear DL Malloc (Specialized::ZenAllocator::<MemAllocDl283>)	876	407392	336	2448	465	136	245
26: Gear Fixed-Size Allocator (SpecificPool_Size_144_Align_16::<Pool	825	118800	144	144	144	24	44
22: Gear Fixed-Size Allocator (SpecificPool_Size_80_Align_16::<PoolA	613	49040	80	80	80	329	418
38: Gear Fixed-Size Allocator (Judy_Size48_Align8)	522	20880	40	40	40	13	19
14: Gear Fixed-Size Allocator (Size_40_Align_8)	437	17295	34	40	39	311	354
39: Gear Fixed-Size Allocator (Judy_Size64_Align8)	383	21608	56	64	56	36	28
7: Gear Fixed-Size Allocator (Size_12_Align_4)	350	3822	8	12	10	90	80
25: Gear Fixed-Size Allocator (SpecificPool_Size_128_Align_16::<Pool	319	40828	124	128	127	97	62
44: Gear Fixed-Size Allocator (Judy_Size256_Align8)	249	53016	184	256	212	26	17
23: Gear Fixed-Size Allocator (SpecificPool_Size_88_Align_16::<PoolA	249	21904	80	88	87	243	123
24: Gear Fixed-Size Allocator (SpecificPool_Size_96_Align_16::<PoolA	241	23056	92	96	95	99	46
3: Gear DL Malloc (Shears::Control::Allocator)	232	7424	32	32	32	342	159
42: Gear Fixed-Size Allocator (Judy_Size128_Align8)	208	25000	120	128	120	39	20
9: Gear Fixed-Size Allocator (Size_20_Align_4)	196	3645	14	20	18	34	11

Compilation Config: Engine - Debug, Version String: C1691768_D262390_S0_LOCALBUILD, Session ID: dcff4732-34e1-4fe2-b014-0af6e6567940

Sessions

X dcff4732-34e1-4fe2-b014-0af6e6567940

Memory allocators

Name

- ☑ Gear Fixed-Size Allocator (MemAllocDl283::SharedSegmentAllo
- ☑ Gear DL Malloc (Gear::MemTagTracker::DefaultAllocator)
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- ☑ Gear Fixed-Size Allocator (Size_16_Align_16)
- ☑ Gear Fixed-Size Allocator (Size_20_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_24_Align_8)
- ☑ Gear Fixed-Size Allocator (Size_28_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_32_Align_16)
- ☑ Gear Fixed-Size Allocator (Size_36_Align_4)
- ☑ Gear Fixed-Size Allocator (Size_40_Align_8)

UBISOFT

Array Analyzer

```
Array<float> x;
x.Reserve(1024);
for (…)
    x.Add(…);
```

Array Analyzer

```
InplaceArray<float, 8> x;
x.Reserve(…);
for (…)
    x.Add(…);
```

In C#...

```
Array(…,
    [CallerFilePath] string path = "",
    [CallerLineNumber] int line = 0)
{…}
```

Array Analyzer

```
ubiArrayInlining Array() {
    void* addr = _ReturnAddress();
    …
}
```

Array Analyzer

```
void Foo() {
    Array<ubiVector4> someVec4Array;
    Array<float> someFloatArray;
    …
}
```

Array Analyzer

```
class MyClass {
    …
    Array<float> m_SomeMember;
};
```

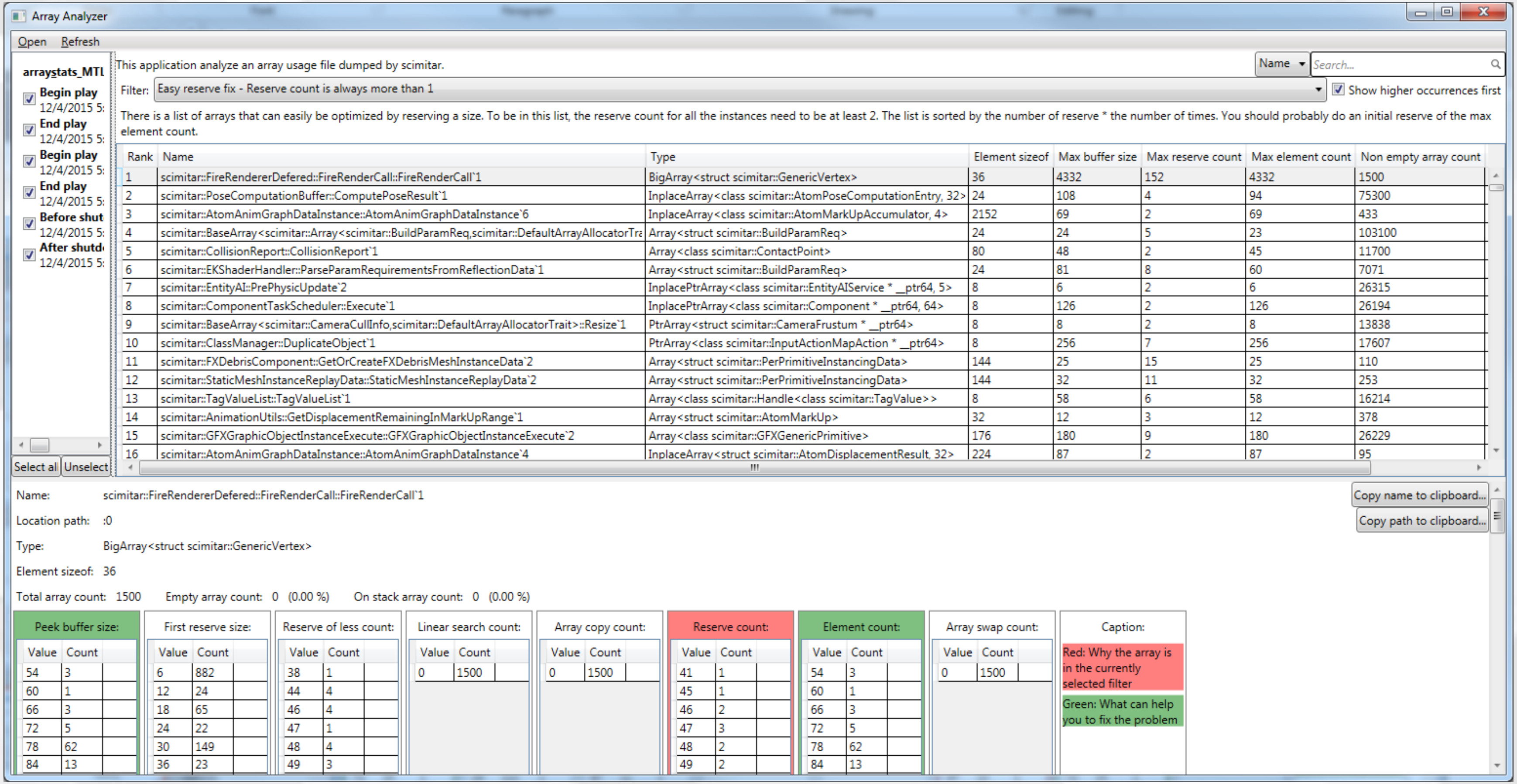
Array Analyzer

```
#define ubiRegisterArrayStats(type)
   GetArrayStats().Init(_ReturnAddress(),
   sizeof(Base::ValueType),
   ArrayStats::ArrayType::type,
   typeid(Base::ValueType).name())


Array(…) … {
   ubiRegisterArrayStats(Array);
```

Array Analyzer

```
~Array()
{
#ifdef UBI_ARRAY_STATS
  if(m_IsMemoryOwner)
    ArrayStats::RegisterStats(m_ArrayStats);
#endif
}
```


Array Analyzer
Open
Refresh
arraystats_MTL
☑ Begin play 12/4/2015 5:
☑ End play 12/4/2015 5:
☑ Begin play 12/4/2015 5:
☑ End play 12/4/2015 5:
☑ Before shut 12/4/2015 5:
☑ After shutd 12/4/2015 5:
Select al
Unselect
Name
Search...
Copy name to clipboard...
Copy path to clipboard...

This application analyze an array usage file dumped by scimitar.

Filter: Easy reserve fix - Reserve count is always more than 1

☑ Show higher occurrences first

There is a list of arrays that can easily be optimized by reserving a size. To be in this list, the reserve count for all the instances need to be at least 2. The list is sorted by the number of reserve * the number of times. You should probably do an initial reserve of the max element count.

Rank	Name	Type	Element sizeof	Max buffer size	Max reserve count	Max element count	Non empty array count
1	scimitar::FireRendererDefered::FireRenderCall::FireRenderCall`1	BigArray<struct scimitar::GenericVertex>	36	4332	152	4332	1500
2	scimitar::PoseComputationBuffer::ComputePoseResult`1	InplaceArray<class scimitar::AtomPoseComputationEntry, 32>	24	108	4	94	75300
3	scimitar::AtomAnimGraphDataInstance::AtomAnimGraphDataInstance`6	InplaceArray<class scimitar::AtomMarkUpAccumulator, 4>	2152	69	2	69	433
4	scimitar::BaseArray<scimitar::Array<scimitar::BuildParamReq,scimitar::DefaultArrayAllocatorTra	Array<struct scimitar::BuildParamReq>	24	24	5	23	103100
5	scimitar::CollisionReport::CollisionReport`1	Array<class scimitar::ContactPoint>	80	48	2	45	11700
6	scimitar::EKShaderHandler::ParseParamRequirementsFromReflectionData`1	Array<struct scimitar::BuildParamReq>	24	81	8	60	7071
7	scimitar::EntityAI::PrePhysicUpdate`2	InplacePtrArray<class scimitar::EntityAIService * __ptr64, 5>	8	6	2	6	26315
8	scimitar::ComponentTaskScheduler::Execute`1	InplacePtrArray<class scimitar::Component * __ptr64, 64>	8	126	2	126	26194
9	scimitar::BaseArray<scimitar::CameraCullInfo,scimitar::DefaultArrayAllocatorTrait>::Resize`1	PtrArray<struct scimitar::CameraFrustum * __ptr64>	8	8	2	8	13838
10	scimitar::ClassManager::DuplicateObject`1	PtrArray<class scimitar::InputActionMapAction * __ptr64>	8	256	7	256	17607
11	scimitar::FXDebrisComponent::GetOrCreateFXDebrisMeshInstanceData`2	Array<struct scimitar::PerPrimitiveInstancingData>	144	25	15	25	110
12	scimitar::StaticMeshInstanceReplayData::StaticMeshInstanceReplayData`2	Array<struct scimitar::PerPrimitiveInstancingData>	144	32	11	32	253
13	scimitar::TagValueList::TagValueList`1	Array<class scimitar::Handle<class scimitar::TagValue> >	8	58	6	58	16214
14	scimitar::AnimationUtils::GetDisplacementRemainingInMarkUpRange`1	Array<struct scimitar::AtomMarkUp>	32	12	3	12	378
15	scimitar::GFXGraphicObjectInstanceExecute::GFXGraphicObjectInstanceExecute`2	Array<class scimitar::GFXGenericPrimitive>	176	180	9	180	26229
16	scimitar::AtomAnimGraphDataInstance::AtomAnimGraphDataInstance`4	InplaceArray<struct scimitar::AtomDisplacementResult, 32>	224	87	2	87	95

Name: scimitar::FireRendererDefered::FireRenderCall::FireRenderCall`1

Location path: :0

Type: BigArray<struct scimitar::GenericVertex>

Element sizeof: 36

Total array count: 1500 Empty array count: 0 (0.00 %) On stack array count: 0 (0.00 %)

Peek buffer size:

Value	Count
54	3
60	1
66	3
72	5
78	62
84	13

First reserve size:

Value	Count
6	882
12	24
18	65
24	22
30	149
36	23

Reserve of less count:

Value	Count
38	1
44	4
46	4
47	1
48	4
49	3

Linear search count:

Value	Count
0	1500

Array copy count:

Value	Count
0	1500

Reserve count:

Value	Count
41	1
45	1
46	2
47	3
48	2
49	2

Element count:

Value	Count
54	3
60	1
66	3
72	5
78	62
84	13

Array swap count:

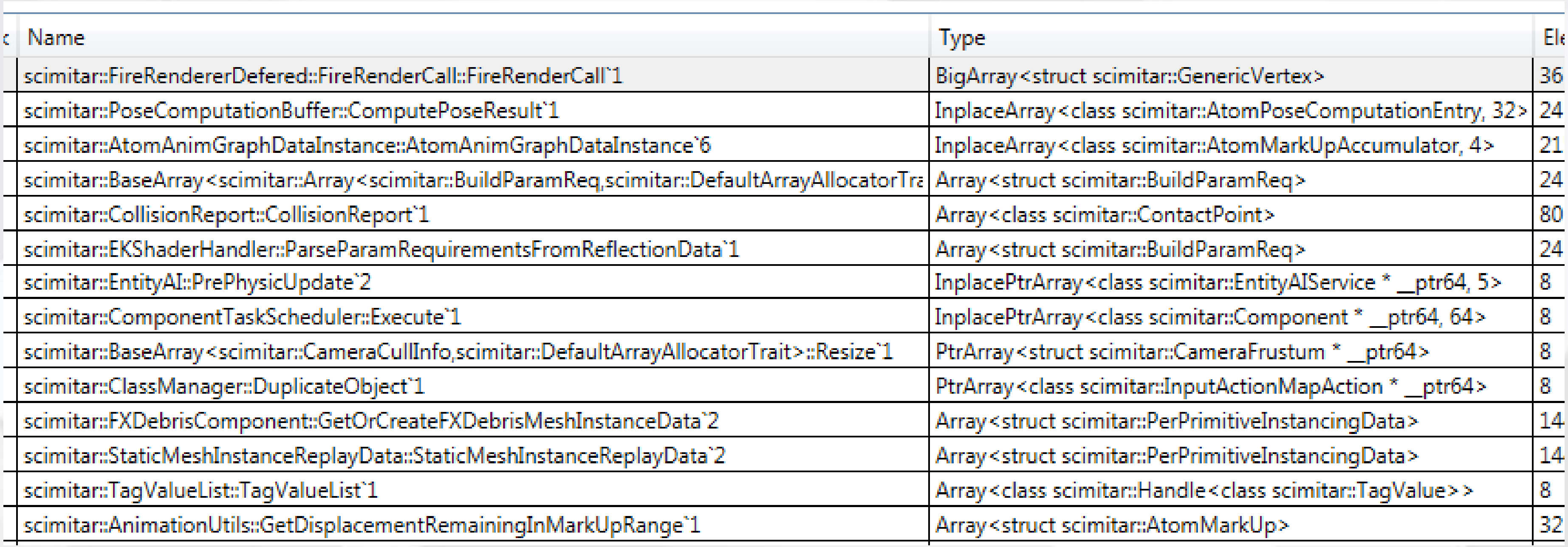
Value	Count
0	1500

Caption:

Red: Why the array is in the currently selected filter

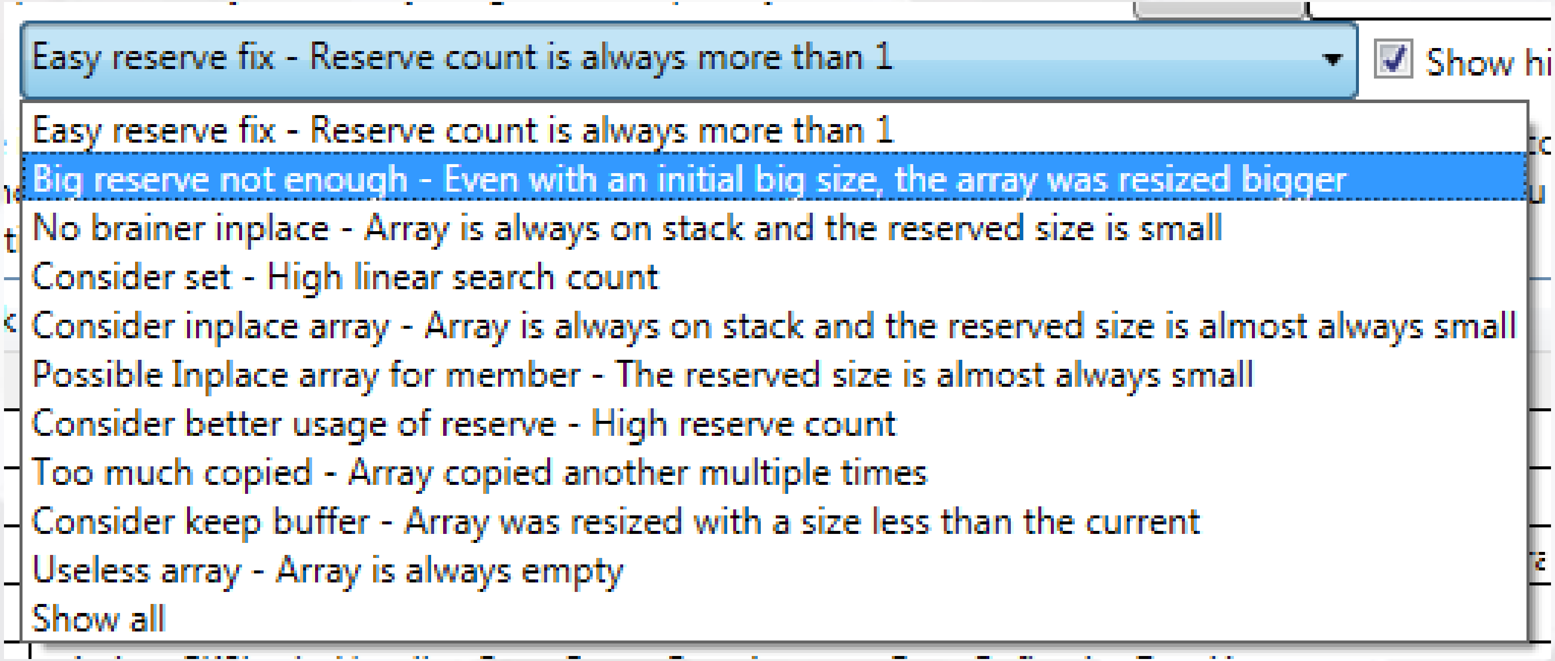
Green: What can help you to fix the problem

Array Analyzer



Name	Type	Ele
scimitar::FireRendererDefered::FireRenderCall::FireRenderCall`1	BigArray<struct scimitar::GenericVertex>	36
scimitar::PoseComputationBuffer::ComputePoseResult`1	InplaceArray<class scimitar::AtomPoseComputationEntry, 32>	24
scimitar::AtomAnimGraphDataInstance::AtomAnimGraphDataInstance`6	InplaceArray<class scimitar::AtomMarkUpAccumulator, 4>	21
scimitar::BaseArray<scimitar::Array<scimitar::BuildParamReq,scimitar::DefaultArrayAllocatorTra	Array<struct scimitar::BuildParamReq>	24
scimitar::CollisionReport::CollisionReport`1	Array<class scimitar::ContactPoint>	80
scimitar::EKShaderHandler::ParseParamRequirementsFromReflectionData`1	Array<struct scimitar::BuildParamReq>	24
scimitar::EntityAI::PrePhysicUpdate`2	InplacePtrArray<class scimitar::EntityAIService * __ptr64, 5>	8
scimitar::ComponentTaskScheduler::Execute`1	InplacePtrArray<class scimitar::Component * __ptr64, 64>	8
scimitar::BaseArray<scimitar::CameraCullInfo,scimitar::DefaultArrayAllocatorTrait>::Resize`1	PtrArray<struct scimitar::CameraFrustum * __ptr64>	8
scimitar::ClassManager::DuplicateObject`1	PtrArray<class scimitar::InputActionMapAction * __ptr64>	8
scimitar::FXDebrisComponent::GetOrCreateFXDebrisMeshInstanceData`2	Array<struct scimitar::PerPrimitiveInstancingData>	14
scimitar::StaticMeshInstanceReplayData::StaticMeshInstanceReplayData`2	Array<struct scimitar::PerPrimitiveInstancingData>	14
scimitar::TagValueList::TagValueList`1	Array<class scimitar::Handle<class scimitar::TagValue> >	8
scimitar::AnimationUtils::GetDisplacementRemainingInMarkUpRange`1	Array<struct scimitar::AtomMarkUp>	32

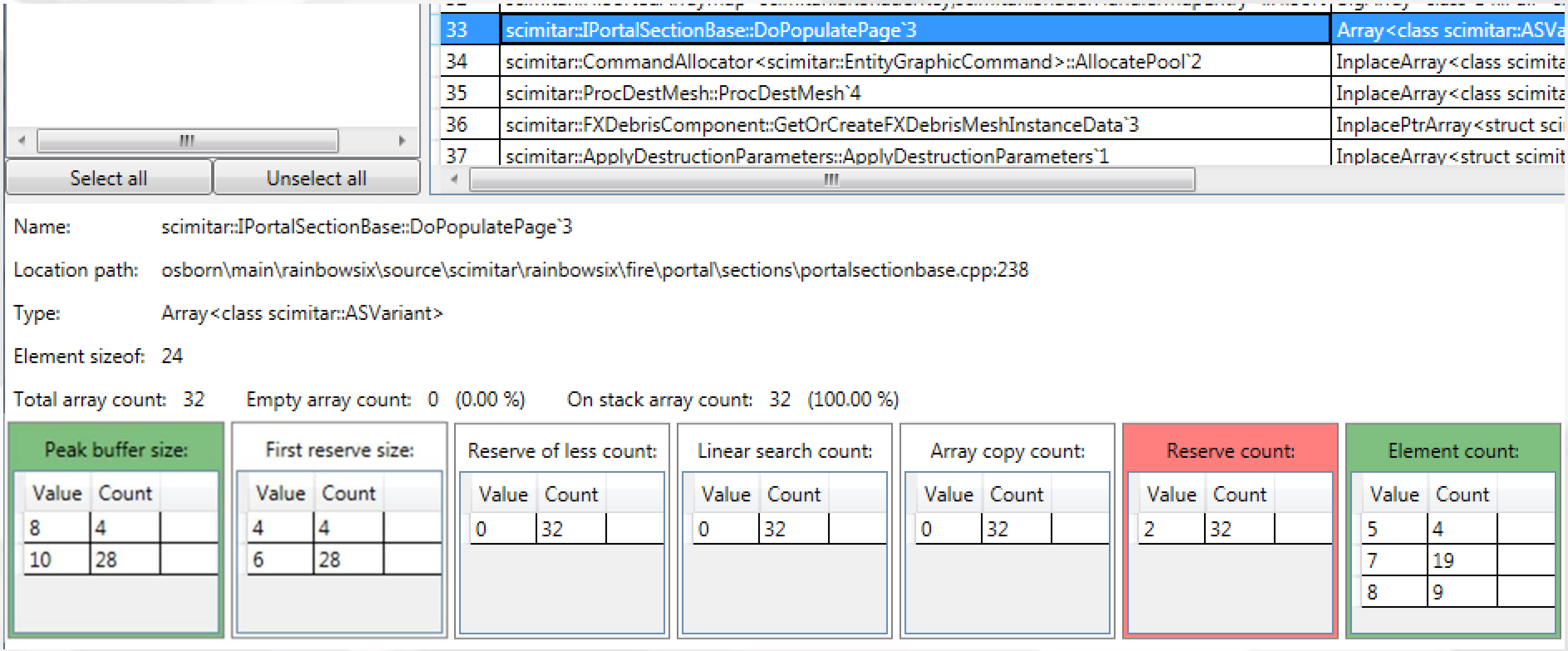
Array Analyzer



Easy reserve fix - Reserve count is always more than 1

☑ Show hi

Easy reserve fix - Reserve count is always more than 1
Big reserve not enough - Even with an initial big size, the array was resized bigger
No brainer inplace - Array is always on stack and the reserved size is small
Consider set - High linear search count
Consider inplace array - Array is always on stack and the reserved size is almost always small
Possible Inplace array for member - The reserved size is almost always small
Consider better usage of reserve - High reserve count
Too much copied - Array copied another multiple times
Consider keep buffer - Array was resized with a size less than the current
Useless array - Array is always empty
Show all



33	scimitar::IPortalSectionBase::DoPopulatePage`3	Array<class scimitar::ASVa
34	scimitar::CommandAllocator<scimitar::EntityGraphicCommand>::AllocatePool`2	InplaceArray<class scimita
35	scimitar::ProcDestMesh::ProcDestMesh`4	InplaceArray<class scimita
36	scimitar::FXDebrisComponent::GetOrCreateFXDebrisMeshInstanceData`3	InplacePtrArray<struct sci
37	scimitar::ApplyDestructionParameters::ApplyDestructionParameters`1	InplaceArray<struct scimit

Name: scimitar::IPortalSectionBase::DoPopulatePage`3

Location path: osborn\main\rainbowsix\source\scimitar\rainbowsix\fire\portal\sections\portalsectionbase.cpp:238

Type: Array<class scimitar::ASVariant>

Element sizeof: 24

Total array count: 32 Empty array count: 0 (0.00 %) On stack array count: 32 (100.00 %)

Peak buffer size:

Value	Count
8	4
10	28

First reserve size:

Value	Count
4	4
6	28

Reserve of less count:

Value	Count
0	32

Linear search count:

Value	Count
0	32

Array copy count:

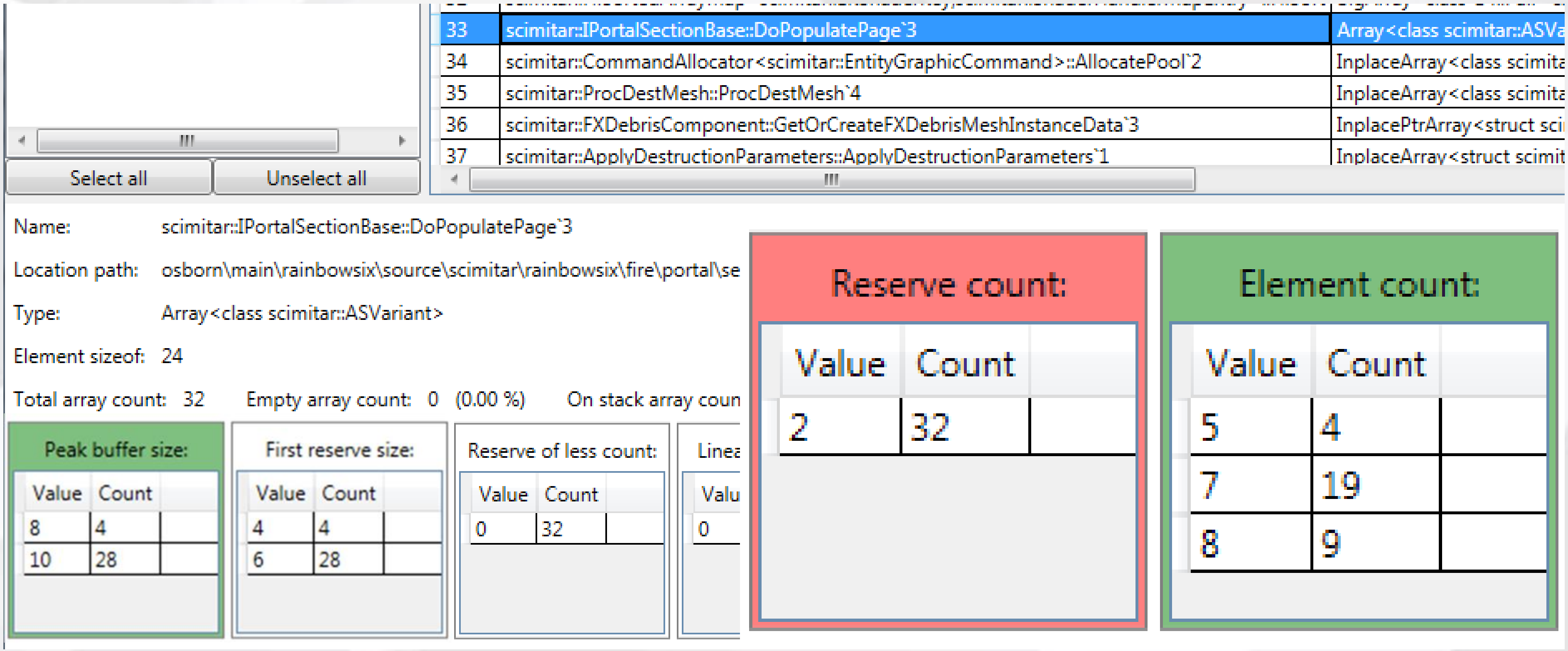
Value	Count
0	32

Reserve count:

Value	Count
2	32

Element count:

Value	Count
5	4
7	19
8	9



33	scimitar::IPortalSectionBase::DoPopulatePage`3	Array<class scimitar::ASVa
34	scimitar::CommandAllocator<scimitar::EntityGraphicCommand>::AllocatePool`2	InplaceArray<class scimita
35	scimitar::ProcDestMesh::ProcDestMesh`4	InplaceArray<class scimita
36	scimitar::FXDebrisComponent::GetOrCreateFXDebrisMeshInstanceData`3	InplacePtrArray<struct sci
37	scimitar::ApplyDestructionParameters::ApplyDestructionParameters`1	InplaceArray<struct scimit

Name: scimitar::IPortalSectionBase::DoPopulatePage`3

Location path: osborn\main\rainbowsix\source\scimitar\rainbowsix\fire\portal\se

Type: Array<class scimitar::ASVariant>

Element sizeof: 24

Total array count: 32 Empty array count: 0 (0.00 %) On stack array coun

Peak buffer size:

Value	Count
8	4
10	28

First reserve size:

Value	Count
4	4
6	28

Reserve of less count:

Value	Count
0	32

Linea

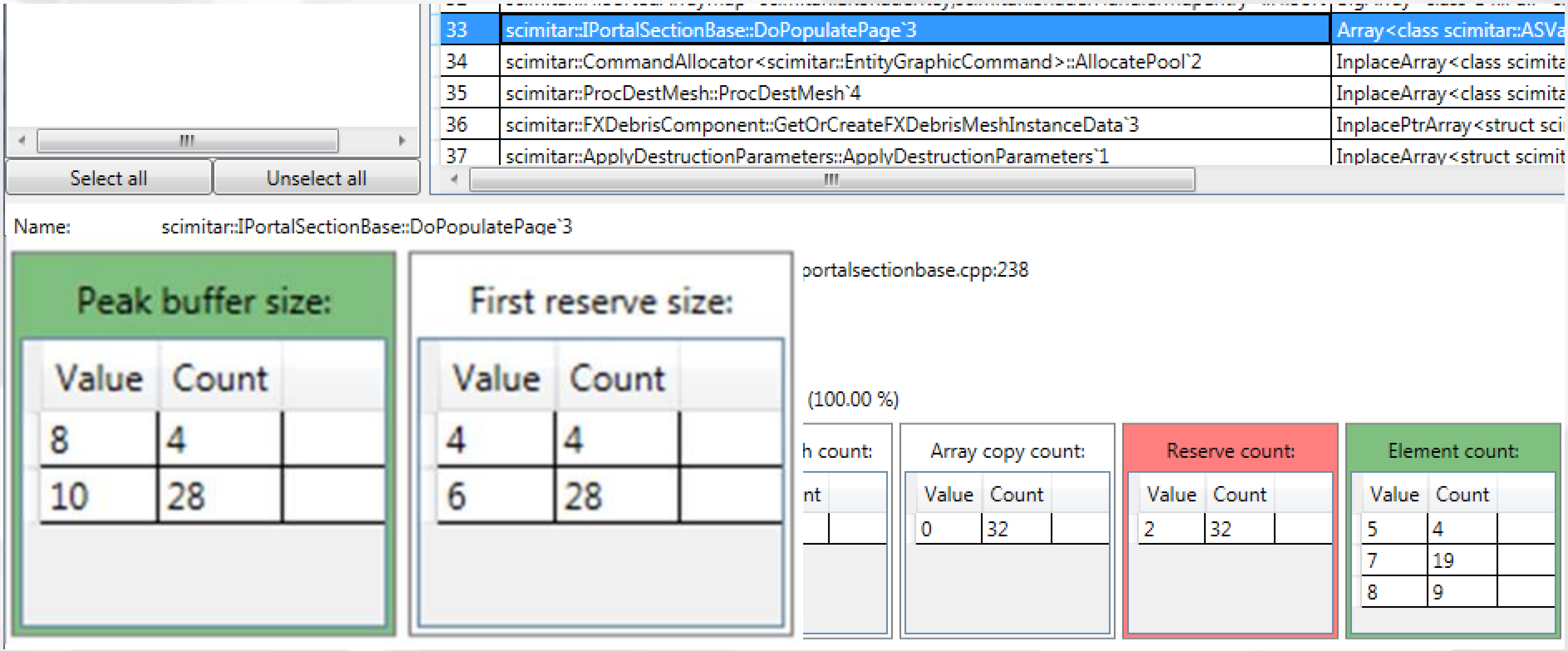
Valu
0

Reserve count:

Value	Count
2	32

Element count:

Value	Count
5	4
7	19
8	9



33	scimitar::IPortalSectionBase::DoPopulatePage`3	Array<class scimitar::ASVa
34	scimitar::CommandAllocator<scimitar::EntityGraphicCommand>::AllocatePool`2	InplaceArray<class scimita
35	scimitar::ProcDestMesh::ProcDestMesh`4	InplaceArray<class scimita
36	scimitar::FXDebrisComponent::GetOrCreateFXDebrisMeshInstanceData`3	InplacePtrArray<struct sci
37	scimitar::ApplyDestructionParameters::ApplyDestructionParameters`1	InplaceArray<struct scimit

Name: scimitar::IPortalSectionBase::DoPopulatePage`3

ortalsectionbase.cpp:238

(100.00 %)

Peak buffer size:

Value	Count
8	4
10	28

First reserve size:

Value	Count
4	4
6	28

h count:

nt

Array copy count:

Value	Count
0	32

Reserve count:

Value	Count
2	32

Element count:

Value	Count
5	4
7	19
8	9

Array Analyzer

Advantages

- Optimizing more arrays
- Can be made by junior programmer

std::function

```
…
std::function<void ()> func = [&] {
    someObj.Foo(someVector4);
};  // not using heap
```

std::function

```
…
std::function<void ()> func = [&] {
    someObj.Foo(someVector4, someOtherVector4);
}  // now using heap!
```

Proposal: inplace_function

```
…
std::inplace_function<void ()> func = [&] {
    someObj.Foo(someVector4, someOtherVector4);
}  // not compiling
```

Proposal: inplace_function

```
…
std::inplace_function<void (), 64> func = [&] {
    someObj.Foo(someVector4, someOtherVector4);
}  // compiling, no heap usage
```

Proposal: inplace_function

```
…
std::inplace_function<void (), 64> func = [&] {
    someObj.Foo(someVector4, someOtherVector4);
}  // compiling, no heap usage
```

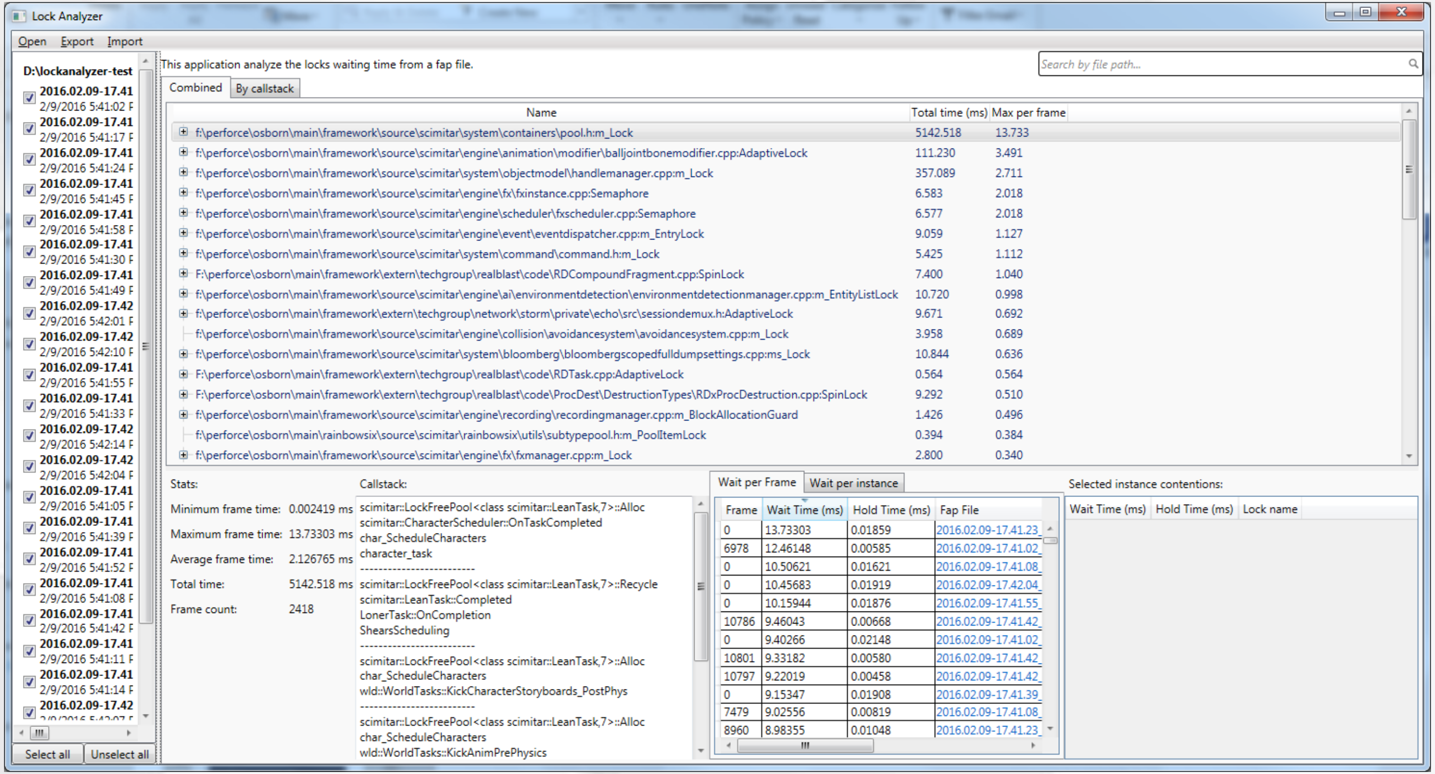
- Co-author of proposal with Carl Cook
- Example implementation: https://github.com/WG21-SG14/SG14/blob/master/SG14/inplace_function.h

Lock-Free Solutions

Lock Analyzer

```
UbiAdaptiveMutex m_Lock;
void SomeFunc() {
    ubiAutoLock(m_Lock);
    …
}
```

Lock Analyzer



D:\lockanalyzer-test

- ☑ **2016.02.09-17.41** 2/9/2016 5:41:02 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:17 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:24 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:45 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:58 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:30 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:49 F
- ☑ **2016.02.09-17.42** 2/9/2016 5:42:01 F
- ☑ **2016.02.09-17.42** 2/9/2016 5:42:10 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:55 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:33 F
- ☑ **2016.02.09-17.42** 2/9/2016 5:42:14 F
- ☑ **2016.02.09-17.42** 2/9/2016 5:42:04 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:05 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:39 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:52 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:08 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:42 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:11 F
- ☑ **2016.02.09-17.41** 2/9/2016 5:41:14 F
- ☑ **2016.02.09-17.42** 2/9/2016 5:42:07 F

This application analyze the locks waiting time from a fap file.

Name	Total time (ms)	Max per frame
⊞ f:\perforce\osborn\main\framework\source\scimitar\system\containers\pool.h:m_Lock	5142.518	13.733
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\animation\modifier\balljointbonemodifier.cpp:AdaptiveLock	111.230	3.491
⊞ f:\perforce\osborn\main\framework\source\scimitar\system\objectmodel\handlemanager.cpp:m_Lock	357.089	2.711
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\fx\fxinstance.cpp:Semaphore	6.583	2.018
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\scheduler\fxscheduler.cpp:Semaphore	6.577	2.018
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\event\eventdispatcher.cpp:m_EntryLock	9.059	1.127
⊞ f:\perforce\osborn\main\framework\source\scimitar\system\command\command.h:m_Lock	5.425	1.112
⊞ F:\perforce\osborn\main\framework\extern\techgroup\realblast\code\RDCompoundFragment.cpp:SpinLock	7.400	1.040
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\ai\environmentdetection\environmentdetectionmanager.cpp:m_EntityListLock	10.720	0.998
⊞ f:\perforce\osborn\main\framework\extern\techgroup\network\storm\private\echo\src\sessiondemux.h:AdaptiveLock	9.671	0.692
f:\perforce\osborn\main\framework\source\scimitar\engine\collision\avoidancesystem\avoidancesystem.cpp:m_Lock	3.958	0.689
⊞ f:\perforce\osborn\main\framework\source\scimitar\system\bloomberg\bloombergscopedfulldumpsettings.cpp:ms_Lock	10.844	0.636
⊞ F:\perforce\osborn\main\framework\extern\techgroup\realblast\code\RDTask.cpp:AdaptiveLock	0.564	0.564
⊞ F:\perforce\osborn\main\framework\extern\techgroup\realblast\code\ProcDest\DestructionTypes\RDxProcDestruction.cpp:SpinLock	9.292	0.510
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\recording\recordingmanager.cpp:m_BlockAllocationGuard	1.426	0.496
f:\perforce\osborn\main\rainbowsix\source\scimitar\rainbowsix\utils\subtypepool.h:m_PoolItemLock	0.394	0.384
⊞ f:\perforce\osborn\main\framework\source\scimitar\engine\fx\fxmanager.cpp:m_Lock	2.800	0.340

Stats:

Minimum frame time:	0.002419 ms
Maximum frame time:	13.73303 ms
Average frame time:	2.126765 ms
Total time:	5142.518 ms
Frame count:	2418

Callstack:

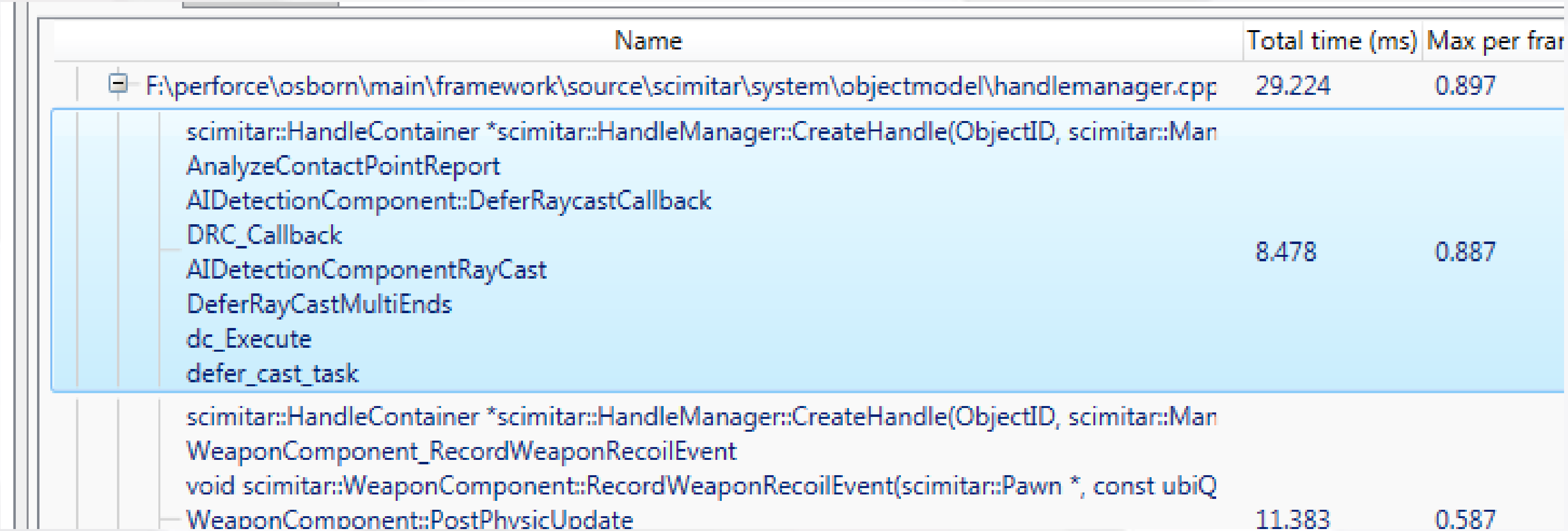
```
scimitar::LockFreePool<class scimitar::LeanTask,7>::Alloc
scimitar::CharacterScheduler::OnTaskCompleted
char_ScheduleCharacters
character_task
------------------------
scimitar::LockFreePool<class scimitar::LeanTask,7>::Recycle
scimitar::LeanTask::Completed
LonerTask::OnCompletion
ShearsScheduling
------------------------
scimitar::LockFreePool<class scimitar::LeanTask,7>::Alloc
char_ScheduleCharacters
wld::WorldTasks::KickCharacterStoryboards_PostPhys
------------------------
scimitar::LockFreePool<class scimitar::LeanTask,7>::Alloc
char_ScheduleCharacters
wld::WorldTasks::KickAnimPrePhysics
```

Frame	Wait Time (ms)	Hold Time (ms)	Fap File
0	13.73303	0.01859	2016.02.09-17.41.23_
6978	12.46148	0.00585	2016.02.09-17.41.02_
0	10.50621	0.01621	2016.02.09-17.41.08_
0	10.45683	0.01919	2016.02.09-17.42.04_
0	10.15944	0.01876	2016.02.09-17.41.55_
10786	9.46043	0.00668	2016.02.09-17.41.42_
0	9.40266	0.02148	2016.02.09-17.41.02_
10801	9.33182	0.00580	2016.02.09-17.41.42_
10797	9.22019	0.00458	2016.02.09-17.41.42_
0	9.15347	0.01908	2016.02.09-17.41.39_
7479	9.02556	0.00819	2016.02.09-17.41.08_
8960	8.98355	0.01048	2016.02.09-17.41.23_

Selected instance contentions:

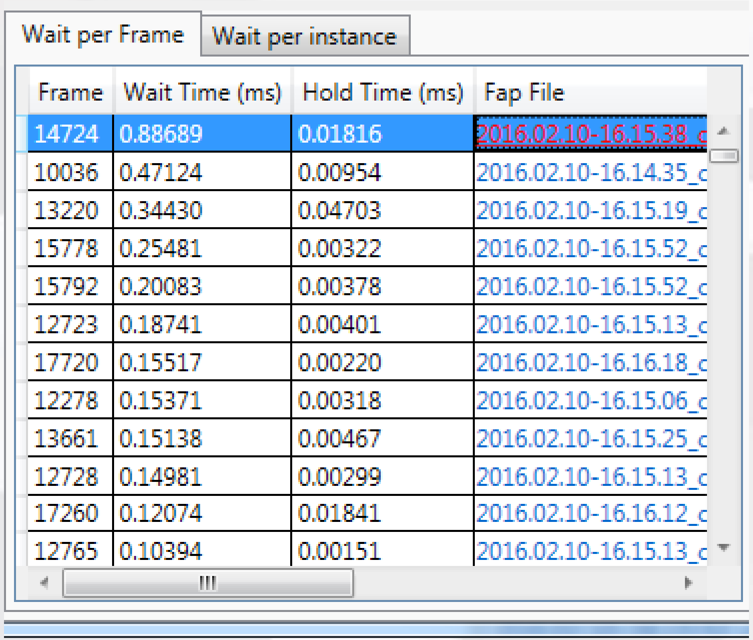
Wait Time (ms)	Hold Time (ms)	Lock name

Lock Analyzer



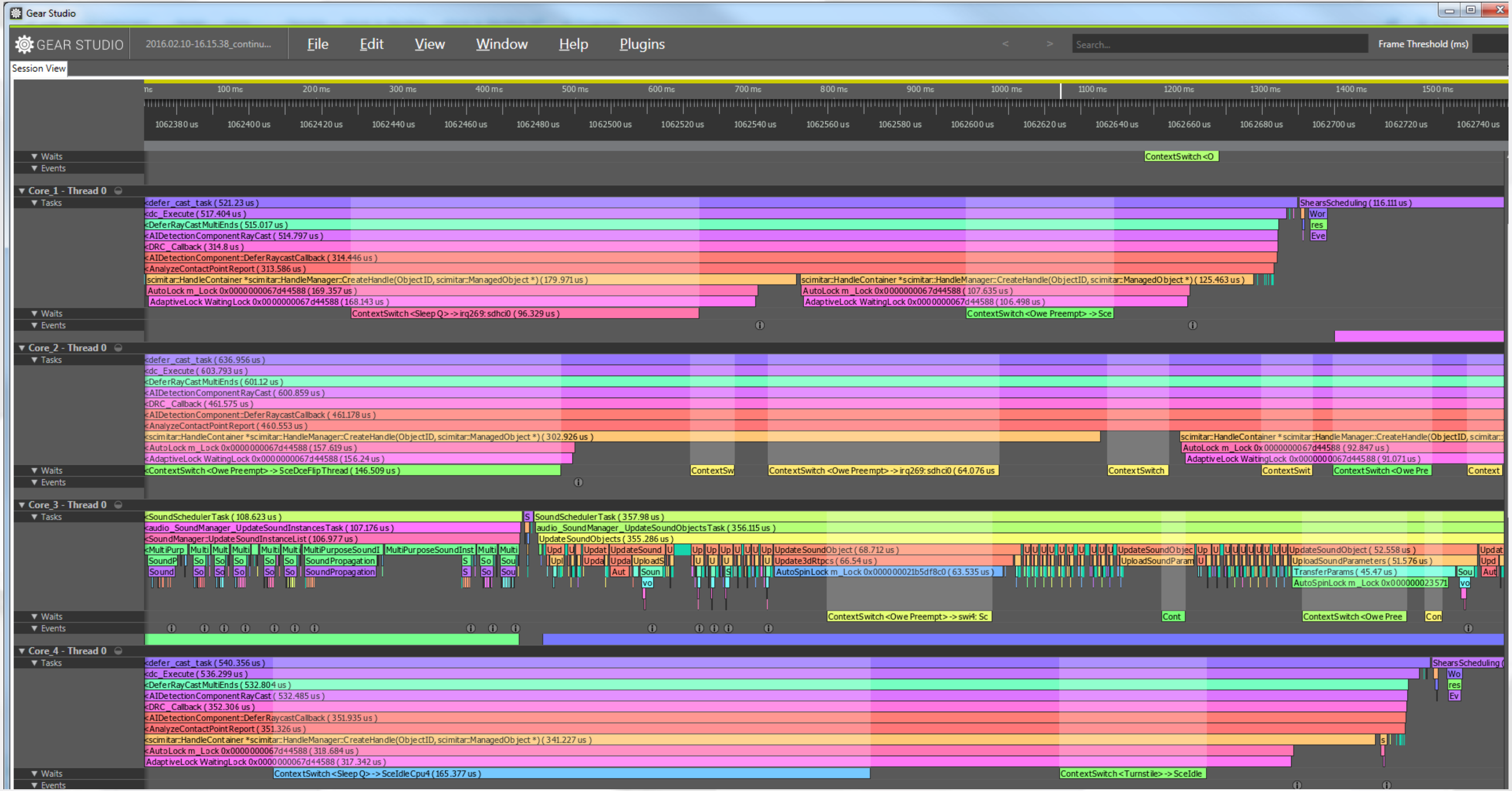
Name	Total time (ms)	Max per fra
F:\perforce\osborn\main\framework\source\scimitar\system\objectmodel\handlemanager.cpp	29.224	0.897
scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::Man AnalyzeContactPointReport AIDetectionComponent::DeferRaycastCallback DRC_Callback AIDetectionComponentRayCast DeferRayCastMultiEnds dc_Execute defer_cast_task	8.478	0.887
scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::Man WeaponComponent_RecordWeaponRecoilEvent void scimitar::WeaponComponent::RecordWeaponRecoilEvent(scimitar::Pawn *, const ubiQ WeaponComponent::PostPhysicUpdate	11.383	0.587

Lock Analyzer



Frame	Wait Time (ms)	Hold Time (ms)	Fap File
14724	0.88689	0.01816	2016.02.10-16.15.38_c
10036	0.47124	0.00954	2016.02.10-16.14.35_c
13220	0.34430	0.04703	2016.02.10-16.15.19_c
15778	0.25481	0.00322	2016.02.10-16.15.52_c
15792	0.20083	0.00378	2016.02.10-16.15.52_c
12723	0.18741	0.00401	2016.02.10-16.15.13_c
17720	0.15517	0.00220	2016.02.10-16.16.18_c
12278	0.15371	0.00318	2016.02.10-16.15.06_c
13661	0.15138	0.00467	2016.02.10-16.15.25_c
12728	0.14981	0.00299	2016.02.10-16.15.13_c
17260	0.12074	0.01841	2016.02.10-16.16.12_c
12765	0.10394	0.00151	2016.02.10-16.15.13_c

gearstudio://…?zoom_to_region=…


Gear Studio
GEAR STUDIO
2016.02.10-16.15.38_continu...
File
Edit
View
Window
Help
Plugins
Search...
Frame Threshold (ms)
Session View
100 ms
200 ms
300 ms
400 ms
500 ms
600 ms
700 ms
800 ms
900 ms
1000 ms
1100 ms
1200 ms
1300 ms
1400 ms
1500 ms
1062380 us
1062400 us
1062420 us
1062440 us
1062460 us
1062480 us
1062500 us
1062520 us
1062540 us
1062560 us
1062580 us
1062600 us
1062620 us
1062640 us
1062660 us
1062680 us
1062700 us
1062720 us
1062740 us
Waits
Events
ContextSwitch <O
Core_1 - Thread 0
Tasks
<defer_cast_task (521.23 us)
<dc_Execute (517.404 us)
<DeferRayCastMultiEnds (515.017 us)
<AIDetectionComponentRayCast (514.797 us)
<DRC_Callback (314.8 us)
<AIDetectionComponent::DeferRaycastCallback (314.446 us)
<AnalyzeContactPointReport (313.586 us)
scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::ManagedObject *) (179.971 us)
AutoLock m_Lock 0x0000000067d44588 (169.357 us)
AdaptiveLock WaitingLock 0x0000000067d44588 (168.143 us)
ContextSwitch <Sleep Q> -> irq269: sdhci0 (96.329 us)
scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::ManagedObject *) (125.463 us)
AutoLock m_Lock 0x0000000067d44588 (107.635 us)
AdaptiveLock WaitingLock 0x0000000067d44588 (106.498 us)
ContextSwitch <Owe Preempt> -> Sce
ShearsScheduling (116.111 us)
Wor
res
Eve
Core_2 - Thread 0
<defer_cast_task (636.956 us)
<dc_Execute (603.793 us)
<DeferRayCastMultiEnds (601.12 us)
<AIDetectionComponentRayCast (600.859 us)
<DRC_Callback (461.575 us)
<AIDetectionComponent::DeferRaycastCallback (461.178 us)
<AnalyzeContactPointReport (460.553 us)
<scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::ManagedObject *) (302.926 us)
<AutoLock m_Lock 0x0000000067d44588 (157.619 us)
<AdaptiveLock WaitingLock 0x0000000067d44588 (156.24 us)
<ContextSwitch <Owe Preempt> -> SceDceFlipThread (146.509 us)
ContextSw
ContextSwitch <Owe Preempt> -> irq269: sdhci0 (64.076 us
ContextSwitch
scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::
AutoLock m_Lock 0x0000000067d44588 (92.847 us)
AdaptiveLock WaitingLock 0x0000000067d44588 (91.071 us)
ContextSwit
ContextSwitch <Owe Pre
Context
Core_3 - Thread 0
<SoundSchedulerTask (108.623 us)
<audio_SoundManager_UpdateSoundInstancesTask (107.176 us)
<SoundManager::UpdateSoundInstanceList (106.977 us)
MultiPurp
SoundP
Sound
MultiPurposeSoundI
MultiPurposeSoundInst
SoundPropagation
SoundSchedulerTask (357.98 us)
audio_SoundManager_UpdateSoundObjectsTask (356.115 us)
UpdateSoundObjects (355.286 us)
UpdateSound
UploadS
UpdateSoundObject (68.712 us)
Update3dRtpcs (66.54 us)
AutoSpinLock m_Lock 0x000000021b5df8c0 (63.535 us)
UpdateSoundObjec
UploadSoundParam
UpdateSoundObject (52.558 us)
UploadSoundParameters (51.576 us)
TransferParams (45.47 us)
AutoSpinLock m_Lock 0x00000002357
ContextSwitch <Owe Preempt> -> swi4: Sc
Cont
ContextSwitch <Owe Pree
Con
Core_4 - Thread 0
<defer_cast_task (540.356 us)
<dc_Execute (536.299 us)
<DeferRayCastMultiEnds (532.804 us)
<AIDetectionComponentRayCast (532.485 us)
<DRC_Callback (352.306 us)
<AIDetectionComponent::DeferRaycastCallback (351.935 us)
<AnalyzeContactPointReport (351.326 us)
<scimitar::HandleContainer *scimitar::HandleManager::CreateHandle(ObjectID, scimitar::ManagedObject *) (341.227 us)
<AutoLock m_Lock 0x0000000067d44588 (318.684 us)
AdaptiveLock WaitingLock 0x0000000067d44588 (317.342 us)
ContextSwitch <Sleep Q> -> SceIdleCpu4 (165.377 us)
ContextSwitch <Turnstile> -> SceIdle
ShearsScheduling (
Wo
res
Ev

UBISOFT

LockFreeQueue

```
template<typename T, std::uint32_t SizeT,
    typename TypeTraitT = LockFreeQueueDefaultTrait<T>,
    typename DataPolicyT = LockFreeQueueEmbeddedDataPolicy<T, SizeT> >
class LockFreeQueue
{
public:
    typedef LockFreeQueue<T, SizeT, TypeTraitT, DataPolicyT> Type;
    enum { MAX_SIZE = (SizeT - TypeTraitT::MAX_THREAD_COUNT) };
    …
private:
    DataPolicyT m_Elements;
    std::atomic<std::uint32_t> m_QueueReadPos;
    std::atomic<std::uint32_t> m_QueueWritePos;
    std::atomic<std::int32_t> m_QueueCount;
};
```

LockFreeQueue

```
void Enqueue(T value)
{
    static_assert((0xFFFFFFFF % SizeT) == (SizeT - 1),
        "(U32 max + 1) must be a multiple of SizeT");
    std::uint32_t index = m_QueueWritePos++ % SizeT;
    m_Elements[index] = value;
    std::int32_t count = ++m_QueueCount;
    ubiAssert(count <= MAX_SIZE);
}
```

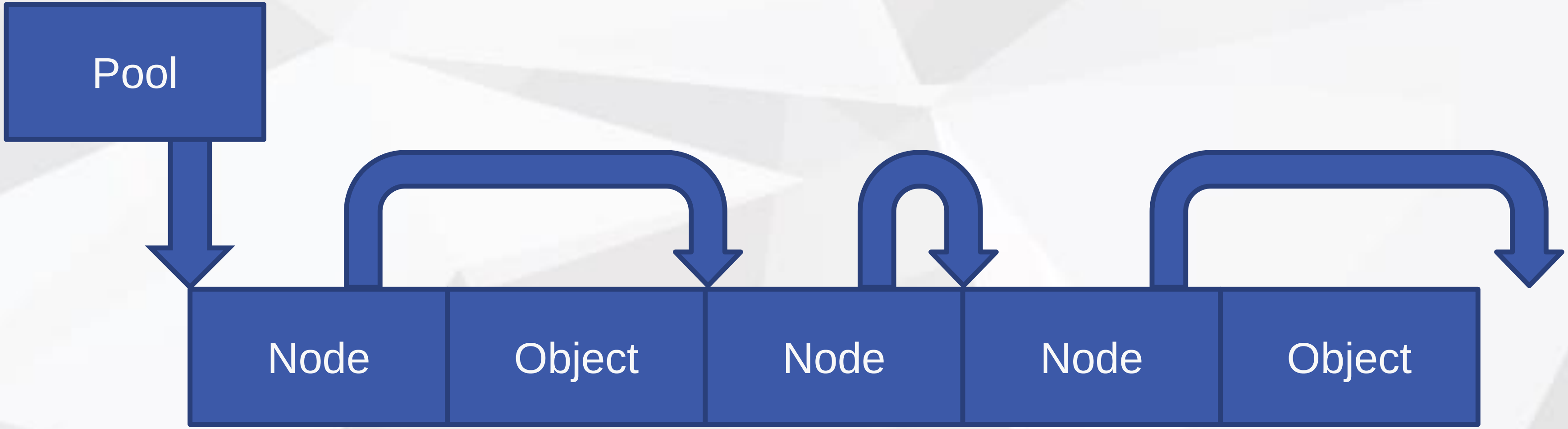
LockFreeQueue

```
T Dequeue()
{
    std::int32_t count = --m_QueueCount;
    if (count < 0)
    {
        ++m_QueueCount;
        return TypeTraitT::GetNull();
    }
    std::uint32_t index = m_QueueReadPos++ % SizeT;
    return m_Elements[index];
}
```

LockFreeQueue

```
class DequeueSingleThreadScope
{
public:
    DequeueSingleThreadScope(Type& queue);
    DequeueSingleThreadScope(Type& queue, std::int32_t dequeueCount);
    ~DequeueSingleThreadScope();
    class Iterator  { … };
    Iterator begin() { return Iterator(m_Queue, m_QueueReadPosSnapshot % SizeT); }
    Iterator end() { return Iterator(m_Queue, (m_QueueReadPosSnapshot +
         m_QueueCountSnapshot) % SizeT); }
private:
    Type& m_Queue;
    std::int32_t m_QueueCountSnapshot;
    std::uint32_t m_QueueReadPosSnapshot;
};
```

Typical Non Lock-Free Pool



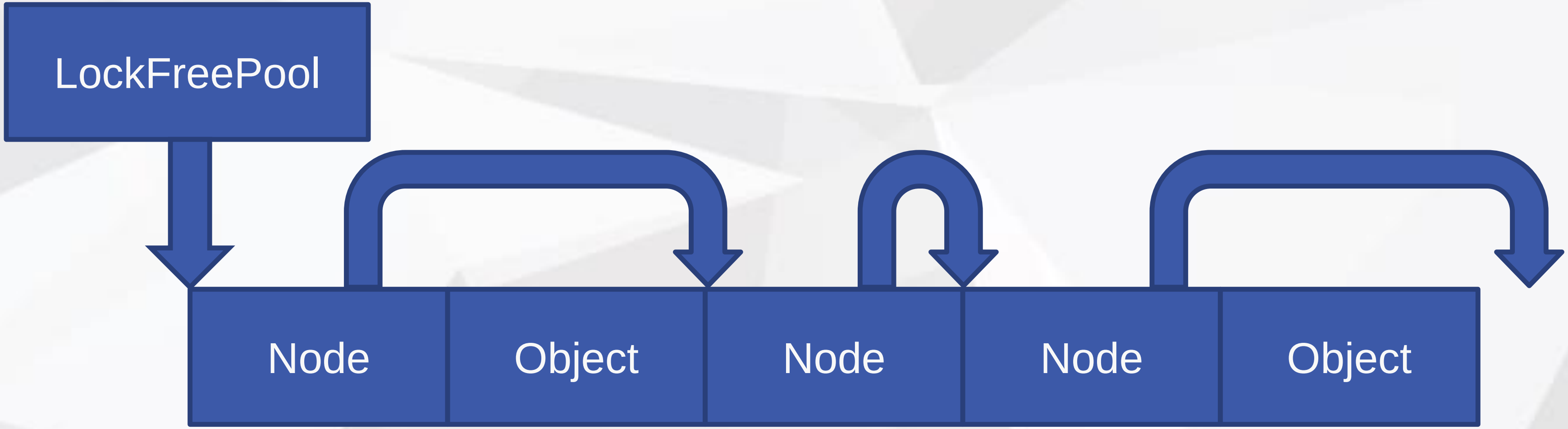
Typical Lock-Free Pool

Lock-Free Queue

+

Object Buffer

LockFreePool


LockFreePool

Node

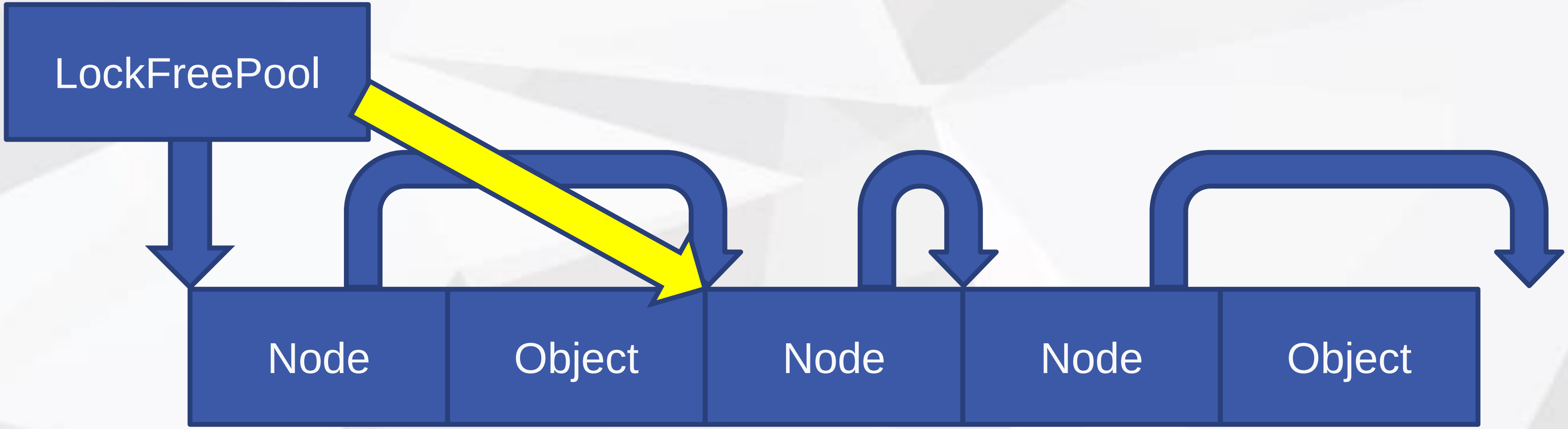
Object

Node

Node

Object

LockFreePool



LockFreePool

```
struct NextFreeInfo
{
    NextFreeInfo(std::uint32_t nextFreeIndex, std::uint32_t nextNextFreeIndex) …
    NextFreeInfo(std::uint64_t nextFreeAtomic) …
    union
    {
        struct
        {
            std::uint32_t m_NextFreeIndex;
            std::uint32_t m_NextNextFreeIndex;
        };
        std::atomic<std::uint64_t> m_NextFreeAtomic;
    };
};
```

LockFreePool

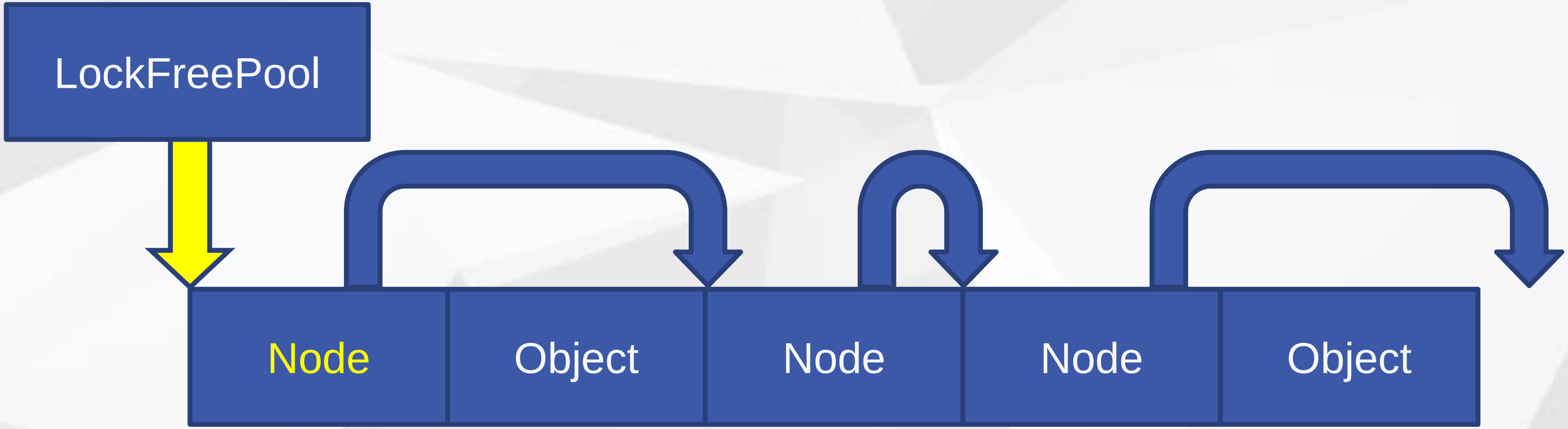
```
struct NextFreeInfo
{
    NextFreeInfo(std::uint32_t nextFreeIndex, std::uint32_t nextNextFreeIndex) …
    NextFreeInfo(std::uint64_t nextFreeAtomic) …
    union
    {
        struct
        {
            std::uint32_t m_NextFreeIndex;
            std::uint32_t m_NextNextFreeIndex;
        };
        std::atomic<std::uint64_t> m_NextFreeAtomic;
    };
};
```

ABA Problem

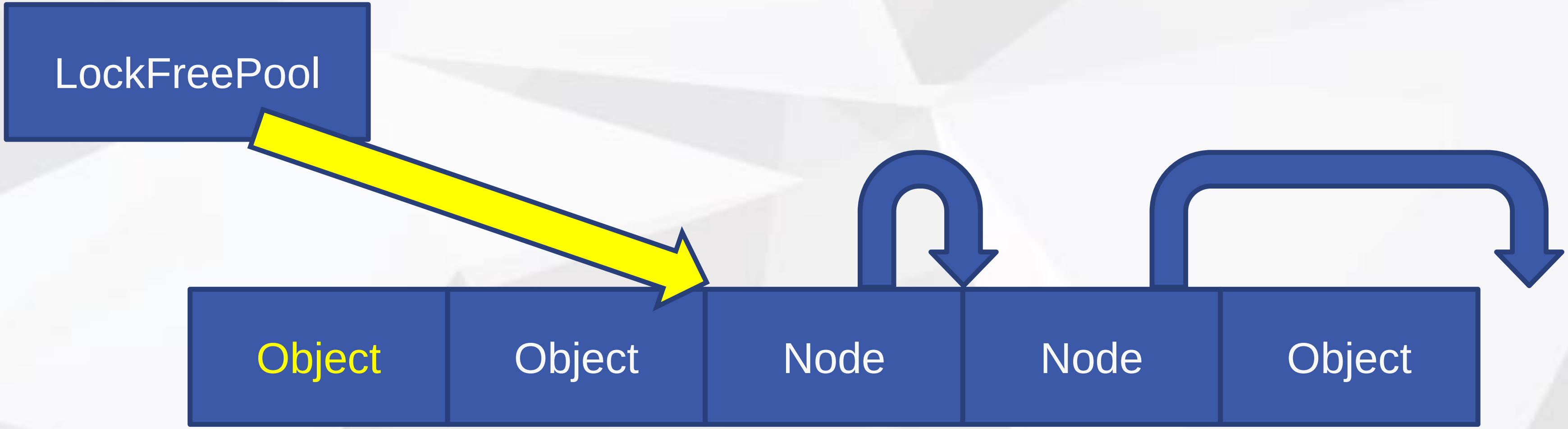
LockFreePool

```
struct NextFreeInfo
{
    NextFreeInfo(std::uint32_t nextFreeIndex, std::uint32_t versionCounter) …
    NextFreeInfo(std::uint64_t nextFreeAtomic) …
    union
    {
        struct
        {
            std::uint32_t m_NextFreeIndex;
            std::uint32_t m_VersionCounter;
        };
        std::atomic<std::uint64_t> m_NextFreeAtomic;
    };
};
```

LockFreePool



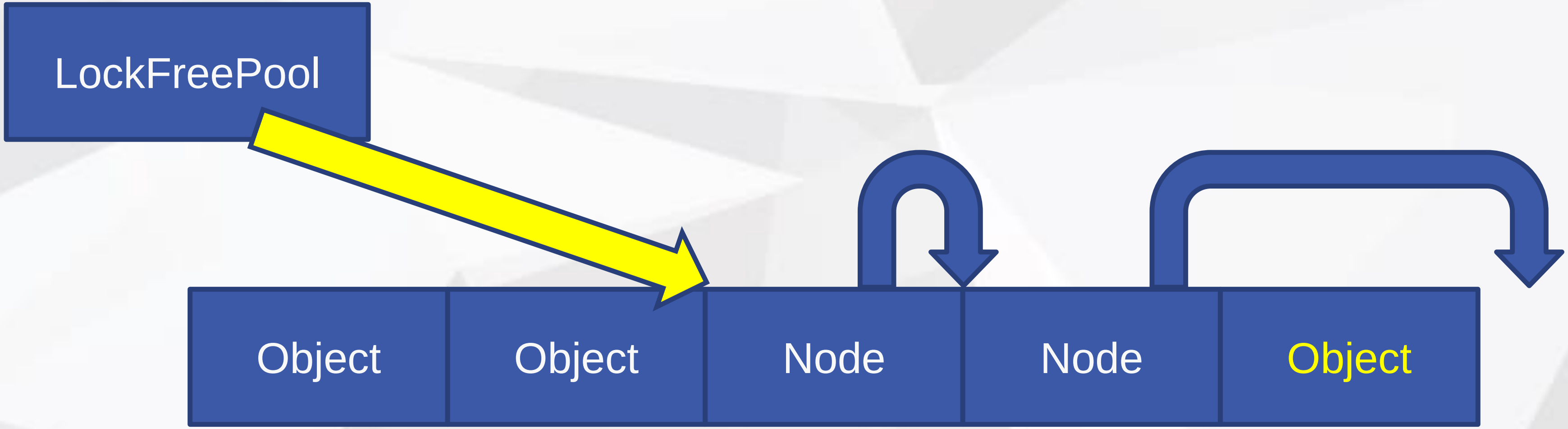
LockFreePool



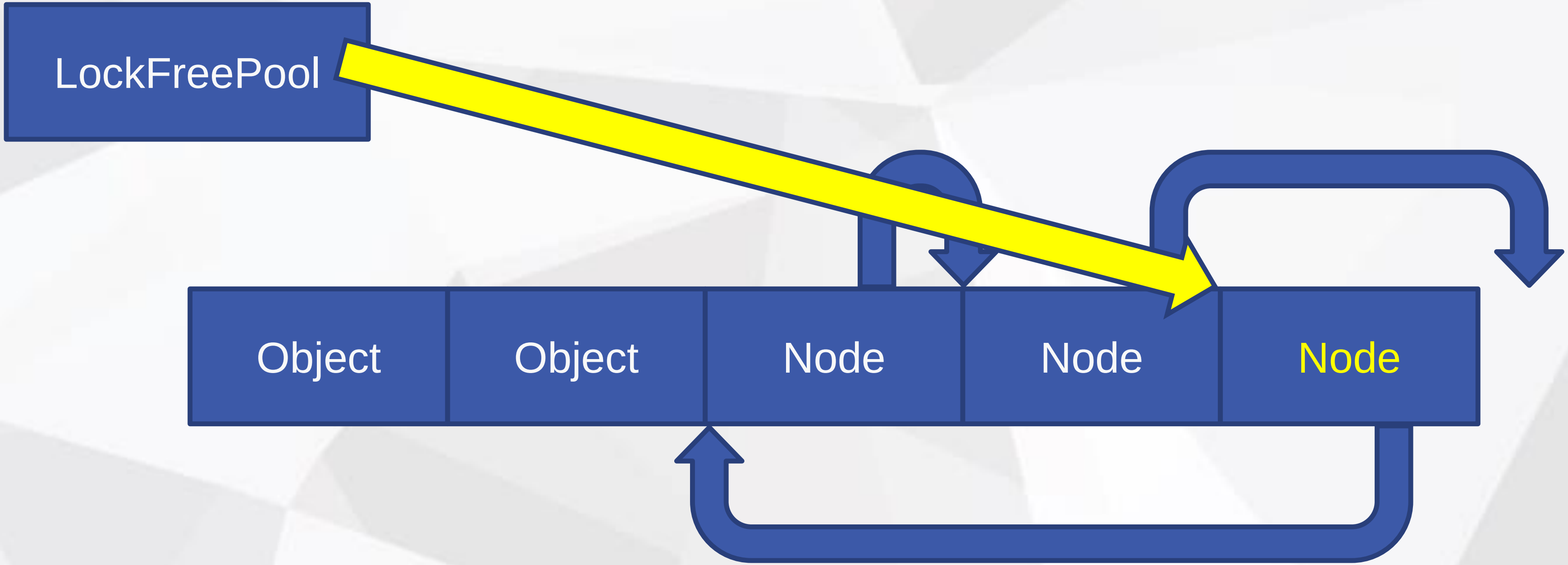
```
T* CreateWithoutConstructor() {
  while (true) {
    NextFreeInfo currentFreeInfo(m_NextFreeInfo.m_NextFreeAtomic);
    std::uint32_t nextFreeIndex = currentFreeInfo.m_NextFreeIndex;
    if (!m_DataPolicy.IsValidObjectIndex(nextFreeIndex))
      return nullptr;  // pool is full
    std::uint32_t nextNextFreeIndex =
      m_DataPolicy.GetNodeFromIndexCanExpand(nextFreeIndex)->m_NextFreeIndex;
    NextFreeInfo newNextFreeInfo(
      nextNextFreeIndex, currentFreeInfo.m_VersionCounter + 1);
    if (m_NextFreeInfo.CompareExchange(currentFreeInfo, newNextFreeInfo))
    {
      Node* node = (Node*)m_DataPolicy.GetNodeFromIndex(nextFreeIndex);
      return (T*)node;
    }
  }
}
```

```cpp
T* CreateWithoutConstructor() {
  while (true) {
    NextFreeInfo currentFreeInfo(m_NextFreeInfo.m_NextFreeAtomic);
    std::uint32_t nextFreeIndex = currentFreeInfo.m_NextFreeIndex;
    if (!m_DataPolicy.IsValidObjectIndex(nextFreeIndex))
      return nullptr;  // pool is full
    std::uint32_t nextNextFreeIndex =
      m_DataPolicy.GetNodeFromIndexCanExpand(nextFreeIndex)->m_NextFreeIndex;
    NextFreeInfo newNextFreeInfo(
      nextNextFreeIndex, currentFreeInfo.m_VersionCounter + 1);
    if (m_NextFreeInfo.CompareExchange(currentFreeInfo, newNextFreeInfo))
    {
      Node* node = (Node*)m_DataPolicy.GetNodeFromIndex(nextFreeIndex);
      return (T*)node;
    }
  }
}
```

LockFreePool



LockFreePool

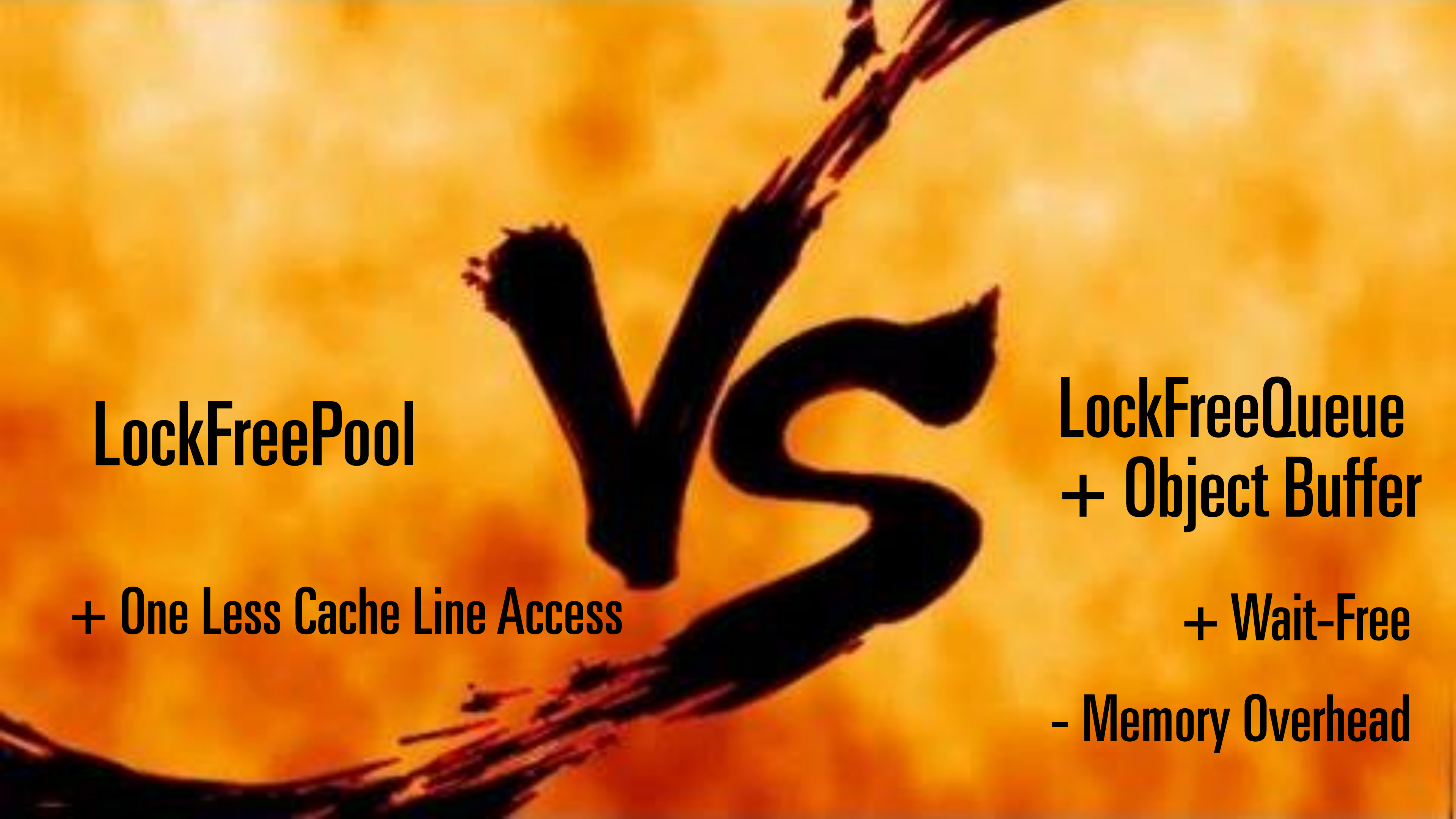


```
void DestroyWithoutDestructor(T* object)
{
  Node* objectAsNode = (Node*)object;
  Node* newHead = objectAsNode;
  std::uint32_t newNextFreeIndex = m_DataPolicy.GetIndexFromNode(newHead);
  while (true)
  {
    NextFreeInfo currentFreeInfo(m_NextFreeInfo.m_NextFreeAtomic);
    std::uint32_t currentFreeIndex = currentFreeInfo.m_NextFreeIndex;
    NextFreeInfo newNextFreeInfo(
      newNextFreeIndex, currentFreeInfo.m_VersionCounter + 1);
    newHead->m_NextFreeIndex = currentFreeIndex;  // important: before atomic
    if (m_NextFreeInfo.CompareExchange(currentFreeInfo, newNextFreeInfo))
    {
      return;
    }
  }
}
```

```
void DestroyWithoutDestructor(T* object)
{
  Node* objectAsNode = (Node*)object;
  Node* newHead = objectAsNode;
  std::uint32_t newNextFreeIndex = m_DataPolicy.GetIndexFromNode(newHead);
  while (true)
  {
    NextFreeInfo currentFreeInfo(m_NextFreeInfo.m_NextFreeAtomic);
    std::uint32_t currentFreeIndex = currentFreeInfo.m_NextFreeIndex;
    NextFreeInfo newNextFreeInfo(
      newNextFreeIndex, currentFreeInfo.m_VersionCounter + 1);
    newHead->m_NextFreeIndex = currentFreeIndex;  // important: before atomic
    if (m_NextFreeInfo.CompareExchange(currentFreeInfo, newNextFreeInfo))
    {
      return;
    }
  }
}
```

LockFreePool

LockFreeQueue
+ Object Buffer



LockFreePool

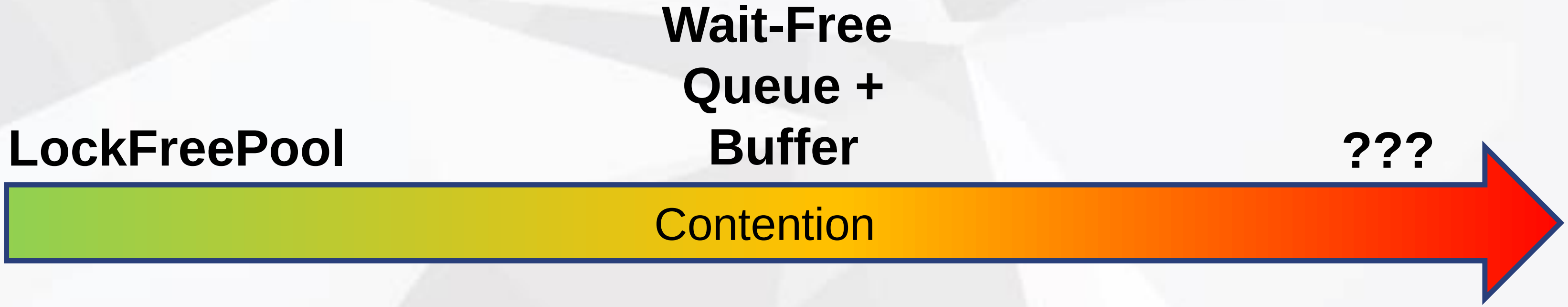
+ One Less Cache Line Access

LockFreeQueue
+ Object Buffer

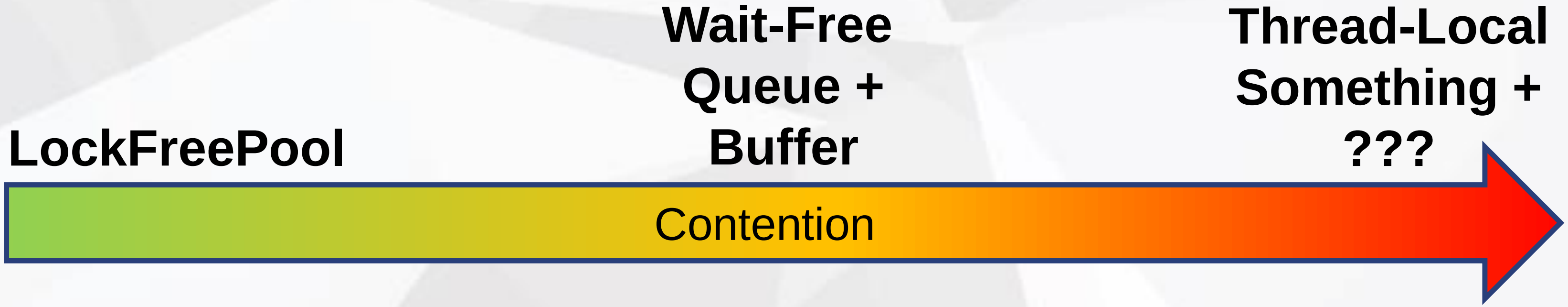
+ Wait-Free

- Memory Overhead

LockFreePool



LockFreePool



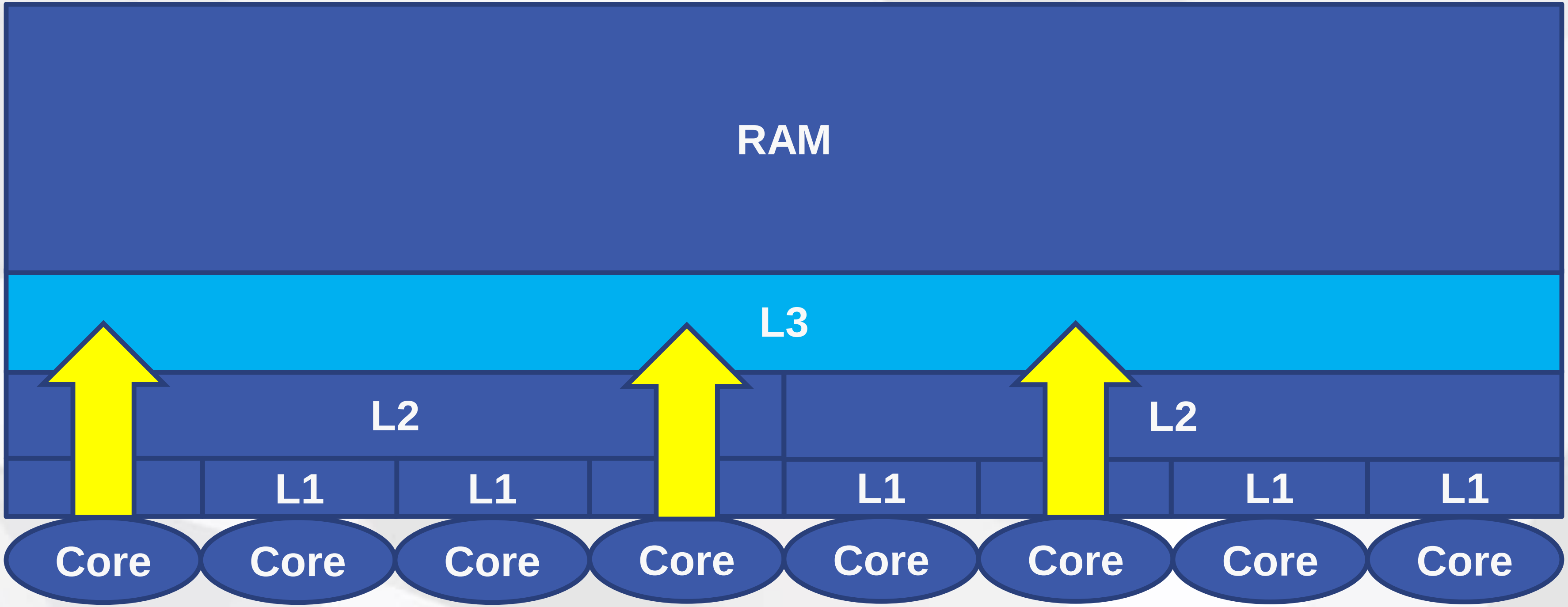
LockFreePool

Wait-Free
Queue +
Buffer

Thread-Local
Something +
???

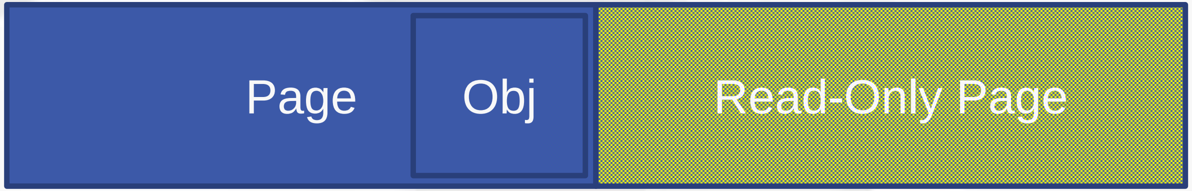
Contention

L3 is Slow!

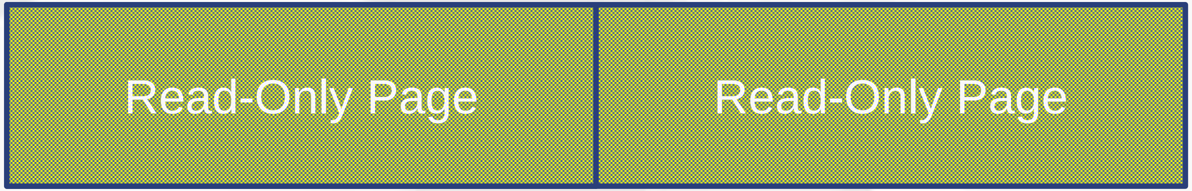

RAM
L3
L2
L2
L1
L1
L1
L1
L1
Core
Core
Core
Core
Core
Core
Core
Core

(

PageProtect Allocator



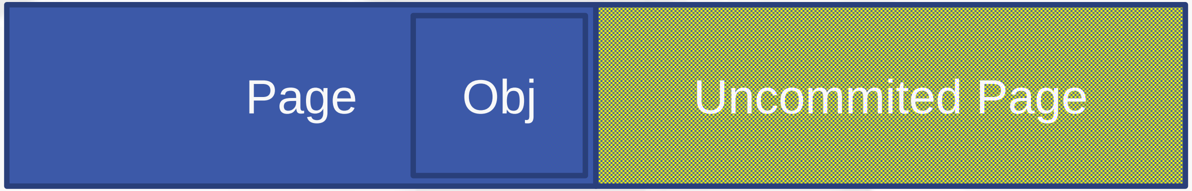
PageProtect Allocator



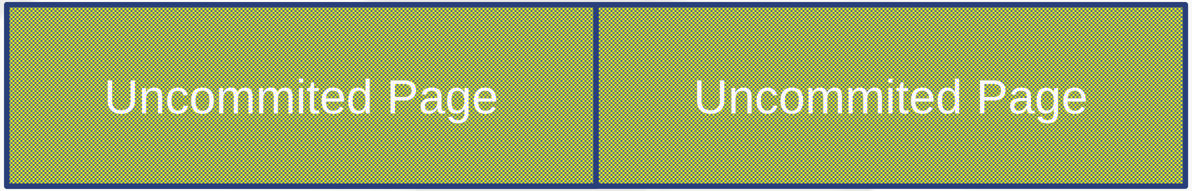
Read-Only Page

Read-Only Page

PageProtect Allocator



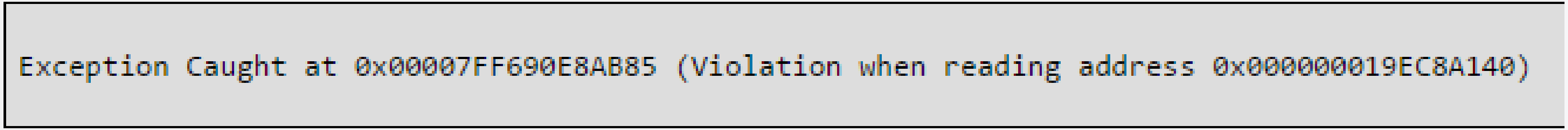
PageProtect Allocator



Uncommited Page

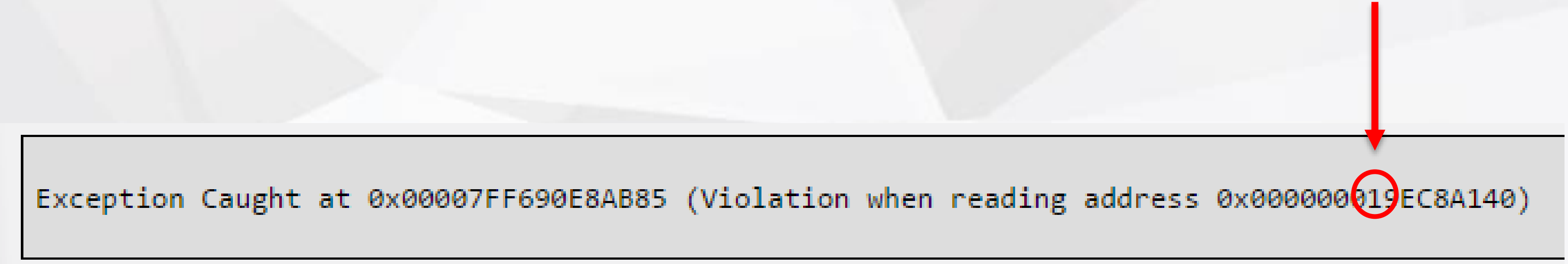
Uncommited Page

PageProtect Allocator



```
Exception Caught at 0x00007FF690E8AB85 (Violation when reading address 0x000000019EC8A140)
```

PageProtect Allocator



```
Exception Caught at 0x00007FF690E8AB85 (Violation when reading address 0x000000019EC8A140)
```

PageProtect Allocator

```
…
case 72:
    return g_PageProtectAllocator;
…
```

)

LockFreePool: PageProtect

```
LockFreePool<
   MyType, 1024,
   PageProtectPolicy<MyType, 1024>>
   myPool;
```

```
#if defined(UBI_FINAL) || defined(UBI_PROFILE)
#define DefaultDataPolicy FixedDataPolicy<T, SizeT>
#elif defined(UBI_EDITOR)
#define DefaultDataPolicy MultiDataPolicy<T, SizeT, 100, 10>
#else
#define DefaultDataPolicy MultiDataPolicy<T, SizeT, 10, 1>
#endif

template <typename T, size_t SizeT, typename DataPolicyT =
    DefaultDataPolicy>
class LockFreePool …
```

Recap

- Situation and workflow overview
  - 7th core!, 4 core clusters, Telemetry, Perf Test
- Reduce memory allocation cost
  - Some lock-free allocators, Task Allocator
- Reduce memory allocation number
  - Telemetry, Array Analyzer, inplace_function
- Lock-free solutions
  - Lock Analyzer, Queue, Pool

Notes

- These slides are just for reference. Better watch the Youtube video.

Special Thanks and Q&A

- Sebastien Lussier: Low Level Memory Optimizations
- Maurizio De Pascale: Unified Telemetry
- Jean-René Minville: Analysis Tools
- Pascal Drolet and Sebastien Lussier: Profiler Implementation