

tag_invoke in 0443

- [D2220R0](#) - *redefine properties in P0443*
- [D2221R0](#) - *define P0443 cpos with tag_invoke*

these papers are implemented in a fork of asio ([github](#))

tag_invoke (<http://wg21.link/P1895R0>)

abstract .. a single ADL customization point named `tag_invoke` that takes as its first argument a CPO that is used as a tag to select an overload. A new CPO, `std::is_foable(t)`, rather than dispatching via ADL to `is_foable(t)`, would dispatch instead to `tag_invoke(std::is_foable, t)`.

tag_invoke solves two problems

Creating a new CPO as described in *[customization.point.object]* solves problems related to ADL customization. There are two additional problems solved by creating new CPOs in terms of `tag_invoke`

problem	description
identifier collisions:	Each CPO internally dispatches via ADL to a free function of the same name, which has the effect of globally reserving that identifier (within some constraints). Two independent libraries that pick the same name for an ADL customization point still risk collision.
no generic forwarding:	There is occasionally a need to write wrapper types that ought to be transparent to customization. (Type-erasing wrappers are one such example.) With C++20's CPOs, there is no way to generically forward customizations through the transparent wrappers.

D2221R0 - *define P0443 cpos with tag_invoke*

changes not intended to change functionality

D2221R0 - *define P0443 cpos with tag_invoke*

changes to the wording of a CPO in 0443

Before

- `0.name()`, if that expression is valid.
- Otherwise, `name(0)`, if that expression is valid, with overload resolution performed in a context that includes the declaration

```
void name();
```

and that does not include a declaration of `execution::name`.

After

- `tbd::tag_invoke(name, 0)`, if that expression is valid.

D2221R0 - *define P0443 cpos with tag_invoke*

changes to the definition of a CPO in 0443

Before

```
namespace _name {
    void name();

    struct _free_fn {
        template <typename Target, typename... Args>
        constexpr auto operator()(
            Target&& t, Args&&... args) const
            noexcept(noexcept(
                name(
                    (Target &&) t, (Args &&) args...)))
            -> decltype(
                name(
                    (Target &&) t, (Args &&) args...)) {
            return name(
                (Target &&) t, (Args &&) args...);
        }
    };

    struct _member_fn {
        template <typename Target, typename... Args>
        requires (!std::invocable<
            _free_fn, Target, Args...>)
        constexpr auto operator()(
            Target&& t, Args&&... args) const
            noexcept(noexcept(
                ((Target &&) t).name(
                    (Args &&) args...)))
            -> decltype(
                ((Target &&) t).name(
                    (Args &&) args...)) {
            return ((Target &&) t).name(
                (Args &&) args...);
        }
    };

    struct _fn : _free_fn, _member_fn {
        using _free_fn::operator();
        using _member_fn::operator();
    };
} // namespace _name

namespace _name_cpo {
    inline constexpr _name::_fn name{};
}
using namespace _name_cpo;
```

After

```
namespace _name_cpo {
    inline constexpr struct _fn {
        template<typename Target, typename... Args>
        requires tag_invocable<
            _fn, Target, Args...>
        auto operator()(
            Target&& t, Args&& args...) const
            noexcept(
                is_nothrow_tag_invocable_v<
                    _fn, Target, Args...>) ->
            tag_invoke_result_t<
                _fn, Target, Args...> {
            return tbd::tag_invoke(
                _fn{}, (Target&&)t, (Args&&)args...);
        }
    } name{};
} // namespace _name

using _name_cpo::name;
```

D2221R0 - *define P0443 cpos with tag_invoke*

changes to the inline_executor example in 0443

Before

```
struct inline_executor {  
    // define execute as friend  
    template<class F>  
    friend void execute(  
        //  
        const inline_executor&,  
        F&& f) noexcept {  
        std::invoke(std::forward<F>(f));  
    }  
  
    // enable comparisons  
    auto operator<==>(  
        const inline_executor&) const = default;  
};
```

After

```
struct inline_executor {  
    // define execute as friend  
    template<class F>  
    friend void tag_invoke(  
        tag_t<execution::execute>,  
        const inline_executor&,  
        F&& f) noexcept {  
        std::invoke(std::forward<F>(f));  
    }  
  
    // enable comparisons  
    auto operator<==>(  
        const inline_executor&) const = default;  
};
```

D2221R0 - *define P0443 cpos with tag_invoke*

summary

P0443R13 defines the following cpos: `set_value`, `set_done`, `set_error`, `execute`, `connect`, `start`, `submit`, `schedule`, and `bulk_execute`.

D2221R0 has the changes to P0443R13 wording needed to define these cpos in terms of `tag_invoke`.

- removes the globally reserved names
- adds support for generic forwarding

Any questions?

'properties' (<http://wg21.link/P1393R0>)

In general When the property customization mechanism is being employed for some library facility, an object's behavior and effects on that facility in generic contexts may be determined by a set of applicable properties, and each property imposes certain requirements on that object's behavior or exposes some attribute of that object. As well as modifying the behavior of an object, properties can be applied to an object to enforce the presence of an interface, potentially resulting in an object of a new type that satisfies some concept associated with that property.

'properties' were designed to satisfy requirements of executors

Requirement	Definition
Extensible	users are able to define their own
Survivable	passing objects around does not lose information
Forwardable	it is possible to write a catch-all that forwards to a contained object
Overridable	it is possible to modify or block forwarding
Defaultable and Ignorable	must be able to define a default when not customized and ignore when not customized

(from: <https://github.com/executors/executors/issues/191>)

tag_invoke and 'properties' satisfy those requirements

Requirement	tag_invoke	'properties'
Extensible	define a new tag function type in a namespace	define a new traits struct in a new namespace
Survivable	defined as overloads of the tag_invoke() function	defined as overloads of require(), require_concept(), prefer(), and query() functions
Forwardable	a tag_invoke() function that does not constrain the namespaced tag function argument	require(), require_concept(), prefer(), and query() functions that do not constrain the namespaced tag struct argument
Overridable	a tag_invoke() function constrained to a specific namespaced tag function	require(), require_concept(), prefer(), and query() functions constrained to a specific namespaced tag struct
Defaultable and Ignorable	the namespaced tag function type has an overload of operator() constrained with tag_invocable<..> == false	the namespaced tag struct overloads require(), require_concept(), prefer(), and query() hidden friend functions with the target unconstrained and constrained with can_require<..>, can_require_concept<..>, can_prefer<..>, and can_query<..> == false

definition

property

```
struct my_property
{
    template<class... Ps>
        static constexpr bool
            is_applicable_property_v;

    /* optional */
    static constexpr bool
        is_requirable_concept = /* ... */;

    /* optional */
    static constexpr bool
        is_requirable = /* ... */;

    /* optional */
    static constexpr bool
        is_preferable = /* ... */;

    /* optional */
    template<class... Ps>

        class polymorphic_wrapper_type;

    /* optional */
    using
        polymorphic_query_result_type = /*...*/;

    /* optional */
    template<class T>
        static constexpr /* ... */
            static_query_v = /* ... */;

    /* optional */
    static constexpr /* ... */
        value() const { return /* ... */; }
};
```

tag_invoke function

```
inline constexpr struct my_function_fn {
    template<typename... Tn>
    auto operator()(Tn&&... tn) const
        noexcept(noexcept(
            tbd::tag_invoke(*this, (Tn&&)tn...)))
        -> decltype(
            tbd::tag_invoke(*this, (Tn&&)tn...)) {
        return
            tbd::tag_invoke(*this, (Tn&&)tn...);
    }
} my_function{};
```

'properties' has additional functionality

Meaning

- A fixed set of functions are defined (`require`, `prefer`, `query`, `require_concept`)
- These functions are defined to have the same meaning across all properties.
- Some things are not good properties because they do not have a good mapping to the meanings available (eg. `execute()`).
- Each property author selects the subset of meanings that 'make sense' for that property.

.. each property imposes certain requirements on that object's behavior or exposes some attribute of that object. As well as modifying the behavior of an object, properties can be applied to an object to enforce the presence of an interface, potentially resulting in an object of a new type that satisfies some concept associated with that property.

'properties' has additional functionality

function	best-guess meaning	trait members
require	make a new instance of the target instance that satisfies the supplied property <i>iff</i> the target instance does not satisfy the supplied property, otherwise return the original target instance unchanged	is_requirable, polymorphic_wrapper_type
prefer	make a new instance of the target instance that satisfies the supplied property <i>iff</i> the supplied property is supported by the target and the target instance does not satisfy the supplied property, otherwise return the original target instance unchanged	is_preferable, polymorphic_wrapper_type
require_concept	make a new instance of a type that satisfies a concept determined by the supplied property <i>iff</i> the target instance does not satisfy the concept determined by the supplied property, otherwise return the original target instance unchanged	is_requirable_concept, polymorphic_wrapper_type
query	return the value of the supplied property that this target instance satisfies	polymorphic_query_result_type, static_query_v, value()

'properties' has additional functionality

trait member	meaning
<code>is_applicable_property_v<T></code>	true <i>iff</i> T is allowed to support this property. In [P0443R13] - <i>executors</i> this is always derived from concepts
<code>is_requirable_concept</code>	true <i>iff</i> this property can be used with <code>require_concept()</code>
<code>is_requirable</code>	true <i>iff</i> this property can be used with <code>require()</code>
<code>is_preferable</code>	true <i>iff</i> this property can be used with <code>prefer()</code>
<code>static_query_v<T></code>	accesses the value that would be returned from a call to <code>query()</code> that is targeted on T <i>iff</i> the value has been made available at compile-time.
<code>value()</code>	provides a value that will be compared to <code>static_query_v<T></code> to "determine whether invoking <code>require</code> or <code>require_concept</code> would result in an identity transformation." - [P1393R0] - <i>properties</i>
<code>polymorphic_wrapper_type<SupportableProperties...></code>	defines the polymorphic type for a specific concept. The concept-specific expressions are built-in (like <code>execute()</code> for <code>any_executor<></code>)

trait member	meaning
	defines the result type for <code>query</code> when used by any

'properties' has additional functionality

Polymorphism

- `is_applicable` to potentially many concepts (eg. all the properties in P0443)
- Each concept is expected to author a polymorphic type that implements that concept and supports forwarding of properties.
- Defines the polymorphic types to use when type-erasing the results of functions that operate on properties (`require`, `prefer`, `query`, and `require_concept`).
- The author of a property is unlikely to choose a polymorphic type implementation that all users of that property will find satisfying.

Behaviour properties in P0443R13

Behaviour properties are a pattern of using nested properties and bespoke polymorphism to define a group of mutually-exclusive behaviours.

Polymorphism

- A property `group_t` (eg. `mapping_t`) will be a value type that is *equality-comparable* and that can be constructed from values of each of the nested property types.
- Each of the nested property types are value types that are *equality-comparable*.
- `group_t` will be *equality-comparable* to the nested type that was used to construct it. The implementation of this polymorphism is unspecified - asio uses an integer and each constructor taking a nested property will set a specific value to the integer.
- users and libraries cannot add additional nested behaviours to a standardized property.

open question: can any new nested behaviour type be standardized? what are the ABI implications?

D2220R0 - *redefine properties in P0443*

changes not intended to change functionality

D2220Ro - *redefine properties in P0443*

move `prefer_only` to P1393 - '*properties*'

- composes with a property and blocks support for `require`.
- used to allow a polymorphic type to support a property 'optionally'.
- nothing to do with executors

D2220R0 - *redefine properties in P0443*

remove any_executor

- There is an implementation of `any_ref<>`, with `tag_invoke` forwarding, in my changes to asio ([github](#)) that works to construct `any_executor<>` as a templated type alias.
- Polymorphism for `tag_invoke` functions is a separate concern from both `tag_invoke` and executors.
- There will be several `any_` types for `tag_invoke` (eg. `any_value`, `any_ref`, `any_unique`, `any_shared`, etc..)

D2220R0 - *redefine properties in P0443*

naming functions

query	requires	prefer		function
<code>query(t, allocator)</code>	<code>requires(t, allocator(a))</code>	<code>prefer(t, allocator(a))</code>	vs	<code>get_allocator(t) & make_with_allocator(t, a)</code>

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naming behaviours

requires	prefer		behaviour
<code>requires(t, mapping.thread)</code>	<code>prefer(t, mapping.thread)</code>	vs	<code>make_with_mapping(t, thread_mapping)</code>
<code>requires(t, mapping.new_thread)</code>	<code>prefer(t, mapping.new_thread)</code>	vs	<code>make_with_mapping(t, new_thread_mapping)</code>
<code>requires(t, mapping.other)</code>	<code>prefer(t, mapping.other)</code>	vs	<code>make_with_mapping(t, other_mapping)</code>

D2220R0 - *redefine properties in P0443*

usage example from P0443R13

Before

```
// obtain an executor
executor auto ex = ...;

// require the execute operation to block
executor auto blocking_ex =
    std::require(
        ex, execution::blocking.always);

// prefer to execute with a particular
// priority p
executor auto blocking_ex_with_priority =
    std::prefer(
        blocking_ex, execution::priority(p));

// execute my blocking, possibly prioritized
// work
execution::execute(
    blocking_ex_with_priority, work);
```

After

```
// obtain an executor
executor auto ex = ...;

// require the execute operation to block
executor auto blocking_ex =
    execution::make_with_blocking(
        ex, execution::always_blocking);

// prefer to execute with a particular
// priority p
executor auto blocking_ex_with_priority =
    tbd::prefer(execution::make_with_priority,
        blocking_ex, p);

// execute my blocking, possibly prioritized
// work
execution::execute(
    blocking_ex_with_priority, work);
```


D2220R0 - *redefine properties in P0443*

redefine properties in P0443R13

before	after
context_t	get_context()
blocking_t	get_blocking(),make_with_blocking()
blocking_t::possibly_t	possibly_blocking_t
blocking_t::always_t	always_blocking_t
blocking_t::never_t	never_blocking_t
relationship_t	get_relationship(),make_with_relationship()
relationship_t::continuation_t	continuation_relationship_t
relationship_t::fork_t	fork_relationship_t

D2220R0 - *redefine properties in P0443*

redefine properties in P0443R13

before	after
<code>outstanding_work_t</code>	<code>get_outstanding_work(),make_with_outstanding_work()</code>
<code>outstanding_work_t::untracked_t</code>	<code>untracked_outstanding_work_t</code>
<code>outstanding_work_t::tracked_t</code>	<code>tracked_outstanding_work_t</code>
<code>mapping_t</code>	<code>get_mapping(),make_with_mapping()</code>
<code>mapping_t::thread_t</code>	<code>thread_mapping_t</code>
<code>mapping_t::new_thread_t</code>	<code>new_thread_mapping_t</code>
<code>mapping_t::other_t</code>	<code>other_mapping_t</code>
<code>allocator_t<Allocator></code>	<code>get_allocator(),make_with_allocator()</code>

Any Questions?

