SPU gameplay

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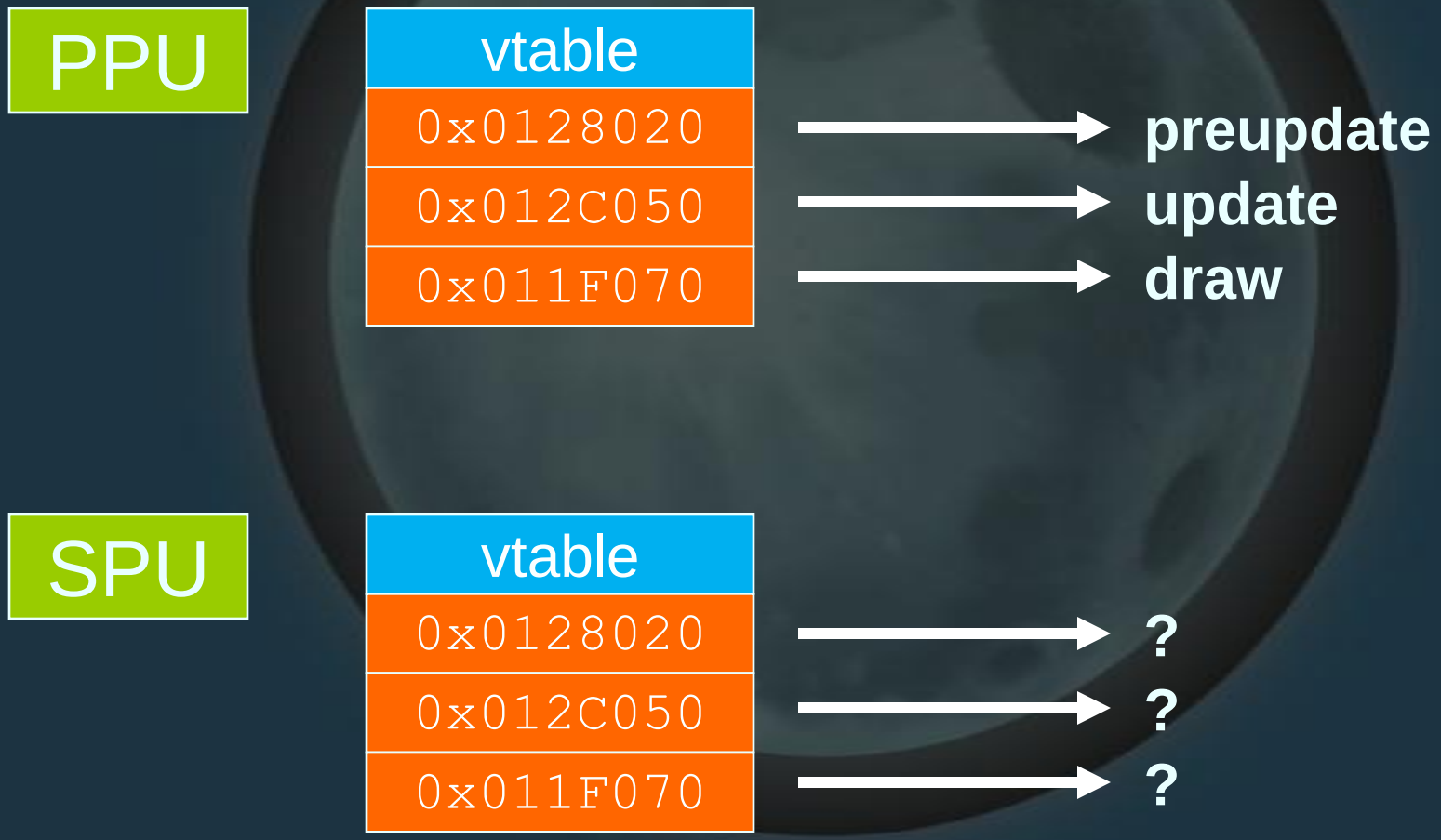
glossary

- mobys
  - class
  - instances
- update classes
- AsyncMobyUpdate
  - Guppys
  - Async
- aggregateupdate

spu gameplay difficulties

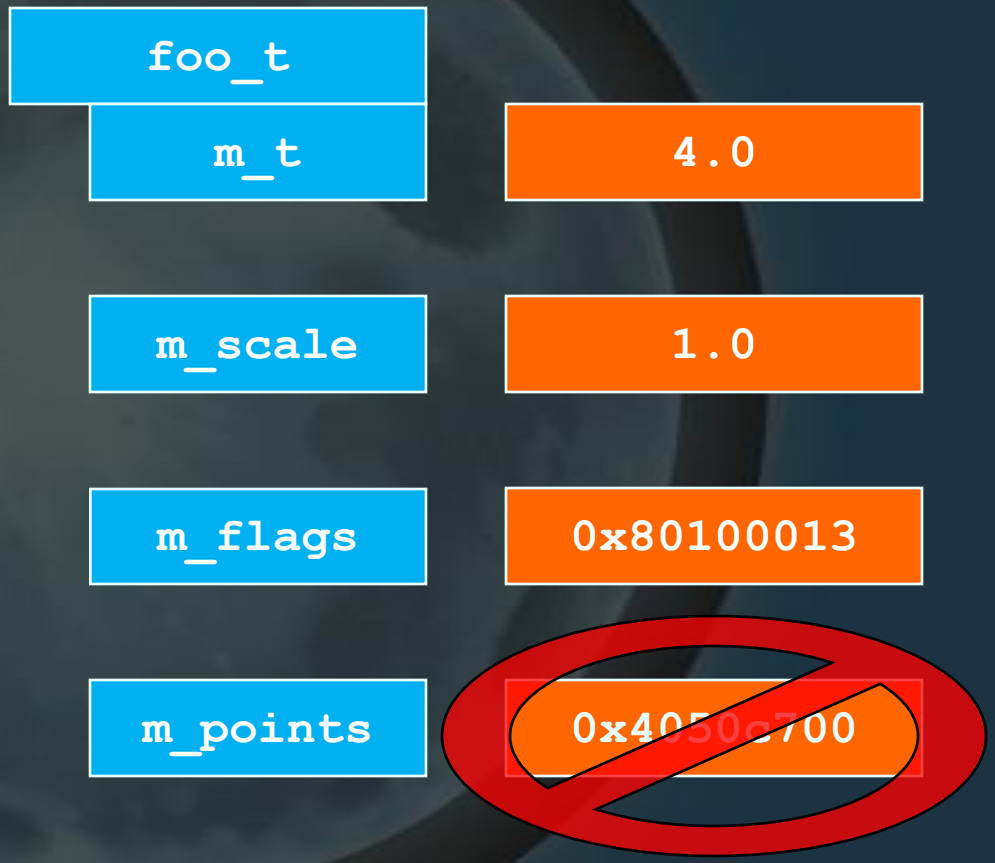
- multiprocessor
- NUMA
- different ISA
- it’s different
  - takes time and effort to retrofit code
  - unfamiliarity with the necessary upfront design

your virtual functions don’t work



your pointers don’t work

```
struct foo_t
{
 float m_t;
 float m_scale;
 u32   m_flags;
 u16*  m_points;
};
```



your code doesn’t compile

```
x:/core/code/users/jvalenzu/shared/igCore/igsys/igDebug.h(19,19): error:
    libsn.h: No such file or directory
x:/core/code/users/jvalenzu/shared/igCore/igTime/igTimer.h(15,27): error:
    sys/time_util.h: No such file or directory
pickup/pickupbase_preupdate_raw.inc(160): error: 'DEFAULT_FLAGS' is not a
    member of 'COLL'
pickup/pickupbase_preupdate_raw.inc(160): error: 'EXCLUDE_HERO_ONLY' is
    not a member of 'COLL'
x:/core/code/users/jvalenzu/shared/igCore/igPhysics/ppu/igPhysics.h(293):
    error: expected unqualified-id before '*' token
x:/core/code/users/jvalenzu/shared/igCore/igPhysics/ppu/igPhysics.h(293):
    error: expected ',' or '...' before '*' token
x:/core/code/users/jvalenzu/shared/igCore/igPhysics/ppu/igPhysics.h(293):
    error: ISO C++ forbids declaration of 'parameter' with no type
x:/core/code/users/jvalenzu/shared/igCore/igg/igShaderStructs.h: At global
    scope:
x:/core/code/users/jvalenzu/shared/igCore/igg/igShaderStructs.h(22):
    error: redefinition of 'struct VtxVec4'
x:/core/code/users/jvalenzu/shared/igCore/igsys/igTypes.h(118): error:
    previous definition of 'struct VtxVec4'
```

object driven update

```
for(i = 0; i < num_entities; ++i) {
  entity* e = &g_entity_base[i];

  e->collect_info();
  e->update();

  e->move();
  e->animate();
  e->etc();
}
```

- can’t amortize setup costs
- can’t hide much deferred work

more modular update

1

```
for(i = 0, e = &g_entity_base[0]; i < num_ent; ++i, ++e) {
  e->collect_info();
  e->issue_anim_request();
}

for(i = 0, e = &g_entity_base[0]; i < num_ent; ++i, ++e)
  e->update();
```

2

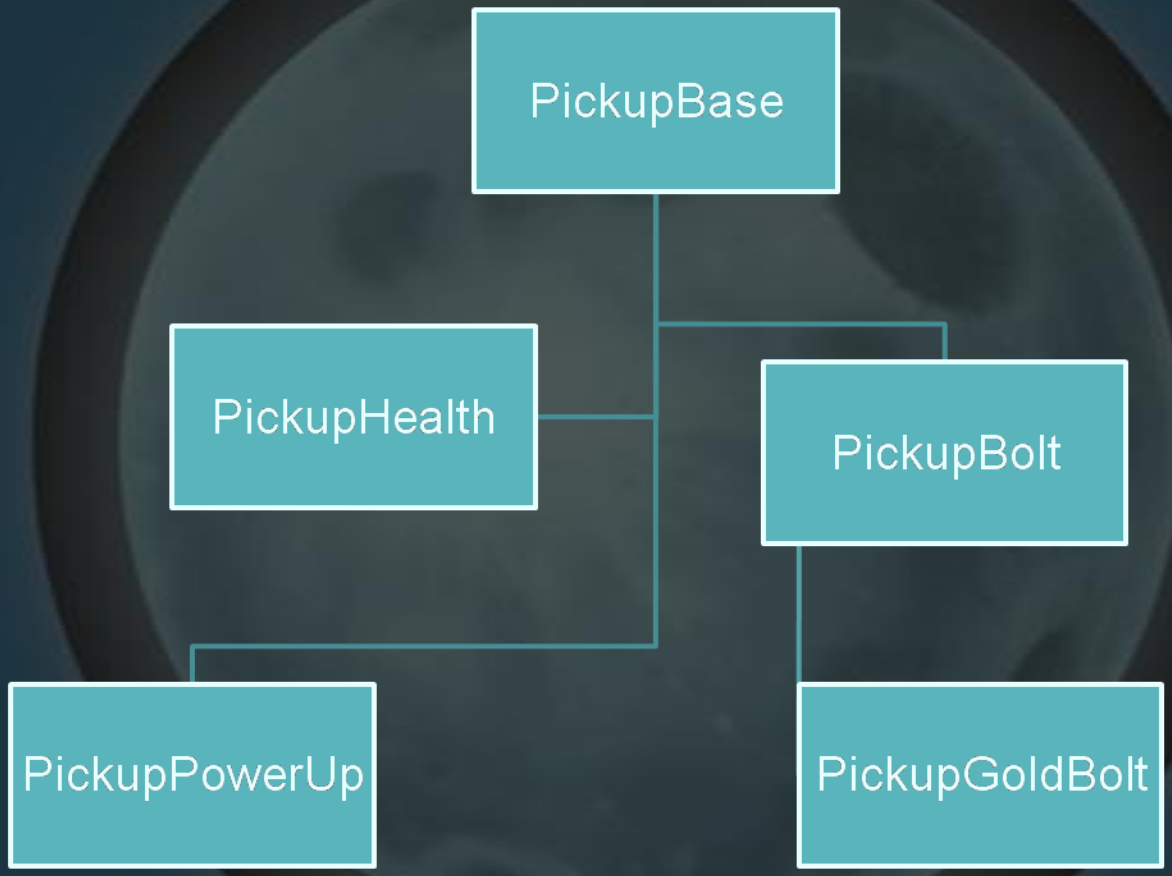
```
finalize_animation();

for(i = 0, e = &g_entity_base[0]; i < num_ent; ++i, ++e)
  e->postupdate();
```

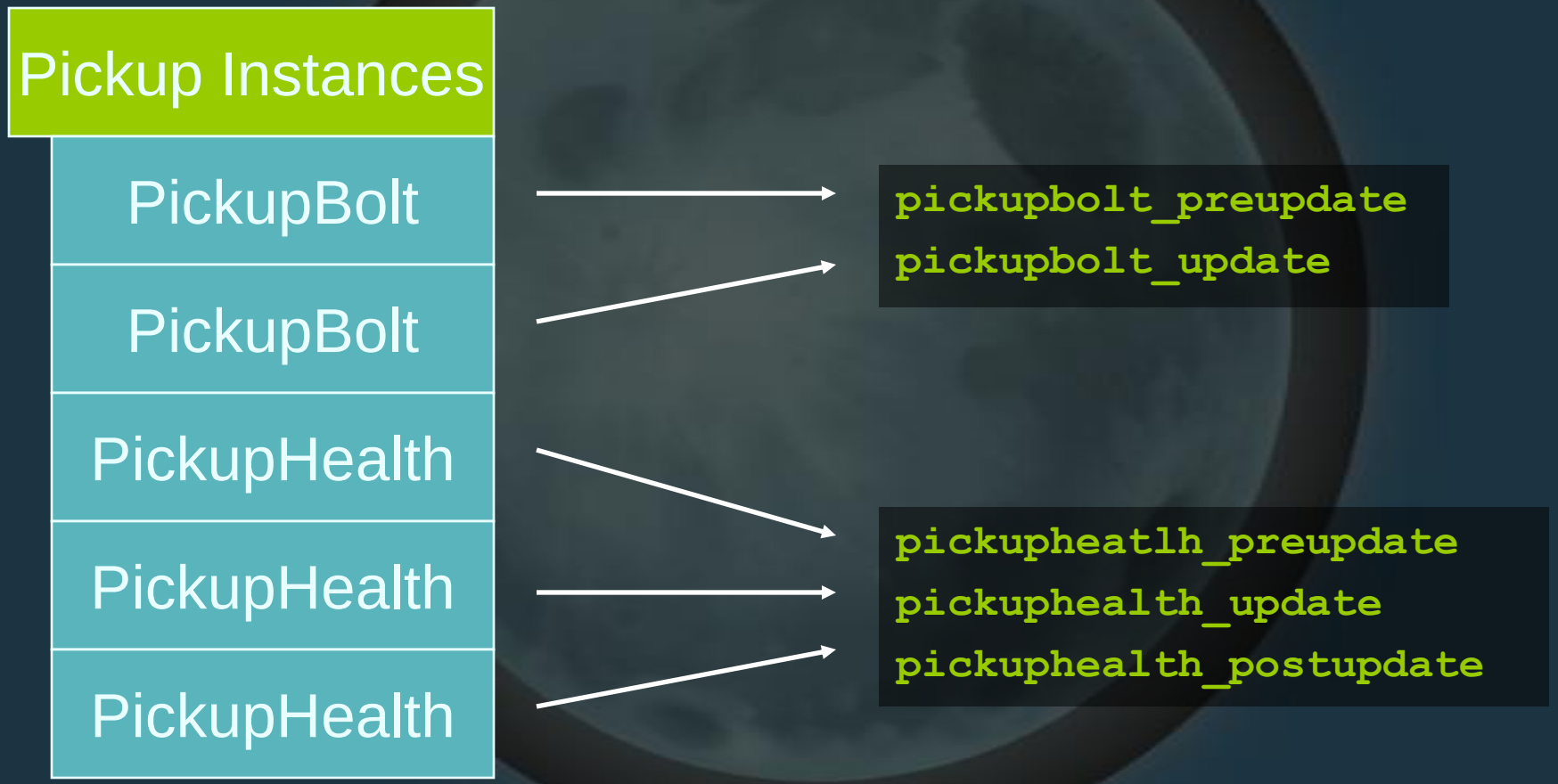
aggregate updating

- group instances by type
  - further sort each group to minimize state change
- one aggregate updater per type, with multiple code fragments
- combined ppu & spu update
- more opportunity to amortize cost of expensive setup

aggregate example (pickup)



aggregate example cont…



a trivial optimization

```
void TruckUpdate::Update()
{
  if(m_wait_frame > TIME::GetCurrentFrame())
  {
    return;
  }

  // … more work
}
```

a trivial optimization

```
void TruckUpdate::Update()
{
  if(m_wait_frame > TIME::GetCurrentFrame())
  {
    return;
  }

  // … more work
}
```

a trivial optimization (cont)

```
void Aggregate_TruckUpdate_Update()
{
  u32 current_frame = TIME::GetCurrentFrame();

  for(u32 i = 0; i < m_count; ++i)
  {
    TruckUpdate* self = &m_updates[i];
    if(self->m_wait_frame > current_frame)
    {
      continue;
    }

    // … more work
  }
}
```

SPU gameplay systems

SPU gameplay intro

- systems built around applying shaders to lots of homogenous data
  - AsyncMobyUpdate
  - Guppys
  - AsyncEffect
- small, simple code overlays
  - user-supplied
  - compiled offline
  - debuggable
  - analogous to graphics shaders

async moby update overview

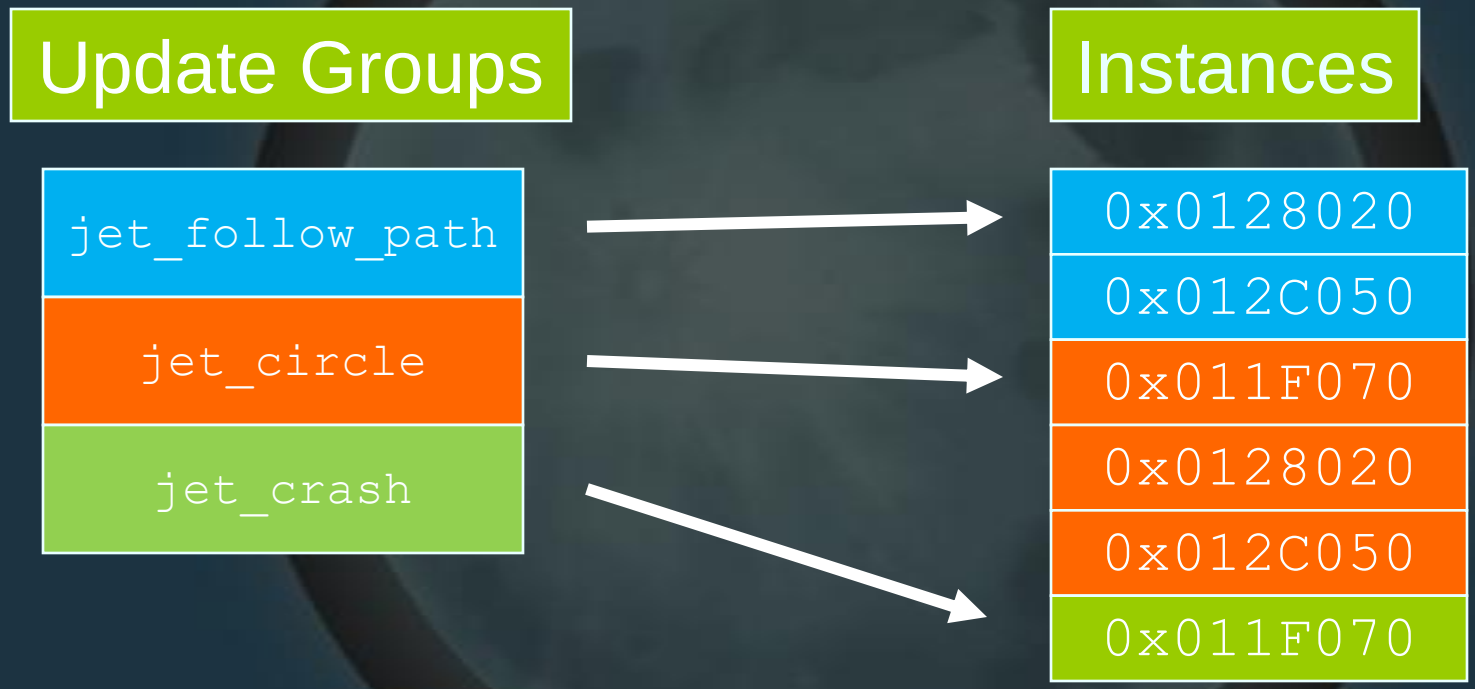
overview

- AsyncMobyUpdate
  - base framework, meant to work with update classes
  - retains MobyInstance rendering pipeline
- Guppys
  - “light” MobyInstance replacement
  - 100% SPU update, no update class
  - 90% MobyInstance rendering pipeline
- AsyncEffect
  - very easy fire & forget SPU “effects”
  - user-selectable, not user-written, shaders

async moby update

- designed to move update classes to SPU
- user supplied update routine in code fragment
- multiple code fragments per update class
  - one per AI state, for example
- user-defined instance data format
- user-defined common data
- extern code provided through function pointer tables

async moby update (cont...)



- update group per code fragment
- instances bound to update group each frame

instance vs common

- instance data
  - data transformed by your update routine
  - *e.g.* a Jet, or zombie limb
- common data
  - data common to all instances of the same type
  - *e.g.* class-static variables, current frame

function pointer table interface

```
struct global_funcs_t
{
 void (*print)(const char *fmt, ...);
 // …
 f32  (*get_current_time)();
 u32  (*read_decrementer)();
 u32  (*coll_swept_sphere)(qword p0, qword p1, u32 flags);
 void (*coll_get_result)  (COLL::Result *dest, u32 id, u32 tag);
};
```

- debug, print functions
- access to common data, timestep
- collision & FX routines

simple API

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

allocate tag

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

register fragment

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

set common block info

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

set instances info

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

add instances per frame

setup:

```
u32 tag = AsyncMobyUpdate::AllocTag();

AsyncMobyUpdate::RegisterType          (tag, truck_frag_start, truck_frag_size);

// common setup
AsyncMobyUpdate::SetNumCommonBlocks(tag, 1);
AsyncMobyUpdate::SetCommonBlock    (tag, 0,
                                    &g_TruckCommon, sizeof g_TruckCommon);

// instance setup
AsyncMobyUpdate::SetNumInstanceStreams(tag, 1);
AsyncMobyUpdate::SetOffset             (tag, 0, 0);
AsyncMobyUpdate::SetStride             (tag, 0, sizeof(TruckClass));
```

use:

```
AsyncMobyUpdate::AddInstances          (tag, instance_block, count);
```

our gameplay shaders

- 32k relocatable programs
- makefile driven process combines code, data into fragment
- instance types
  - user defined (Async Moby Update)
  - predefined (Guppys, AsyncEffect)

more shader talk

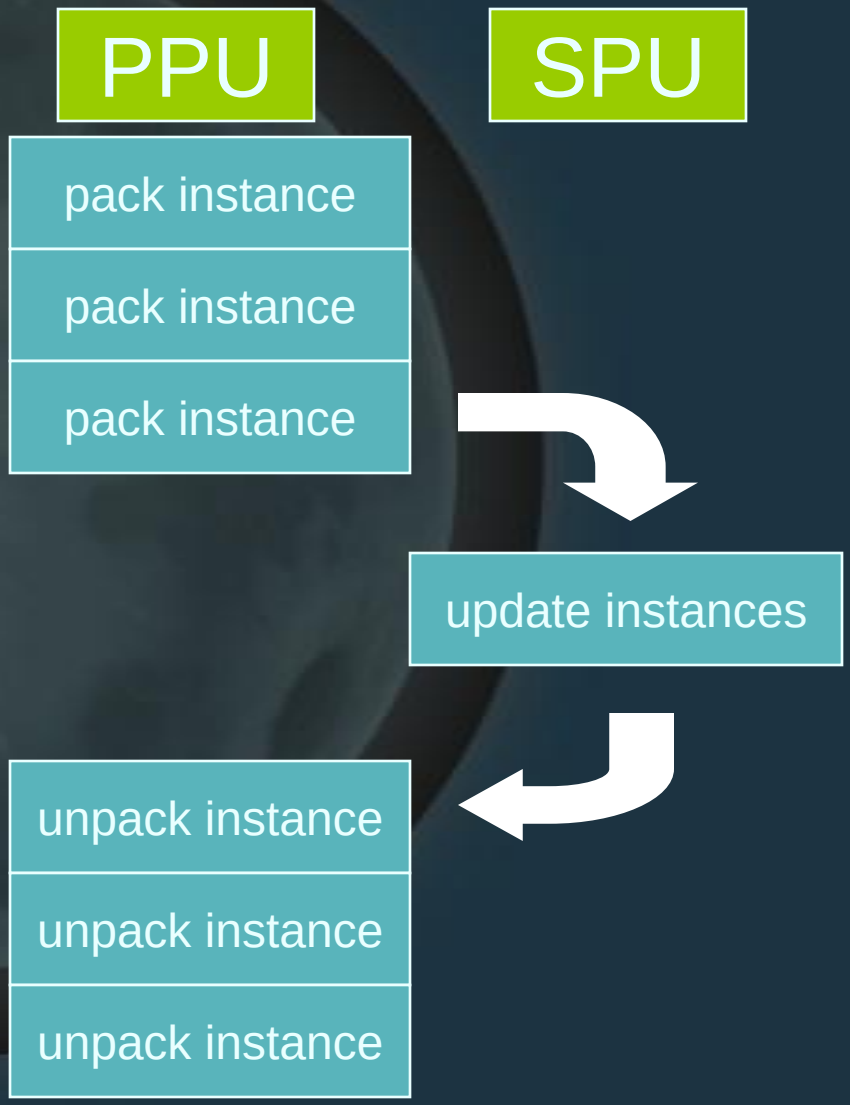
- What do our code fragments do?
  - dma up instances
  - transform instance state, position
  - maybe set some global state
  - dma down instances
- typical gameplay stuff
  - preupdate, update, postupdate

more about instance data

- what is our instance data?
  - not an object
  - generally, a subset of an update class
  - different visibility across PU/SPU
- where does instance data live?
  - could be copied into a separate array
  - could read directly from the update classes
  - we support and use both forms

packed instance array

- advantages
  - simplicity
  - lifetime guarantees
  - compression
- disadvantages
  - explicit fragmentation
  - pack each frame



data inside update class

- advantages
  - pay memory cost as you go
  - don’t need to know about every detail of an update class
- disadvantages
  - no longer control “lifetime” of objects
- specify interesting data with stride/offset

instance prefetch problem

- ea_base = starting address of our instances
- num_instances = number of instances

```
Instance pipe[2];
dma_get(&pipe[0], ea_base, sizeof(Instance), tag);

for(int i = 0; i < num_instances; ++i) {
  Instance* cur_inst  = &pipe[i&1];
  Instance* next_inst = &pipe[(i+1)&1];

  dma_sync(tag);
  dma_get(next_inst, ea_base + (i+1) * sizeof(Instance), tag);

  // ... do work
}
```

instance prefetch problem (cont)

- ... we almost always need to fetch an associated data member out of our instances immediately

```
Instance pipe[2];
dma_get(&pipe[0], ea_base, sizeof(Instance), tag);

for(int i = 0; i < num_instances; ++i) {
  Instance* cur_inst  = &pipe[i&1];
  Instance* next_inst = &pipe[(i+1)&1];

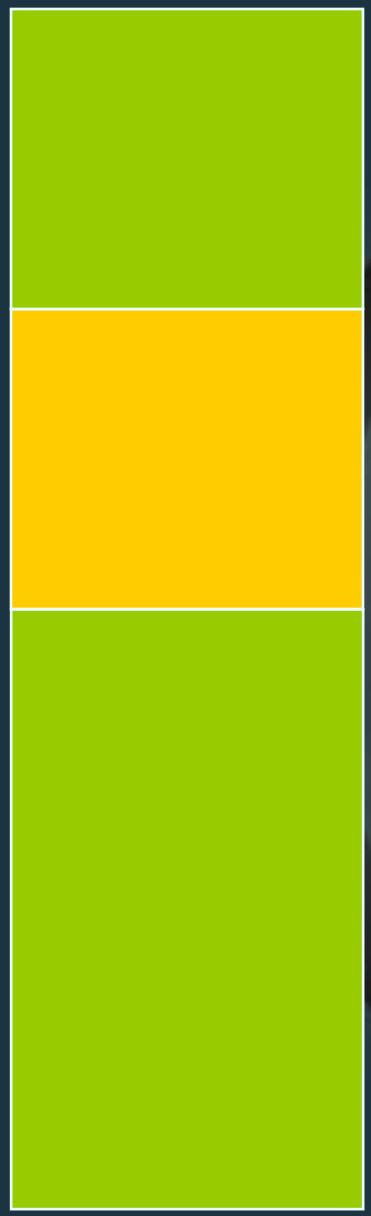
  dma_sync(tag);
  dma_get(next_inst, ea_base + (i+1) * sizeof(Instance), tag);

  MobyInstance cur_moby;
  dma_get(&cur_moby, cur_inst->m_moby_ea, sizeof(MobyInstance), tag);
  dma_sync(tag);

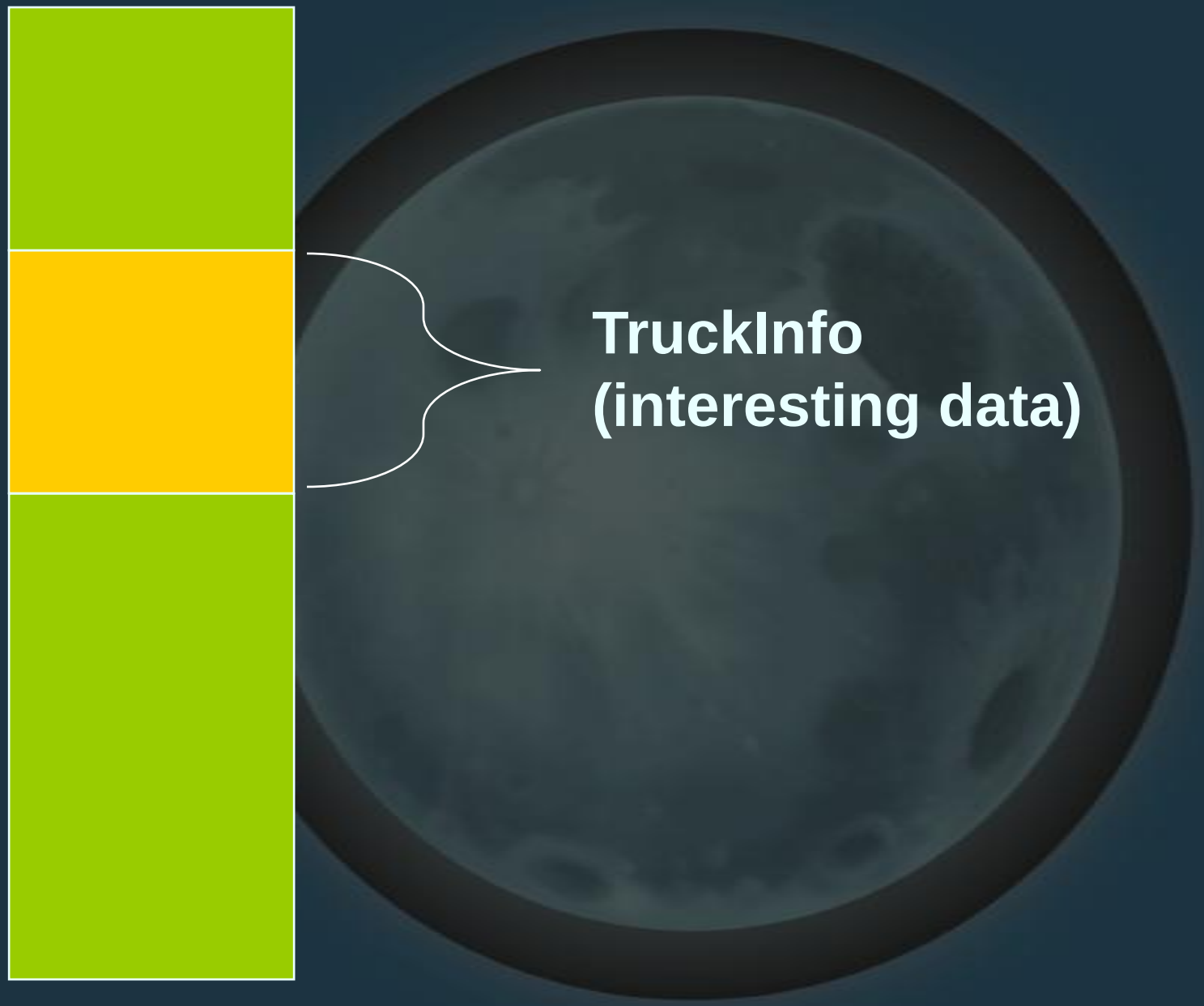
  // do work
}
```

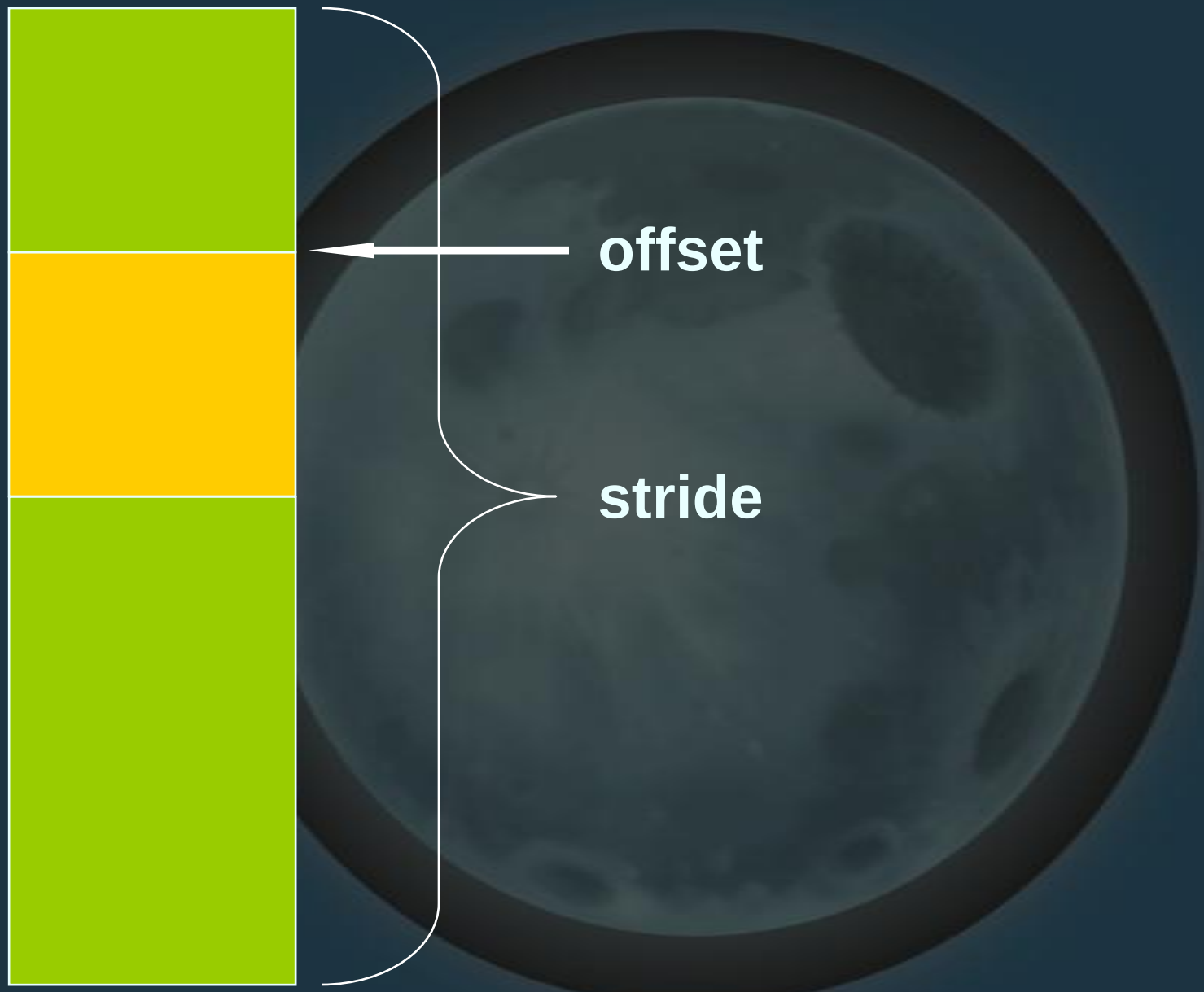
instance “streams”

- instances are available as “streams”
  - each has its own base, count, offset, stride, and addressing mode
- allows one to prefetch multiple associated elements without stalling
- also useful for getting slices of interesting data out of an untyped blob



TruckUpdate (PPU) instance


TruckInfo
(interesting data)


offset
stride

memory addressing

- direct
  - contiguous block of instances
- direct indexed
  - indices used to deference an array of instances
- indirect indexed
  - indices used to source an array of instance pointers

More Memory Addressing

- common blocks are preloaded
- shaders must DMA up their own instances
- meta-information is preloaded
  - indices
  - EA base pointer (direct)
  - EA pointer array (indirect)
- buffering logic is very context sensitive

indirect indexed example

```
struct DroneInfo
{
 u32 m_stuff;
};

class DroneUpdate : public AI::Component
{
  // …
  DroneInfo      m_info;
  MobyInstance* m_moby;
};
```

indirect indexed example (cont)…

```
// once
AsyncMobyUpdate::SetNumInstanceStreams(amu_tag, 2);
AsyncMobyUpdate::SetStride(amu_tag, 0, sizeof DroneUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 0, OFFSETOF(DroneUpdate,
                                                m_info));
AsyncMobyUpdate::SetStride(amu_tag, 1, sizeof MobyInstance);
AsyncMobyUpdate::SetOffset(amu_tag, 1, 0);

// per frame
AsyncMobyUpdate::BeginAddInstances(amu_tag);
AsyncMobyUpdate::SetStreamIndirect(0,
   /* base */                m_updates,
   /* indices */             m_truck_update_indices,
   /* count */               m_num_trucks,
   /* max_index */           m_num_trucks);
AsyncMobyUpdate::SetStream(1, IGG::g_MobyInsts.m_array,
                           m_moby_indices, m_num_trucks);
AsyncMobyUpdate::EndAddInstance ();
```

indirect indexed example (cont)…

```
// once
AsyncMobyUpdate::SetNumInstanceStreams(amu_tag, 2);
AsyncMobyUpdate::SetStride(amu_tag, 0, sizeof DroneUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 0, OFFSETOF(DroneUpdate,
                                        m_info));
AsyncMobyUpdate::SetStride(amu_tag, 1, sizeof MobyInstance);
AsyncMobyUpdate::SetOffset(amu_tag, 1, 0);

// per frame
AsyncMobyUpdate::BeginAddInstances(amu_tag);
AsyncMobyUpdate::SetStreamIndirect(0,
   /* base */              m_updates,
   /* indices */           m_truck_update_indices,
   /* count */             m_num_trucks,
   /* max_index */         m_num_trucks);
AsyncMobyUpdate::SetStream(1, IGG::g_MobyInsts.m_array,
                           m_moby_indices, m_num_trucks);
AsyncMobyUpdate::EndAddInstance ();
```

typical usage: two streams

```
void async_foo_update(global_funcs_t* gt, update_set_info_t* info,
                      common_blocks_t* common_blocks,
                      instance_streams_t* instance_streams,
                      u8* work_buffer, u32 buf_size, u32 tags[4]) {
 u32* drone_array   = instance_streams[0].m_ea_array;
 u16* drone_indices = instance_streams[0].m_indices;
 u32  drone_offset  = instance_streams[0].m_offset;
 u32* moby_array    = instance_streams[1].m_ea_array;
 u16* moby_indices  = instance_streams[1].m_indices;
 u32  moby_offset   = instance_streams[1].m_offset;

 DroneInfo inst;
 MobyInstance moby;
 for(int i = 0; i < instance_streams[0].m_count; ++i) {
  gt->dma_get(&inst, drone_array[drone_indices[i]] + drone_offset,
              sizeof inst, tags[0]);
  gt->dma_get(&moby, moby_array[moby_indices[i]] + moby_offset,
              sizeof moby, tags[0]);
  gt->dma_wait(tags[0]);

  // …
 }
}
```

1

2

indirect indexed example #2

```
struct TruckInfo
{
  u32   m_capacity;
  u32   m_type_info;
  f32   m_hp;
  u32   m_flags;
};

class TruckUpdate : public AI::Component
{
  protected:
    …;
  public:
    u32 m_ai_state;
    TruckInfo m_info __attribute__((aligned(16)));
};
```

indirect indexed example 2 (cont)…

```
// once
AsyncMobyUpdate::SetNumInstanceStreams(amu_tag, 2);
AsyncMobyUpdate::SetStride(amu_tag, 0, sizeof TruckUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 0, OFFSETOF(TruckUpdate, m_info));
AsyncMobyUpdate::SetStride(amu_tag, 1, sizeof TruckUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 1, OFFSETOF(TruckUpdate, m_info));

// per frame
AsyncMobyUpdate::BeginAddInstances(amu_tag);
AsyncMobyUpdate::SetStreamIndirect(0,
   /* base */                m_updates,
   /* indices */             m_truck_update_indices,
   /* count */               m_num_trucks,
   /* max_index */           m_num_trucks);
AsyncMobyUpdate::SetStreamIndirect(1, m_updates,
                                   m_truck_update_indices,
                                   m_num_trucks, m_num_trucks);
AsyncMobyUpdate::EndAddInstance ();
```

indirect indexed example 2 (cont)…

```
// once
AsyncMobyUpdate::SetNumInstanceStreams(amu_tag, 2);
AsyncMobyUpdate::SetStride(amu_tag, 0, sizeof TruckUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 0, OFFSETOF(TruckUpdate, m_info));
AsyncMobyUpdate::SetStride(amu_tag, 1, sizeof TruckUpdate);
AsyncMobyUpdate::SetOffset(amu_tag, 1, OFFSETOF(TruckUpdate, m_info));

// per frame
AsyncMobyUpdate::BeginAddInstances(amu_tag);
AsyncMobyUpdate::SetStreamIndirect(0,
   /* base */              m_updates,
   /* indices */           m_truck_update_indices,
   /* count */             m_num_trucks,
   /* max_index */         m_num_trucks);
AsyncMobyUpdate::SetStreamIndirect(1, m_updates,
                                   m_truck_update_indices,
                                   m_num_trucks, m_num_trucks);
AsyncMobyUpdate::EndAddInstance ();
```

dma up slice of update class

```
void async_foo_update(global_funcs_t* gt, update_set_info_t* info,
                      common_blocks_t* common_blocks,
                      instance_streams_t* instance_streams,
                      u8* work_buffer, u32 buf_size, u32 tags[4])
{
 u32* earray  = instance_streams[0].m_ea_array;
 u16* indices = instance_streams[0].m_indices;
 u32  offset  = instance_streams[0].m_offset;

 TruckInfo inst;
 for(int i = 0; i < instance_streams[0].m_count; ++i)
 {
  gt->dma_get(&inst, earray[ indices[i] ] + offset,
              sizeof inst, tags[0]);
  gt->dma_wait(tags[0]);

  // update
 }
}
```

1

2

dma full update class, slice info out

1

```
u32* earray  = instance_streams[0].m_ea_array;
u16* indices = instance_streams[0].m_indices;
u32  offset  = instance_streams[0].m_offset;
u32  stride  = instance_streams[0].m_stride;

u32* ai_earray  = instance_streams[1].m_ea_array;
u16* ai_indices = instance_streams[1].m_indices;
u32  ai_offset  = instance_streams[1].m_offset;
```

2

```
u8* blob = (u8*) alloc(instance_streams[1].m_stride);
for(int i = 0; i < instance_streams[0].m_count; ++i)
{
 gt->dma_get(&blob, earray[ indices[i] ], stride, tags[0]);
 gt->dma_wait(tags[0]);
```

3

```
 TruckInfo *inst = (TruckInfo*) (blob + instance_streams[0].m_offset);
 u32 *ai_state   = (u32*)       (blob + instance_streams[1].m_offset);

 // …
}
```

code fragment signature

```
extern "C" void
async_foo_update(global_funcs_t* gt,
                 update_set_info_t* info,
                 common_blocks_t* common_blocks,
                 instance_streams_t* instance_streams,
                 u8* work_buffer, u32 buf_size, u32 tags[4])
```

- global_funcs_t - global function pointer table
- update_set_info_t - meta info
- common blocks_t - stream array for common blocks
- instance_streams_t - stream array for instances
- work_buffer & buf_size - access to LS
- dma_tags - 4 preallocated dma tags

guppys

- lightweight alternative to MobyInstance
- update runs entirely on SPU
- one 128byte instance type
- common data contained in “schools”
- simplified rendering

guppys

- common use case: “bangles”
- to cleave a mesh, we previously required an entire new MobyInstance to cleave a mesh
  - turn off arm mesh segment on main instance
  - turn off all other mesh segments on spawned instance
- spawn a guppy now instead

the guppy instance

- position/orientation EA
- 1 word flags
- block of “misc” float/int union data
- animation joints EA
- joint remap table
- Insomniac “special sauce”

Async Effect

- simplified API for launching SPU-updating effects
- no code fragment writing necessary
- specialized at initialization
  - linear/angular movement
  - rigid body physics
  - rendering parameters

Async Effect API

```
u16 moby_iclass   = LookupMobyClassIndex( ART_CLASS_BOT_HYBRID_2_ORGANS );
MobyClass* mclass = &IGG::g_MobyCon.m_classes[ moby_iclass ];



u32 slot = AsyncEffect::BeginEffectInstance(AsyncEffect::EFFECT_STATIONARY,
                                            mclass);
AsyncEffect::SetEffectInstancePo (slot, moby->m_mat3, moby->m_pos);
AsyncEffect::SetEffectInstanceF32(slot, AsyncEffect::EFFECT_PARAM_LIFESPAN,
                                  20.0f);
u32 name = AsyncEffect::Spawn(slot);
```

- stationary effect with 20 second life
- **`name`** can be used to kill the effect

SPU invoked code

different mechanisms

- immediate
  - via global function table
- deferred
  - command buffer
- adhoc
  - PPU shims
  - direct data injection

deferred

- PPU shims
  - flags set in SPU update, querys/events triggered subsequently on PPU
- command buffer
  - small buffer in LS filled with command specific byte-code, flushed to PPU
- atomic allocators
  - relevant data structures packed on SPU, atomically inserted

command buffer: swept sphere

command buffer: results

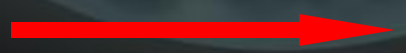
frame n

```
handle_base = ((stage << 5) | (job_number & 0x1f)) << 24;
// …
handle = handle_base + request++;
```

frame n+1

offset table

- frame n, stage 0, job 1
- frame n, stage 1, job 1
- frame n, stage 2, job 1
- frame n, stage 0, job 2

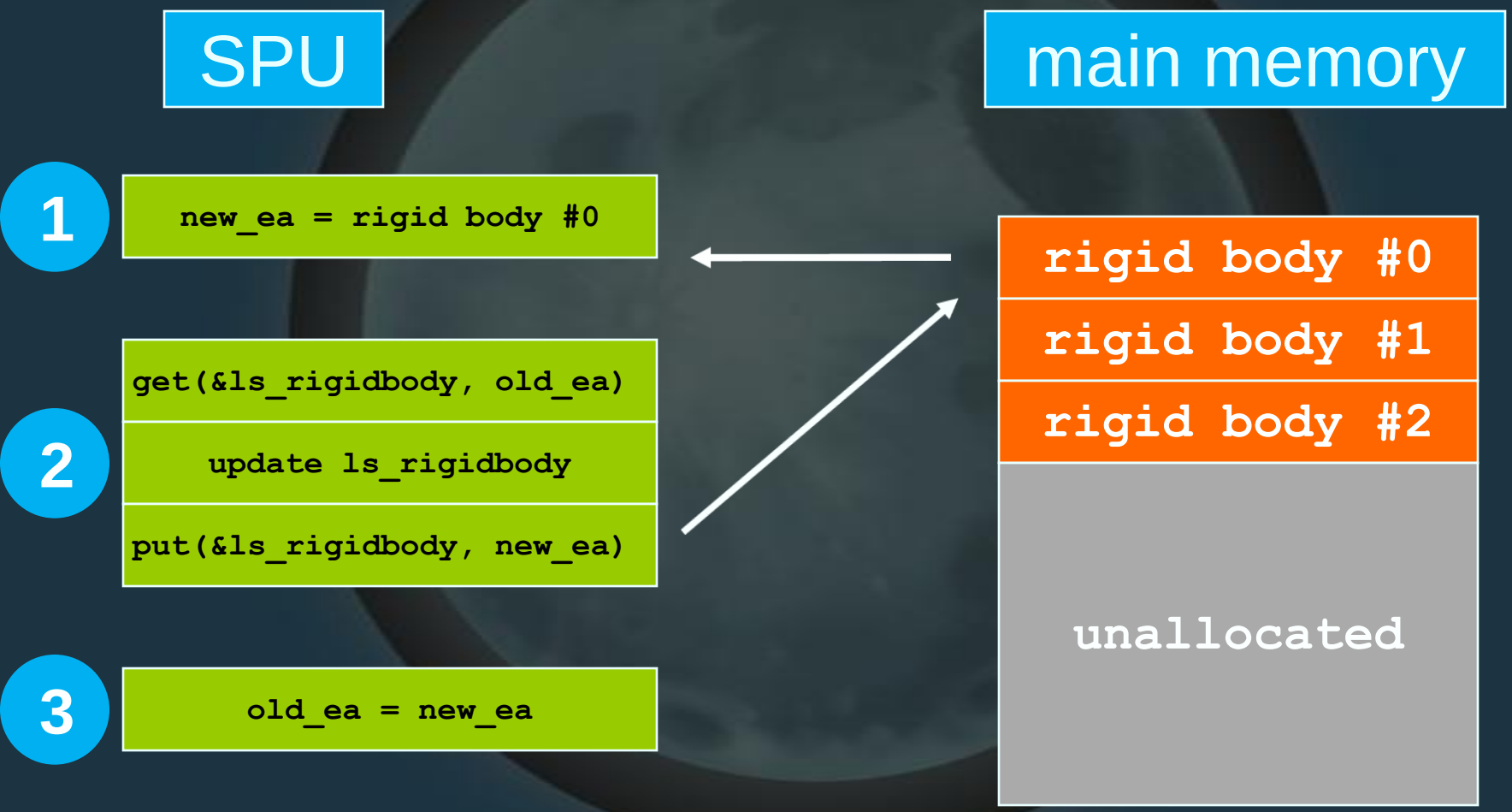


result

direct data

- patch into atomically allocated, double buffered data structures
- instance allocates fresh instance each frame, forwards state between old and new
- deallocation == stop code fragment
- used for rigid body physics

direct data


SPU
main memory
1
new_ea = rigid body #0
2
get(&ls_rigidbody, old_ea)
update ls_rigidbody
put(&ls_rigidbody, new_ea)
3
old_ea = new_ea
rigid body #0
rigid body #1
rigid body #2
unallocated

SPU API

- SPU-API
  - mechanism to expose new functionality through to the AsyncMobyUpdate system
  - library of code fragment code and common data (“fixup”)
  - function pointer table (“interface”) oriented
  - hides immediate or deferred commands

SPU API

h

```
struct rcf_api_interface
{
  u32 (*derived_from)(u32 update_class, u32 base_class);
  u32 (*add_bolts)    (u32 update_class, u32 value);
};
```

cpp

```
rcf_api_interface* rcf_api = gt->get_spu_api("rcf2");

if(rcf_api->derived_from(inst->m_update_class, HERO_Ratchet_CLASS))
{
  rci_api->add_bolts(inst->m_update_class, 25);
}
```

example #1

- Jets
  - uses AsyncMobyUpdate along with an Update Class
  - packed instance array
  - code fragment per AI state
  - little initialization setup, state changes rare
  - events triggered using adhoc method
    - flags checked at pack/unpack time
- inputs:
  - position/orientation
  - state info
- output:
  - position/orientation

example #2

- zombie limbs
  - guppy
  - not much update logic
  - direct data interface to rigid body physics
- input:
  - position/orientation
  - animation joints
  - collision info
- output:
  - packed rigid bodies

porting code

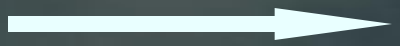
porting code sucks

- difficult to retrofit code
- different set of constraints
- expensive use of time
- can result in over-abstracted systems
  - like, software cache for transparent pointers

couple of tips

Separate interesting information from non-necessary data structures

```
struct foo_t : bar_t
{
  // stuff
  u32 m_first;
  u32 m_second;
  u32 m_third;
  u32 m_fourth;
  // more stuff
};
```



```
struct foo_info_t
{
  u32 m_first;
  u32 m_second;
  u32 m_third;
  u32 m_fourth;
};

struct foo_t : bar_t
{
  // stuff
  foo_info_t m_info;
  // more stuff
};
```

couple of tips (cont)…

avoid pointer fixup, define pointer types to unsigned ints

```
struct baz_t
{
  u32            m_foo;
#ifdef PPU
  MobyInstance* m_moby;
#else
  u32            m_moby_ea;
#endif
  f32            m_scale;
};
```

living with polymorphism

- the described mechanisms have problems with virtual functions
  - would need to port and patch up all possible vtable destinations
  - would end up duplicating/shadowing virtual class hierarchy on SPU
- could work, but we don’t do that

compile-time polymorphism

- do a trace of the class hierarchy: one code fragment per leaf class
- separate base functions into .inc files
- virtual functions selected through sequential macro define/undef pairs
- not described:
  - deferred resolution of base function calls to derived function via preprocessor pass

living with polymorphism (cont)

pickupbolt_preupdate.cpp

```
#include "code_fragment_pickup.inl"
#include "code_fragment_pickup_bolt.inl"
```

code_fragment_pickup.inl

```
void base_on_pickup(CommonInfo* common, InstanceInfo* inst) {
  inst->m_base_info->m_spu_flags |= PICKUP_SPU_FLAGS_PICKED_UP;
}

#define ON_PICKUP(c,i)     base_on_pickup(c, i)
```

code_fragment_pickup_bolt.inl

```
void bolt_on_pickup(CommonInfo* common, InstanceInfo* inst) {
  common->m_active_bolt_delta--;
}
#undef ON_PICKUP
#define ON_PICKUP(c,i)     bolt_on_pickup(c, i)
```

living with polymorphism (cont)

pickupbolt_preupdate.cpp

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code_fragment_pickup.inl

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living with polymorphism (cont)

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```

design from scratch

- parameterized systems
  - not specialized by code
- use atomic allocators as programming interfaces
- no virtual functions in update phase
- separate perception, cognition, action
- plan to interleave ppu/spu

In conclusion

- design up front for deferred, SPU-friendly systems.
- don’t worry too much about writing optimized code, just make it difficult to write unoptimizable code
- remember, this is supposed to be fun. SPU programming is fun.

all pictures U.S. Fish & Wildlife Service except

The Whale Fishery - NOAA National Marine Fisheries Service

jurvetson@flickr “Swarm Intelligence” photo

Thanks

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