sync_ptr

pointer chaining and stealing

using RAII technique

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shared_ptr

```
struct Obj
{ … };
std::shared_ptr<Obj> ptr1 = std::make_shared<Obj>();
std::shared_ptr<Obj> ptr2 = ptr1;
assert(ptr1 == ptr2);
```

shared_ptr

```
struct Obj
{ … };
std::shared_ptr<Obj> ptr1 = std::make_shared<Obj>();
std::shared_ptr<Obj> ptr2 = ptr1;
assert(ptr1 == ptr2);

ptr1.reset(new Obj);
assert(ptr1 != ptr2);
```

shared_ptr

```
struct Obj
{ … };
std::shared_ptr<Obj> ptr1 = std::make_shared<Obj>();
std::shared_ptr<Obj> ptr2 = ptr1;
assert(ptr1 == ptr2);

ptr1.reset(new Obj);
assert(ptr1 != ptr2);
// What if ptr1 == ptr2 ?
```

sync_ptr

```
if ptr1 == ptr2
    Bound
    Connection
    Synchronization
        → Common Behaviour
```

sync_ptr

```
if ptr1 == ptr2
    - Common Propagation
    - Common Set
    - Common Reset
    - Common Release
    - Common Steal
    - …
```

Single Call Operation

sync_ptr

```
struct Obj
{ … };
sync_ptr<Obj> ptr1 = make_sync<Obj>();
sync_ptr<Obj> ptr2 = ptr1;
assert(ptr1 == ptr2);
```

sync_ptr

```
struct Obj
{ … };
sync_ptr<Obj> ptr1 = make_sync<Obj>();
sync_ptr<Obj> ptr2 = ptr1;
assert(ptr1 == ptr2);

ptr1.reset(new Obj);
```

`assert(ptr1 == ptr2);`

Singleton

```
class widget
{
public:
   static widget * widget::instance();
   void do_something();
};

widget * widget::instance()
{
   static widget w;
   return &w;
}
```

```
widget::instance()->do_something();
```

Singleton

```
class widget
{
public:
   static widget * widget::instance();
   void do_something();
   void do_more();
   void do_even_more();
};

widget * widget::instance()
{
   static widget w;
   return &w;
}

   widget::instance()->do_something();
   widget::instance()->do_more();
   widget::instance()->do_even_more();
```

Singleton

```
class widget
{
private:
   static std::shared_ptr<widget> widget_;
public:
   static std::shared_ptr<widget> widget::instance()
   { return widget_; }
   void do_something();
   void do_more();
   void do_even_more();
};

auto w = widget::instance();
w->do_something();
w->do_more();
w->do_even_more();
```

Singleton

```
class widget
{
private:
   static sync_ptr<widget> widget_;
public:
   static sync_ptr<widget> widget::instance()
   { return widget_; }
   void do_something();
   void do_more();
   void do_even_more();
};

auto w = widget::instance();
w->do_something();
w->do_more();
w->do_even_more();
```

Singleton

```
auto w = widget::instance();
w->do_something();
w->do_more();
w->do_even_more();

// Our widget is exhausted, lets use a fresh one.

w.reset(new widget());
w→do_something(); …
```

Singleton

```
auto w = widget::instance();
w->do_something();
w->do_more();
w->do_even_more();

// Our widget is exhausted, lets use a fresh one.

w.reset(new widget());
w→do_something(); …

// Lets all use that fresh one.

auto w2 = widget::instance();
w2→do_something(); …
```

Singleton

```
auto w = widget::instance();
w->do_something();
w->do_more();
w->do_even_more();

// Our widget has better things to do.
std::unique_ptr<widget> busy(w.exchange(new widget()));
w→do_something(); …

// busy can now go on with his duty, a new widget is in use.
auto w2 = widget::instance();
w2→do_something();

busy->do_something_else();
```

Context

```
struct context
{
    void execute(command * p_ptr) const
    { /* Do something with the command. */ }
};

struct command
{
    void do_something(context * p_ctx)
    {
        p_ctx->execute(this);
    }
};

context * ctx = new context();
command * cmd = new command();

cmd->do_something(ctx);

delete cmd;
delete ctx;
```

Context

```
struct context
{
     void execute(command * p_ptr) const
     { /* Do something with the command. */ }
};

struct command
{
     void execute(std::unique_ptr<context> const & p_ctx)
     {
          p_ctx->execute(this);
     }
};

std::unique_ptr<context> ctx = std::make_unique<context>();
std::unique_ptr<command> cmd = std::make_unique<command>();

cmd->execute(ctx);
```

Context

```
struct context
{
     void execute(command * p_ptr) const
     { /* Do something with the command. */ }
};

struct command
{
     // Lets be clever :p
     context const * ctx_;
     void execute(std::unique_ptr<context> const & p_ctx)
     {
          p_ctx->execute(this);
          ctx_ = p_ctx.get();
     }

     // Wups …
     void not_so_clever_execute()
     {
          ctx_->execute(this);
     }
};
```

Context

```
struct command
{
     sync_ptr<context> ctx_;

     unit(sync_ptr<context> const & p_ctx) : ctx_(p_ctx) {}

     void execute()
     {
          ctx_->execute(this);
     }

     void not_so_clever_execute()
     {
          ctx_->execute(this);
     }
};

sync_ptr<context>         ctx = make_sync<context>();
std::unique_ptr<command>  cmd = std::make_unique<command>(ctx);

cmd->execute();

// Change the context.
ctx.reset(new context());

cmd->not_so_clever_execute();
```

Context

```
struct immediate_context : public context
{
     void execute(command * p_ptr)
     { /* Do something with command immediately. */ }
};

struct deferred_context : public context
{
     void execute(command * p_ptr)
     { /* Enqueue command for later execution. */ }
};

auto ctx = make_sync<immediate_context>();
auto cmd = std::make_unique<command>(ctx);

// Immediate execution.
cmd->execute();

// Change the context.
ctx.reset(new deferred_context());

// Deferred execution.
cmd->execute();
```

Context

DirectX 11

```
sync_ptr<ID3D11DeviceContext> immediate_;
sync_ptr<ID3D11DeviceContext> deferred_;

class cbuffer
{
private:
	ID3D11Buffer *			buffer_;
	sync_ptr<ID3D11DeviceContext>	ctx_;

public:
	cbuffer(sync_ptr<ID3D11DeviceContext> const & p_ctx) : ctx_(p_ctx) { … }

	void bind_vs(void) noexcept
	{
		ctx_->VSSetConstantBuffers(0, 1, &buffer_);
	}
}
```

Producer Consumer

```
                                        --- Consumer
                                        |
                                        |
Producer ---- Data Container ------ Consumer
                                        |
                                        |
                                        --- Consumer
```

```
Assume consumer only wants the most up to date data.
```

Producer Consumer

```
class producer
{
private:
     sync_ptr<Data>  data_;

public:
     producer(sync_ptr<Data> const & p_data) : data_(p_data) { … }

     void produce(void) noexcept
     {
          // Produce newData.
          …

          // Data is free for a new one
          if (!data_)
          {
                auto to_reclame = data_.exchange(newData);
          }
     }
     …
}
```

Producer Consumer

```
class consumer
{
private:
     sync_ptr<Data> data_;

public:
     consumer(sync_ptr<Data> const & p_data) : data_(p_data) { … }

     void consume(void) noexcept
     {
          // Produced data.
          auto data = data_.release();
          if (data)
          {
               // Consume data.
          }
     }
     …
}
```

sync_ptr

sync_ptr stands for **synchronized pointer**.

sync_ptr objects that are **copy constructed** or
copy assigned point to the same underlying pointer.

When the original sync_ptr or one of its copy underlying pointer changes, all sync_ptr and copies point to the updated pointer.

sync_ptr and underlying pointer are reference counted.

The underlying pointer memory is returned when the reference count drops to zero or another pointer is assigned.

Implementation

sync_ptr come in 2 different flavours

Policy
- strong execution guarantee
- thread safety using default policies
- easily extensible using the provided policies or any desired one

Default policy uses std::recursive_mutex.

Atomic
- faster concurrent environment execution (lock free and wait free)
- weak execution guarantee

All operation return their success state
leaving the programmer the choice in the response strategy.

Both offer **no-throw** exception guarantee.

Implementation

```
// Construct default empty object.
sync_ptr();

// Construct with compatible pointer.
template<class TPtrCompatible>
sync_ptr(TPtrCompatible * p_ptr);

// Move ctor and assignment operator (p_rhs becomes empty).
sync_ptr(sync_ptr && p_rhs);
sync_ptr_t & operator=(sync_ptr_t && p_ rhs);

// Copy constructor and assignment operator
// (create a bound, increase reference count).
sync_ptr(sync_ptr const & p_rhs);
sync_ptr_t & operator=(sync_ptr_t const & p_ rhs) &;
```

Implementation

Policy

```
template <
   class TPtr,
   template <class T> class TDeleter,
   template <class T> class THolder,
   class TRefCounter>
class sync_ptr
{ … }
```

```
TPtr          // Stored object type.
TDeleter      // Memory reclamation (free, delete, …).
THolder       // Stored object holder (thread safe access, …).
TRefCounter   // Stored object reference counter.
```

Implementation

Policy

```
Deleter
void free(T * p_ptr) const noexcept;

Holder
T * set(T * p_ptr) noexcept;
T * get() const noexcept;

Reference Counter
void increment(void) noexcept;
size_t decrement(void) noexcept;
void increment_ptr(void) noexcept;
size_t decrement_ptr(void) noexcept;
size_t count(void) const noexcept;
inline size_t count_ptr(void) const noexcept;
```

Implementation

Policy

Internal class

```
template<
        class TPtr,
        template <class T> class TDeleter,
        template <class T> class THolder,
        class TRefCounter>
class ref_count_ptr
        : private TDeleter<TPtr>
        , private THolder<TPtr>
        , private TRefCounter
{ … }
```

Holds and managed the object

Implementation

Policy

```
sync_ptr<T> ptr1 = make_sync<T>();
sync_ptr<T> ptr2(ptr1);
sync_ptr<T> ptr3 = ptr2;

assert(ptr1 == ptr2);
assert(ptr2 == ptr3);
```

They point to the same **ref_count_ptr**

Implementation

Policy

```
// Swap the internal ref_count_ptr
void swap(sync_ptr & p_rhs) noexcept
{
    auto tmp = ref_count_ptr_;
    ref_ = p_rhs.ref_count_ptr_;
    p_rhs.ref_count_ptr_ = tmp;
}
```

Implementation

```
Policy

// Set managed object and free previous one.
void reset(TPtr * p_ptr) noexcept;
// Set managed object to null and free previous one.
void reset(void) noexcept;

// Release the ownership of the managed object if any.
// Return the previously owned pointer and set the current to null.
TPtr * release(void) noexcept;

// Set managed object and return previous one.
TPtr * exchange(TPtr * p_ptr) noexcept;
```

Implementation

Policy

```
// Access managed object.
TPtr * get(void) const noexcept;
TPtr & operator*(void) const noexcept;
TPtr * operator->(void) const noexcept;

// Test managed object state (!null).
bool valid(void) const noexcept;
operator bool(void) const noexcept;
```

Implementation

Provided Policy

```
template<
   class TType>
struct default_deleter
{
     void free(
       TType * p_ptr)
       const noexcept
     {
          static_assert(
               0 < sizeof(TType),
               "can't delete an incomplete type");
          delete p_ptr;
     }
};
```

Implementation

```
Provided Policy

class ref_counter
{
private:
     size_t    ref_count_;
     …

     inline void increment(
          void)
          noexcept
     {
          ref_count_++;
     }
     …
```

Implementation

Provided Policy

```
class atomic_ref_counter
{
private:
     std::atomic<size_t>  ref_count_;
     …

     inline void increment(
          void)
          noexcept
     {
          ref_count_.fetch_add(1U);
     }
     …
```

Implementation

Provided Policy

```
template <class TPtr>
class ptr_holder
{
private:
	TPtr *	ptr_;
	…

	inline TPtr * set(TPtr * p_ptr) noexcept
	{
		auto p = ptr_;
		ptr_ = p_ptr;
		return p;
	}

	inline TPtr * get(void) const noexcept
	{
		return ptr_;
	}
	…
```

Implementation

```
Provided Policy

// Recursive mutex protected holder.
template <class TPtr>
class ptr_holder_ts
{
private:
	TPtr *                          ptr_;
	mutable std::recursive_mutex    mtx_;
	…

	inline TPtr * set(TPtr * p_ptr) noexcept
	{
		std::lock_guard<std::recursive_mutex> l(mtx_);
		auto p = ptr_; ptr_ = p_ptr; return p;
	}

	inline TPtr * get(void) const noexcept
	{
		std::lock_guard<std::recursive_mutex> l(mtx_);
		return ptr_;
	}
	…
```

Implementation

Provided Policy

```
// Recursive mutex protected holder.
struct Obj
{ … }

auto s1 = make_sync<Obj>();
auto s2 = make_sync<Obj>();

if (s1.get() != s2.get())
{ /* non recursive is fine */ }
```

Implementation

Provided Policy

```
// Recursive mutex protected holder.
struct Obj
{ … }

auto s1 = make_sync<Obj>();
auto s2 = s1

if (s1.get() != s2.get())
{
     /* non recursive -> deadlock */
     /* recursive is fine */
}
```

Implementation

Provided Policy

```
// Default
template<class TPtr>
using sync_ptr_deleter              = default_deleter<TPtr>;

template<class TPtr>
using sync_ptr_holder               = ptr_holder_ts<TPtr>;

using sync_ptr_ref_counter          = atomic_ref_counter;
```

Implementation

Policy

```
// Make.
template <
     class TPtr,
     template <class T> class TDeleter = sync_ptr_deleter,
     template <class T> class THolder = sync_ptr_holder,
     class TRefCounter = sync_ptr_ref_counter,
     class... TArgs>
inline typename std::enable_if<
     !std::is_array<TPtr>::value,
     mem::sync_ptr<TPtr, TDeleter, THolder, TRefCounter>>::type
     make_sync(
          TArgs&&... p_args)
{
     typedef typename sync_ptr<
          TPtr,
          TDeleter,
          THolder,
          TRefCounter> sync_ptr_t;
     return (sync_ptr_t(new TPtr(std::forward<TArgs>(p_args)...)));
}
```

Implementation

Policy

```
// Make with allocator.
template <
     class TPtr,
     template <class T> class TAllocator,
     template <class T> class TDeleter = sync_ptr_deleter,
     template <class T> class THolder = sync_ptr_holder,
     class TRefCounter = sync_ptr_ref_counter,
     class... TArgs>
inline typename std::enable_if<
     !std::is_array<TPtr>::value,
     mem::sync_ptr<TPtr, TDeleter, THolder, TRefCounter>>::type
     make_sync_with_allocator(
          TAllocator<TPtr> const & p_allocator,
          TArgs&&... p_args)
{
     typedef typename sync_ptr<
          TPtr,
          TDeleter,
          THolder,
          TRefCounter> sync_ptr_t;
     return (sync_ptr_t(p_allocator.allocate(std::forward<TArgs>(p_args)...)));
}
```

Implementation

Provided Policy

```
// Default Allocator
template<
     class TType>
struct default_allocator
{
     …
     template<class ...TArg>
     TType * allocate(
          TArg && ...p_args)
          const
     {
          static_assert(
               0 < sizeof(TType),
               "can't allocate an incomplete type");
          return new TType(std::forward<TArg>(p_args)...);
     }
     …
```

Implementation

Atomic

```
// Construct default empty object.
sync_ptr();

// Construct with compatible pointer.
template<class TPtrCompatible>
sync_ptr(TPtrCompatible * p_ptr);

// Move ctor and assignment operator (p_rhs becomes empty).
sync_ptr(sync_ptr && p_rhs);
sync_ptr_t & operator=(sync_ptr_t && p_ rhs);

// Copy constructor and assignment operator
// (create a bound, increase reference count).
sync_ptr(sync_ptr const & p_rhs);
sync_ptr_t & operator=(sync_ptr_t const & p_ rhs) &;
```

Implementation

Atomic

```
// Set managed object and free previous one
// -> success state.
bool reset(TPtr * p_ptr) noexcept;
// Set managed object to null and free previous one
// -> success state.
bool reset(void) noexcept;

// Release the ownership of the managed object if any.
// Return the previously owned pointer and set the current to null.
// -> success state.
bool release(TPtr ** p_out) noexcept;

// Set managed object and return previous one.
// -> success state.
bool exchange(TPtr ** p_out, TPtr * p_ptr) noexcept;
```

Implementation

`Atomic`

`Compare And Swap (CAS)`

compares the contents of a memory location to a given value and,
if and only if they are the same,
modifies the contents of that memory location to a given new value.

std::atomic::compare_exchange_strong

`bitwise comparison`
read-modify-write **and** load operations
no spurious failing guarantee

Implementation

Atomic

sync_ptr workhorse

```
class ref_count_ptr
{
…
    std::atomic<TPtr *>  ptr_;
    …

    inline bool release_ptr_cas(TPtr * p_ptr) noexcept
    {
        auto ptr = ptr_.load();
        if (ptr_.compare_exchange_strong(ptr, p_ptr))
        {
            if (ptr)
            {
                free(ptr);
            }
            return true;
        }
        return false;
    }
```

Implementation

Atomic

```
auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))
{ /* success ! */ }
```

```
auto ptr = ptr_.load();                            < thread A
if (ptr_.compare_exchange_strong(ptr, p_ptr))      < thread B
{
        /* success ! */
}
else
{
        /* failure ! */
}
```

Implementation

Atomic

```
auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))
{ /* success ! */ }
```

```
auto ptr = ptr_.load();                          < thread C
if (ptr_.compare_exchange_strong(ptr, p_ptr))    < thread A
{
    /* success !  Now contains B value. */       < thread B
}
else
{
    /* failure ! */
}
```

Implementation

Atomic

```
auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))
{ /* success ! */ }


auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))       < thread C
{
        /* success ! */
}
else
{
        /* failure ! Still contains B value. */         < thread A
}
```

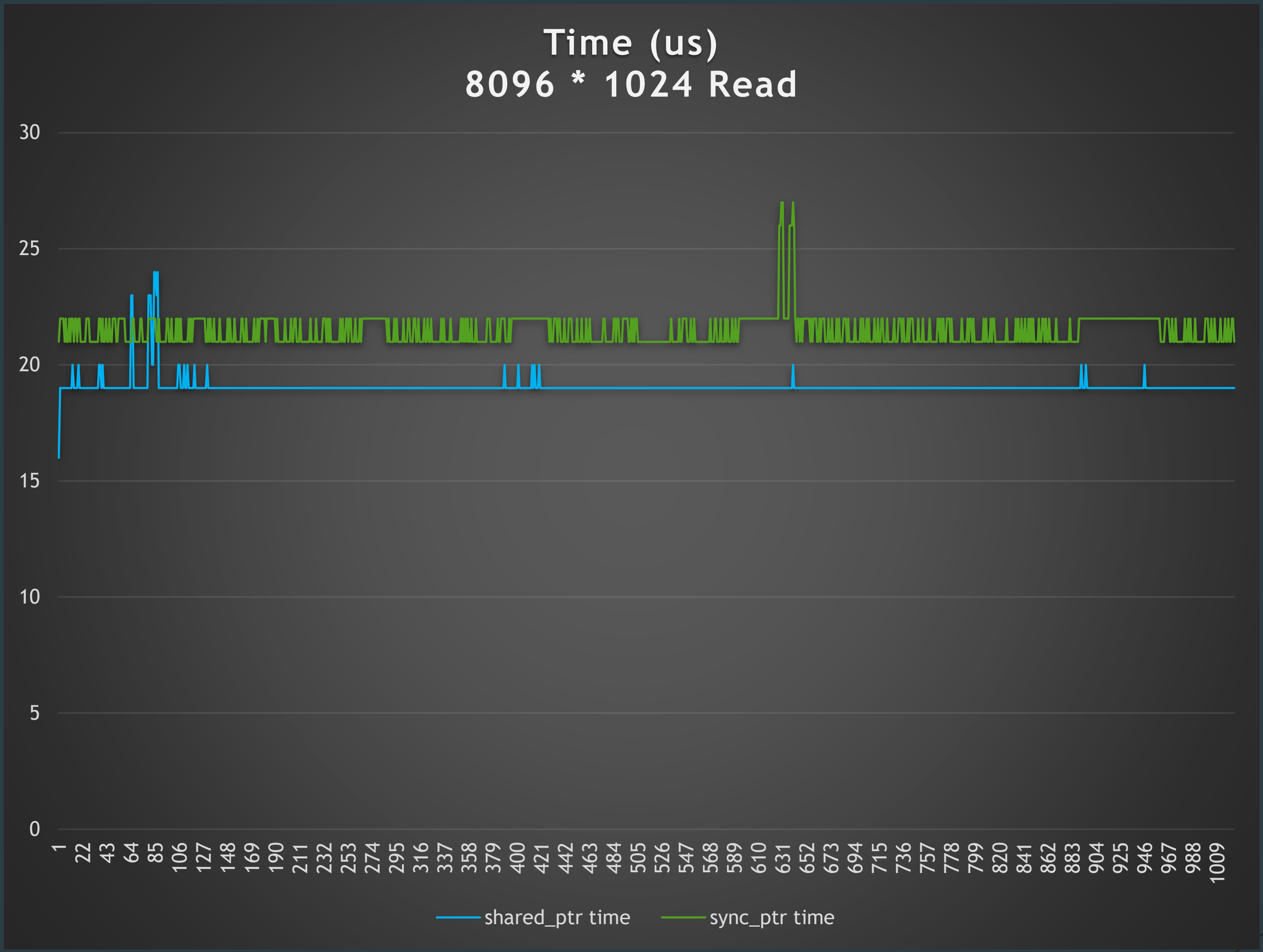
Implementation

Atomic

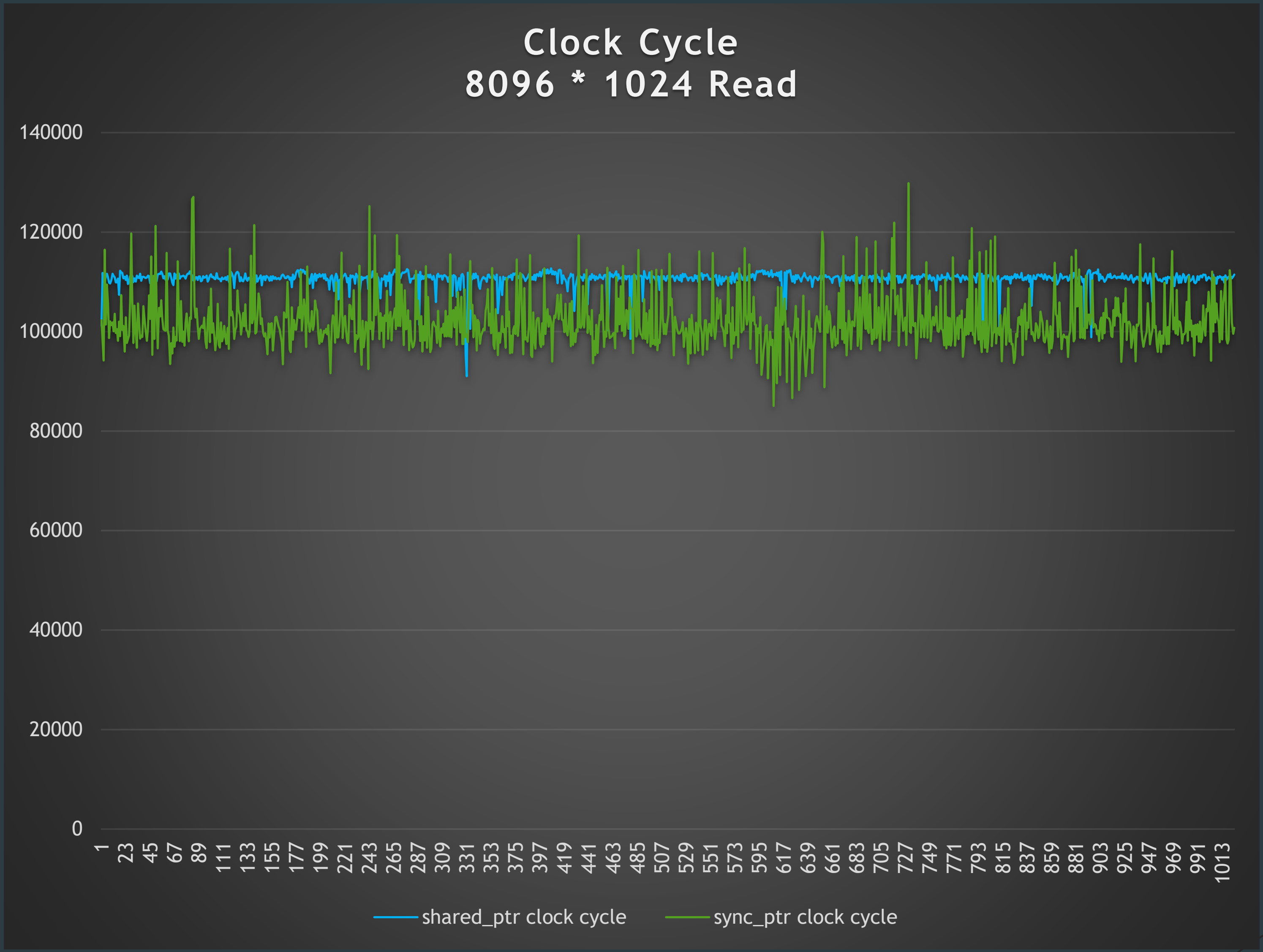
```
auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))
{ /* success ! */ }


auto ptr = ptr_.load();
if (ptr_.compare_exchange_strong(ptr, p_ptr))
{
	/* success ! Now contains C value. */          < thread C
}
else
{
	/* failure ! */
}
```

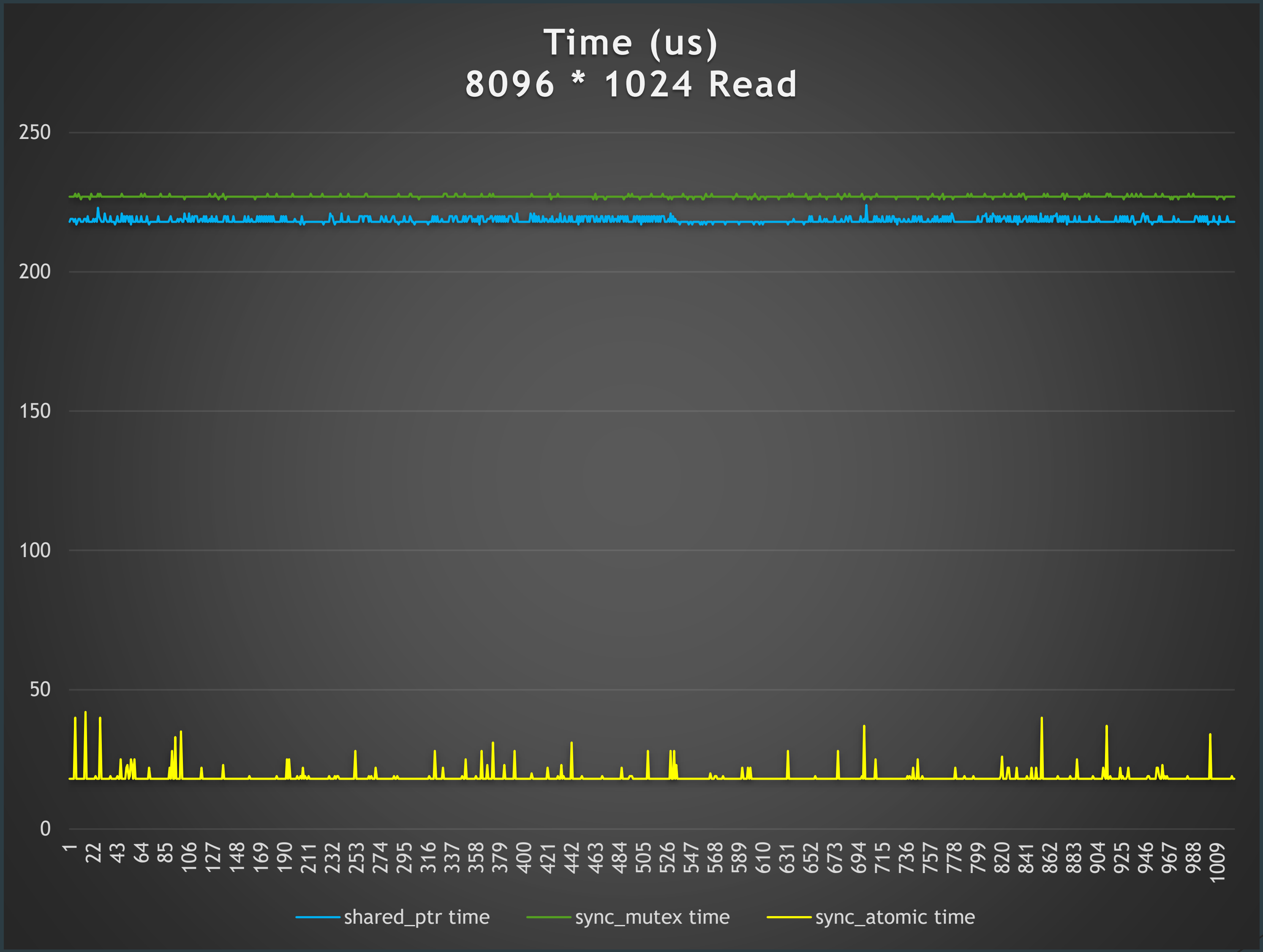
Benchmark: shared_ptr / sync_ptr



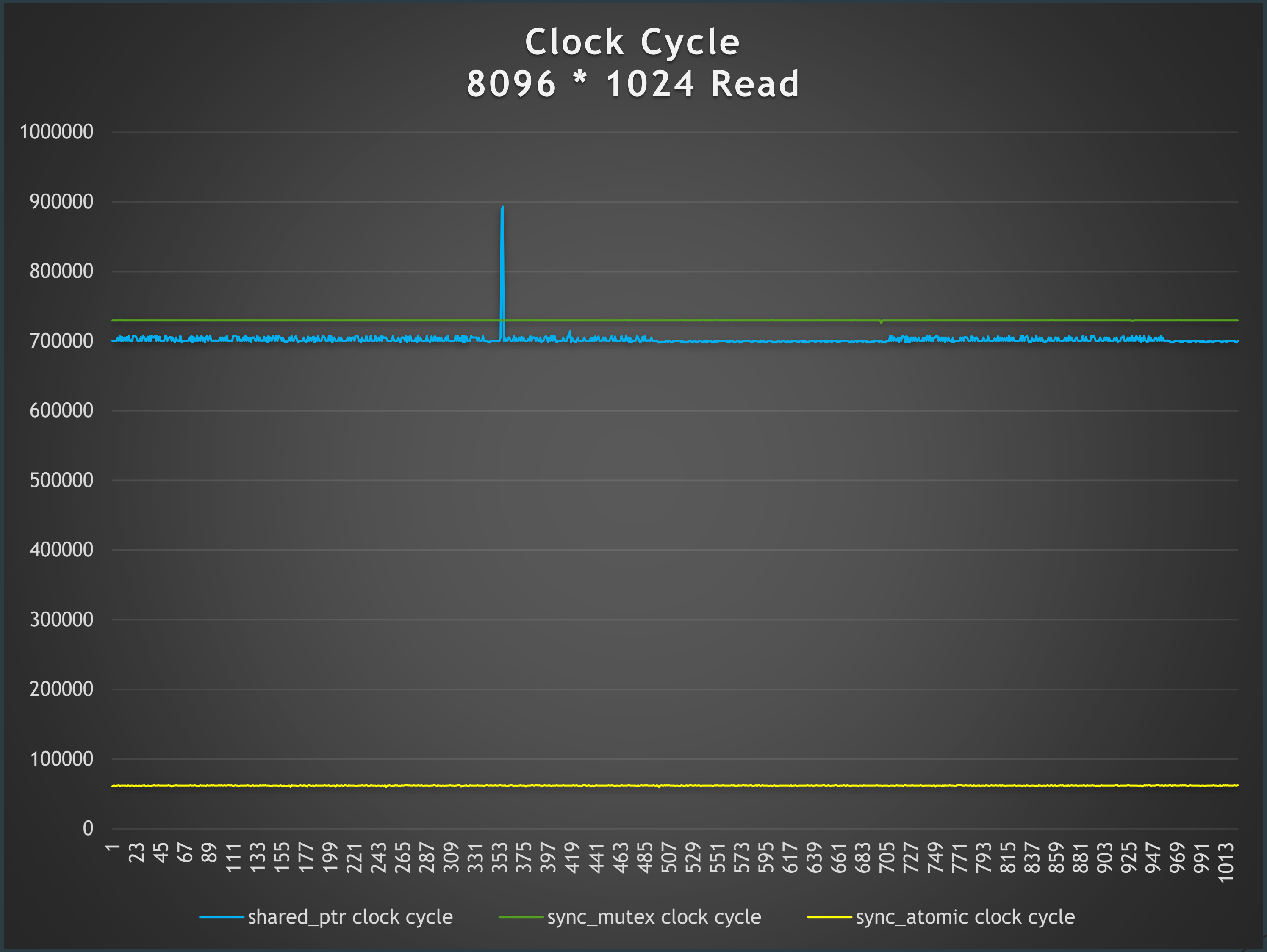
Benchmark : shared_ptr / sync_ptr



Benchmark : mutex / atomic



Benchmark : mutex / atomic



When to use it

Shared ownership / owning cycles.

Modification requires complex / costly operation.

Data race modification is time critical.
“Data path switcher”

Summary

- ✓ Chain using copy construction / copy assignment.
- ✓ Point to the same “body” (handle-body idiom).
- ✓ No need for traversal.
- ✓ Single call modification of all chained sync_ptr.
- ✓ 2 implementations, Policy and Atomic.
- ✓ Use when data race modification is time critical.

github.com/romaincheminade/sync_ptr

BSD License

What is next

- ✓ Faster implementation
  (as fast as std::shared_ptr on read and write).
- ✓ Stronger execution guarantee of Atomic implementation.
- ✓ Safer release (deferred ?)
- ✓ Suggestions and participation are welcome !!!

Q & A