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Implementation of std::common_type

# On topic

- Metafunctions using specializations
- Metafunctions using SFINAE
- Implementation of std::common_type

# Template specialization

```
template<class T>
class container {
   T content{};
};


int main() {
   container<int> cont1;
   container<char> cont2;
   container<std::vector<int>> cont3;
}
```

# Template specialization

```
template<class T>
class container {
   T content{};
};


int main() {
   container<int> cont1; //OK
   container<char> cont2; //OK
   container<std::vector<int>> cont3; //OK
}
```

# Template specialization

```
struct Special {

   Special(int){}

   Special() = delete;

};
```

# Template specialization

```
struct Special {
   Special(int){}
   Special() = delete;
};

template<class T>
class container {
   T content{};
};

int main() {
   container<Special> cont;
}
```

# Template specialization

```
struct Special {
   Special(int){}
   Special() = delete;
};

template<class T>
class container {
   T content{}; //error: use of deleted function ‘container<Special>::container()’
};

int main() {
   container<Special> cont;
}
```

# Template specialization

```
struct Special { /* ... */ };


template<class T>

class container { /* ... */ };


template<>

struct container<Special> {

   Special content{0};

};


int main() {

   container<Special> cont;

}
```

# Template specialization

```
struct Special { /* ... */ };

template<class T>
class container { /* ... */ };

template<>
struct container<Special> {
   Special content{0};
};

int main() {
   container<Special> cont; //OK
}
```

# std::is_same

```
template<class U, class V>
struct is_same {
   static const bool value = false;
};

template<class T>
struct is_same<T, T> {
   static const bool value = true;
};
```

# std::is_same

```
template<class U, class V>
struct is_same { /* ... */ };


template<class T>
struct is_same<T, T> { /* ... */ };


int main() {
   static_assert(is_same<int******, int******>::value);
   static_assert(not is_same<int, char &>::value);
}
```

# std::is_same

```
template<class U, class V>
struct is_same { /* ... */ };


template<class T>
struct is_same<T, T> { /* ... */ };


int main() {
   static_assert(is_same<int******, int******>::value);
   static_assert(not is_same<int, char &>::value);
}
```

# std::is_same

```
template<class U, class V>
struct is_same { /* ... */ };


template<class T>
struct is_same<T, T> { /* ... */ };


int main() {
   static_assert(is_same<int******, int******>::value);
   static_assert(not is_same<int, char &>::value);
}
```

# std::remove_reference

```
template<class T>
struct remove_reference {
   using type = T;
};


template<class T>
struct remove_reference<T&> {
   using type = T;
};


template<class T>
struct remove_reference<T&&> {
   using type = T;
};
```

# std::remove_reference

```
template<class T>
struct remove_reference {
   using type = T;
};


template<class T>
struct remove_reference<T&> { // If l-reference
   using type = T;
};


template<class T>
struct remove_reference<T&&> {
   using type = T;
};
```

# std::remove_reference

```
template<class T>
struct remove_reference {
   using type = T;
};


template<class T>
struct remove_reference<T&> { // If l-reference
   using type = T;
};


template<class T>
struct remove_reference<T&&> { //If r-reference
   using type = T;
};
```

# std::remove_reference

```
template<class T>
struct remove_reference { //Any other type (not reference)
   using type = T;
};


template<class T>
struct remove_reference<T&> { // If l-reference
   using type = T;
};


template<class T>
struct remove_reference<T&&> { //If r-reference
   using type = T;
};
```

# std::remove_reference

```
int main() {

   static_assert(is_same<remove_reference<int&&>::type, int>::value);

   static_assert(is_same<remove_reference<char**&>::type, char**>::value);

   static_assert(is_same<remove_reference<bool*>::type, bool*>::value);

}
```

# std::remove_reference

```
//...
template<class T>
struct remove_reference<T&&> { // If r-reference
    using type = T;
};
//...


int main() {
    static_assert(is_same<remove_reference<int&&>::type, int>::value);
    static_assert(is_same<remove_reference<char**&>::type, char**>::value);
    static_assert(is_same<remove_reference<bool*>::type, bool*>::value);
}
```

# std::remove_reference

```
//...
template<class T>
struct remove_reference<T&> { // If l-reference
   using type = T;
};
//...


int main() {
   static_assert(is_same<remove_reference<int&&>::type, int>::value);
   static_assert(is_same<remove_reference<char**&>::type, char**>::value);
   static_assert(is_same<remove_reference<bool*>::type, bool*>::value);
}
```

# std::remove_reference

```
//...
template<class T>
struct remove_reference { //Any other type (not reference)
   using type = T;
};
//...


int main() {
   static_assert(is_same<remove_reference<int&&>::type, int>::value);
   static_assert(is_same<remove_reference<char**&>::type, char**>::value);
   static_assert(is_same<remove_reference<bool*>::type, bool*>::value);
}
```

# std::remove_reference

```
template<class T>

using remove_reference_t = typename remove_reference<T>::type; //since c++11
```

# std::is_const

```
template<class T>
struct is_const {
   static const bool value = false;
};

template<class T>
struct is_const<const T> {
   static const bool value = true;
};
```

# std::is_function

# std::is_function

```
// primary template
template<class>
struct is_function : std::false_type { };

// specialization for regular functions
template<class Ret, class... Args>
struct is_function<Ret(Args...)> : std::true_type {};

// specialization for variadic functions such as std::printf
template<class Ret, class... Args>
struct is_function<Ret(Args......)> : std::true_type {};

// specialization for function types that have cv-qualifiers
template<class Ret, class... Args>
struct is_function<Ret(Args...) const> : std::true_type {};
template<class Ret, class... Args>
struct is_function<Ret(Args...) volatile> : std::true_type {};
template<class Ret, class... Args>
struct is_function<Ret(Args...) const volatile> : std::true_type {};
template<class Ret, class... Args>
struct is_function<Ret(Args......) const> : std::true_type {};
template<class Ret, class... Args>
struct is_function<Ret(Args......) volatile> : std::true_type {};
template<class Ret, class... Args>
struct is_function<Ret(Args......) const volatile> : std::true_type {};
```

# std::is_function

# std::is_function

# std::is_function

```
template<class T>
struct is_function {
   static const bool value = not std::is_const<const T>::value;
};


template<class T>
struct is_function<T&> {
   static const bool value = false;
};


template<class T>
struct is_function<T&&> {
   static const bool value = false;
};
```

# std::is_function

```
template<class T>
struct is_function {
   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait
};


template<class T>
struct is_function<T&> {
   static const bool value = false;
};


template<class T>
struct is_function<T&&> {
   static const bool value = false;
};
```

# std::is_function

```
template<class T>
struct is_function {
   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait
};
```

```
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);
```

```
template<class T>
struct is_function<T&> {
   static const bool value = false;
};
```

```
template<class T>
struct is_function<T&&> {
   static const bool value = false;
};
```

# std::is_function

```cpp
template<class T>
struct is_function {
   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait
};
```

```cpp
template<class T>
struct is_function<T&> {
   static const bool value = false;
};
```

```cpp
template<class T>
struct is_function<T&&> {
   static const bool value = false;
};
```

```cpp
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);

static_assert(std::is_same_v<l_ref_t, const l_ref_t>);
```

# std::is_function

```cpp
template<class T>

struct is_function {

   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait

};
```

```cpp
template<class T>

struct is_function<T&> {

   static const bool value = false;

};
```

```cpp
template<class T>

struct is_function<T&&> {

   static const bool value = false;

};
```

```cpp
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);

static_assert(std::is_same_v<l_ref_t, const l_ref_t>);
static_assert(std::is_same_v<r_ref_t, const r_ref_t>);
```

# std::is_function

```cpp
template<class T>

struct is_function {

   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait

};
```

```cpp
template<class T>

struct is_function<T&> {

   static const bool value = false;

};
```

```cpp
template<class T>

struct is_function<T&&> {

   static const bool value = false;

};
```

```cpp
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);

static_assert(std::is_same_v<l_ref_t, const l_ref_t>);
static_assert(std::is_same_v<r_ref_t, const r_ref_t>);
static_assert(std::is_same_v<funct_t, const funct_t>);
```

# std::is_function

```cpp
template<class T>

struct is_function {

   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait

};
```

```cpp
template<class T>

struct is_function<T&> {

   static const bool value = false;

};
```

```cpp
template<class T>

struct is_function<T&&> {

   static const bool value = false;

};
```

```cpp
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);

static_assert(std::is_same_v<l_ref_t, const l_ref_t>);
static_assert(std::is_same_v<r_ref_t, const r_ref_t>);
static_assert(std::is_same_v<funct_t, const funct_t>);
```

# std::is_function

```cpp
template<class T>

struct is_function {

   static const bool value = not std::is_const<const T>::value;//Only functions and references have this trait

};
```

```cpp
template<class T>

struct is_function<T&> {

   static const bool value = false;

};
```

```cpp
template<class T>

struct is_function<T&&> {

   static const bool value = false;

};
```

```cpp
using l_ref_t = int&;
using r_ref_t = int&&;
using funct_t = int(char*, bool);

static_assert(std::is_same_v<l_ref_t, const l_ref_t>);
static_assert(std::is_same_v<r_ref_t, const r_ref_t>);
static_assert(std::is_same_v<funct_t, const funct_t>);
```

```cpp
template<class U, class V>
constexpr bool is_same_v = is_same<U, V>::value; //since c++14
```

# std::is_function

```
template<class T>
struct is_function {
   static const bool value = not std::is_const<const T>::value;
};


template<class T>
struct is_function<T&> { //Filtering out l-references
   static const bool value = false;
};


template<class T>
struct is_function<T&&> { //Filtering out r-references
   static const bool value = false;
};
```

# std::is_array

```
template<class T>
struct is_array {
   static const bool value = false;
};

template<class T>
struct is_array<T[]> {
   static const bool value = true;
};

template<class T, auto N>
struct is_array<T[N]> {
   static const bool value = true;
};
```

# std::is_array

```cpp
template<class T>
struct is_array {
   static const bool value = false;
};

template<class T>
struct is_array<T[]> { // Specialization for unknown length array type
   static const bool value = true;
};

template<class T, auto N>
struct is_array<T[N]> {
   static const bool value = true;
};
```

# std::is_array

```
template<class T>
struct is_array {
   static const bool value = false;
};

template<class T>
struct is_array<T[]> { // Specialization for unknown length array type
   static const bool value = true;
};

template<class T, auto N>
struct is_array<T[N]> { // Specialization for length-known array type
   static const bool value = true;
};
```

# std::is_array

```cpp
template<class T>
struct is_array { // Primary template for non-array types
   static const bool value = false;
};

template<class T>
struct is_array<T[]> { // Specialization for unknown length array type
   static const bool value = true;
};

template<class T, auto N>
struct is_array<T[N]> { // Specialization for length-known array type
   static const bool value = true;
};
```

# std::remove_extent

```
template<class T>
struct remove_extent {
   using type = T;
};


template<class T, auto N>
struct remove_extent<T[N]> {
   using type = T;
};


template<class T>
struct remove_extent<T[]> {
   using type = T;
};
```

# std::remove_extent

```
template<class T>
struct remove_extent {
   using type = T;
};


template<class T, auto N>
struct remove_extent<T[N]> {
   using type = T;
};


template<class T>
struct remove_extent<T[]> {
   using type = T;
};
```

# std::remove_extent

```
template<class T>
struct remove_extent {
   using type = T;
};


template<class T, auto N>
struct remove_extent<T[N]> {
   using type = T;
};


template<class T>
struct remove_extent<T[]> {
   using type = T;
};
```

# std::enable_if

```
template<bool b, class IfTrue>
struct enable_if;


template<class IfTrue>
struct enable_if<true,IfTrue> {
   using type = IfTrue;
};


template<class IfTrue>
struct enable_if<false,IfTrue> { };
```

# std::enable_if

```
template<bool b, class IfTrue>
struct enable_if;


template<class IfTrue>
struct enable_if<true,IfTrue> {
   using type = IfTrue;
};


template<class IfTrue>
struct enable_if<false,IfTrue> { };
```

# std::enable_if

```
template<bool b, class IfTrue>
struct enable_if;


template<class IfTrue>
struct enable_if<true,IfTrue> {
   using type = IfTrue;
};


template<class IfTrue>
struct enable_if<false,IfTrue> { };
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type
std::enable_if<true, int>::type
std::enable_if<true, char>::type
std::enable_if<false, int>::type
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
'type' is not a member of 'std::enable_if<false, int>'
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
'type' is not a member of 'std::enable_if<false, int>'
```

```
template<bool b,class T>
using enable_if_t = typename enable_if<b,T>::type; //since c++11
```

# std::enable_if

```
template<bool b, class IfTrue>

struct enable_if;


template<class IfTrue>

struct enable_if<true,IfTrue> {

   using type = IfTrue;

};


template<class IfTrue>

struct enable_if<false,IfTrue> { };
```

```
std::enable_if<true, void>::type    //OK
std::enable_if<true, int>::type     //OK
std::enable_if<true, char>::type    //OK
std::enable_if<false, int>::type    // Error
'type' is not a member of 'std::enable_if<false, int>'
```

```
template<bool b,class T>
using enable_if_t = typename enable_if<b,T>::type; //since c++11
```

# SFINAE (Substitution Fail Is Not An Error)

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) {
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) {
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5);
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) {
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5);
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) {
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5);
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) {
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5);
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { //enable_if<true,void>. OK
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5);
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { //enable_if<true,void>. OK
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) {
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) {
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) {
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) {
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // enable_if<true,void>. OK.
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x');
}
```

# SFINAE (Substitution Failure Is Not An Error)

```
template<class T>
std::enable_if_t<std::is_same_v<T,int>, void> foo(const T&) { // Substitution Failure (not member ‘type’ in std::enable_if<false,void>)
   std::cout<<"I'm foo(int)\n";
}

template<class T>
std::enable_if_t<std::is_same_v<T,char>, void> foo(const T&) { // enable_if<true,void>. OK.
   std::cout<<"I'm foo(char)\n";
}

int main() {
   foo(5); // I'm foo(int)
   foo('x'); // I'm foo(char)
}
```

# std::void_t

```
template<class...>

using void_t = void;
```

# std::void_t

```
template<class...>

using void_t = void;


static_assert(std::is_same_v<std::void_t<char, int, decltype(std::vector<int>{}.begin())>, void>);
```

# std::is_defaut_constructible

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
[T = std::unique_ptr<int>]
[Args... = int*]
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
[T = std::unique_ptr<int>]
[Args... = int*]                    std::unique_ptr<int>(int*{}) //OK
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
[T = std::unique_ptr<int>]
[Args... = int*]                    std::unique_ptr<int>(int*{}) //OK
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
[T = std::unique_ptr<int>]
[Args... = int*]                    std::unique_ptr<int>(int*{})
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, char*>::value);
[T = std::unique_ptr<char*>]
[Args... = char*]                    std::unique_ptr<int>(char*{})
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};

template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> { //SF
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, char*>::value);
[T = std::unique_ptr<char*>]
[Args... = char*]                    std::unique_ptr<int>(char*{})    //NOT OK
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false; //That’s it!
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> { //SF
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, char*>::value);
[T = std::unique_ptr<char*>]
[Args... = char*]                    std::unique_ptr<int>(char*{})    //NOT OK
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false; //That’s it!
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> { //SF
   static const bool value = true;
};
static_assert(is_constructible_impl<std::unique_ptr<int>, void, char*>::value); //Assertion fail!
[T = std::unique_ptr<char*>]
[Args... = char*]                    std::unique_ptr<int>(char*{})     //NOT OK
```

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
```

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
```

???

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
                                                          ???
```

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
                                                          ???

template<class T, class... Args>
struct is_constructible : is_constructible_impl<T, void, Args...> { };
```

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);
```

???

```
template<class T, class... Args>
struct is_constructible : is_constructible_impl<T, void, Args...> { };
```

```
static_assert(is_constructible<std::unique_ptr<int>, int*>::value);
```

# std::is_defaut_constructible

```
static_assert(is_constructible_impl<std::unique_ptr<int>, void, int*>::value);

                                                          ???

template<class T, class... Args>

struct is_constructible : is_constructible_impl<T, void, Args...> { };
```

```
static_assert(is_constructible<std::unique_ptr<int>, int*>::value);

//Looks like all is good...
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
```

# std::declval

```
template<class T>

T&& declval() {};
```

# std::declval

```
template<class T>

T&& declval() {};


static_assert(std::is_same_v<decltype(std::declval<int>()),int&&>);
```

# std::declval

```
template<class T>

T&& declval() {};


static_assert(std::is_same_v<decltype(std::declval<int>()),int&&>);

static_assert(std::is_same_v<decltype(std::declval<char&>()),char&>);
```

# std::declval

```
template<class T>
T&& declval() {};


static_assert(std::is_same_v<decltype(std::declval<int>()),int&&>);
static_assert(std::is_same_v<decltype(std::declval<char&>()),char&>);
static_assert(std::is_same_v<
               decltype(std::declval<std::vector<int>>().begin()),
               std::vector<int>::iterator>
            );
```

# std::declval

```
template<class T>
T&& declval() {};


static_assert(std::is_same_v<decltype(std::declval<int>()),int&&>);
static_assert(std::is_same_v<decltype(std::declval<char&>()),char&>);
static_assert(std::is_same_v<
                decltype(std::declval<std::vector<int>>().begin()),
                std::vector<int>::iterator>
             );
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(Args{}...))>, Args...> {
   static const bool value = true;
};
```

# std::is_defaut_constructible

```
template< class T, class = void, class... Args>
struct is_constructible_impl {
   static const bool value = false;
};


template<class T, class... Args>
struct is_constructible_impl<T, std::void_t<decltype(T(std::declval<Args>()...))>, Args...> {
   static const bool value = true;
};
```

# std::common_type

# std::common_type

```
auto var = true ? bool{} : char{};
```

What is a type of `var`?

# std::common_type

```
auto var = true ? bool{} : char{};        //bool?
```

What is a type of `var`?

# std::common_type

```
auto var = true ? bool{} : char{};        //bool?
```

What is a type of `var`?

```
bool b{};
std::cin>>b;
auto var2 = b ? bool{} : char{};
```

What is a type of `var2`?

# std::common_type

```
auto var = true ? bool{} : char{};        //bool?
```

What is a type of `var`?

```
bool b{};
std::cin>>b;
auto var2 = b ? bool{} : char{};          //???
```

What is a type of `var2`?

# std::common_type

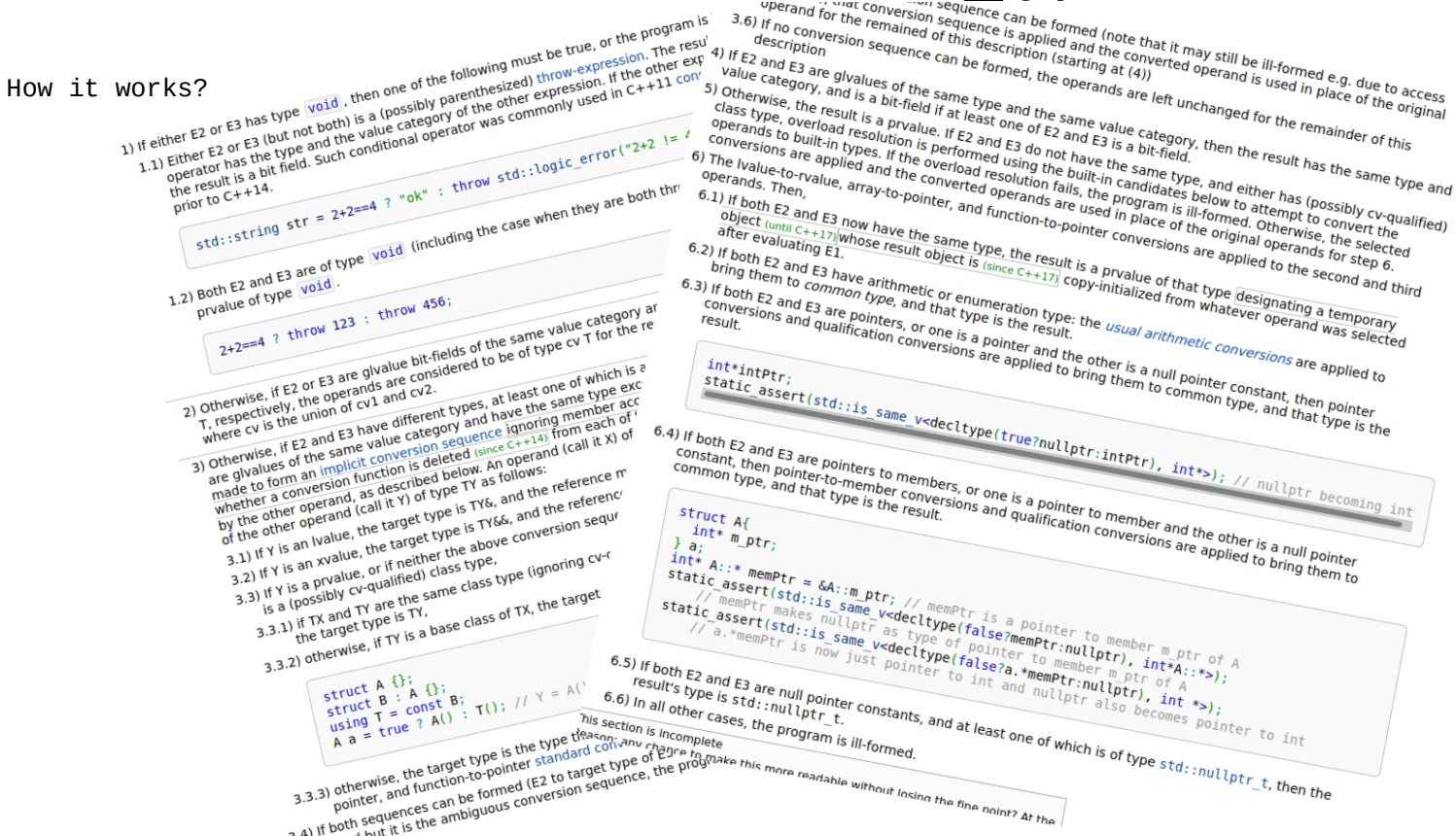
```
auto var = true ? bool{} : char{};        //bool?


What is a type of `var`?                  //int !


bool b{};

std::cin>>b;

auto var2 = b ? bool{} : char{};          //???


What is a type of `var2`?                 //int !
```

# std::common_type

How it works?

# std::common_type

How it works?



# std::common_type

How it works?

# std::common_type

How it works?

```
template<class U, class V>

using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

# std::common_type

How it works?

```
template<class U, class V>

using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

# std::common_type

How it works?

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());

static_assert(std::is_same_v<
       cond_t<int,unsigned long>,
       unsigned long
       >);
```

# std::common_type

```
template<class T1, class T2>
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}
```

# std::common_type

```
template<class T1, class T2>
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}


int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2);
}
```

# std::common_type

```
template<class T1, class T2>
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}


int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
template<class T1, class T2> //[T1 = unsigned, T2 = int]
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}

int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
template<class T1, class T2> //[T1 = unsigned, T2 = int]
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}
static_assert(-5 > 10u);
int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
template<class T1, class T2> //[T1 = unsigned, T2 = int]
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2;
}
static_assert(-5 > 10u);
int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
template<class T1, class T2> //[T1 = unsigned, T2 = int]
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2; //static_cast<unsigned>(-5);
}
static_assert(-5 > 10u);
int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
template<class T1, class T2> //[T1 = unsigned, T2 = int]
auto max(const T1& t1,const T2& t2) {
   return t1 > t2 ? t1 : t2; //static_cast<unsigned>(-5);
}
static_assert(-5 > 10u);
int main() {
   unsigned var1 = 10;
   int var2 = -5;
   std::cout<<max(var1,var2); //4294967291
}
```

# std::common_type

```
struct T1;

struct T2;

struct T1 {

   operator T2();

};

struct T2 {

   operator T1();

};
```

```
int main() {

   static_assert(std::is_same_v<

       cond_t<T1,T2>,

       T1

   >);

}
```

# std::common_type

```
struct T1;

struct T2;

struct T1 {

   operator T2();

};

struct T2 {

   operator T1();

};
```

```
int main() {

   static_assert(std::is_same_v<

       cond_t<T1,T2>,

       T1

   >);

}
```

# std::common_type

```
struct T1;

struct T2;

struct T1 {

   operator T2();

};

struct T2 {

   operator T1();

};
```

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

```
int main() {

   static_assert(std::is_same_v<

       cond_t<T1,T2>,

       T1

   >);

}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};


int main() {
   static_assert(std::is_same_v<
       cond_t<T1,T3>,
       T1
   >);
}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};


int main() {
   static_assert(std::is_same_v< //Assertion fail!
       cond_t<T1,T3>,
       T1
   >);
}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};
```

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

```
int main() {
   static_assert(std::is_same_v< //Assertion fail!
       cond_t<T1,T3>,
       T1
   >);
}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};
```

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

```
int main() {
   static_assert(std::is_same_v< //Assertion fail!
       cond_t<T1,T3>,
       T1
   >);
}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};


int main() {

   static_assert(std::is_same_v< //Assertion fail!

       cond_t<T1,T3>,

       T1

   >);

}
```

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

```
template<class T>
T&& declval() { };
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};
```

```
template<class U, class V>
using cond_t = decltype(false ? std::declval<U>() : std::declval<V>());
```

```
template<class T>
T&& declval() { };
```

```
int main() {

   static_assert(std::is_same_v< //Assertion fail!

       cond_t<T1,T3>,

       T1&&

   >);

}
```

# std::common_type

```
struct T1 {};

struct T2 : T1 {};

struct T3 : T2 {};


int main() {
   static_assert(std::is_same_v< //OK
       cond_t<T1,T3>,
       T1&&
   >);
}
```

# std::common_type

# std::common_type

Our targets:

# std::common_type

Our targets:

- Any amount of types (Variadic templates + recursion)

# std::common_type

Our targets:

- Any amount of types (Variadic templates + recursion)
- No member ‘type’ if no conversions available (SFINAE)

# std::common_type

Our targets:

- Any amount of types (Variadic templates + recursion)
- No member ‘type’ if no conversions available (SFINAE)
- Some changes with references and function types (std::decay)

# std::common_type

```
template<class U, class V>

using cond_t = decltype(false? std::declval<U>() : std::declval<V>());
```

# std::common_type

```
template<class U, class V>
using cond_t = decltype(false? std::declval<U>() : std::declval<V>());


template<class...>
struct common_type {};
```

# std::common_type

```
template<class U, class V>
using cond_t = decltype(false? std::declval<U>() : std::declval<V>());


template<class...>
struct common_type {};


template<class T>
struct common_type<T> : common_type<T,T> {};
```

# std::common_type

```
template<class U, class V>
using cond_t = decltype(false? std::declval<U>() : std::declval<V>());


template<class...>
struct common_type {};


template<class T>
struct common_type<T> : common_type<T,T> {};
```

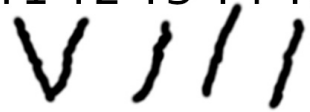
- If `sizeof...(T)` is one (i.e., `T...` contains only one type `T0`), the member type names the same type as `std::common_type<T0, T0>::type` if it exists; otherwise there is no member type.

# std::common_type

T1 T2 T3 T4 T5 ...

# std::common_type

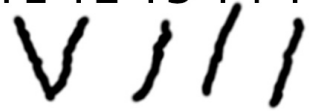
T1 T2 T3 T4 T5 ...



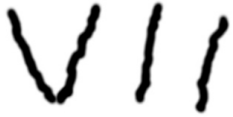
T' T3 T4 T5 ...

# std::common_type

T1 T2 T3 T4 T5 ...



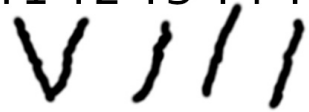
T' T3 T4 T5 ...



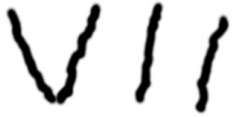
T'' T4 T5 ...

# std::common_type

T1 T2 T3 T4 T5 ...



T' T3 T4 T5 ...



T'' T4 T5 ...

. . .

# std::common_type

# std::common_type

```
template<class U, class V, class = void>
struct common_type_2_impl { };


template<class U, class V>
struct common_type_2_impl<U, V, std::void_t<cond_t<U, V>>> {
   using type = cond_t<U, V>;
};
```

# std::common_type

```
template<class U, class V, class = void>
struct common_type_2_impl { };


template<class U, class V>
struct common_type_2_impl<U, V, std::void_t<cond_t<U, V>>> {
   using type = std::decay_t<cond_t<U, V>>;
};
```

# std::common_type

```
template<class U, class V, class = void>
struct common_type_2_impl { };


template<class U, class V>
struct common_type_2_impl<U, V, std::void_t<cond_t<U, V>>> {
   using type = std::decay_t<cond_t<U, V>>;
};
```

- Otherwise, if `std::decay<decltype(false ? std::declval<T1>() : std::declval<T2>())>::type` is a valid type, the member type denotes that type;

# std::common_type

```
template<class U, class V, class = void>
struct common_type_2_impl { };


template<class U, class V>
struct common_type_2_impl<U, V, std::void_t<cond_t<U, V>>> {
   using type = std::decay_t<cond_t<U, V>>;
};
```

# std::common_type

```
template<class U, class V>

struct common_type<U, V> : common_type_2_impl<U, V> { };
```

- If applying `std::decay` to at least one of T1 and T2 produces a different type, the member type names the same type as `std::common_type<std::decay<T1>::type, std::decay<T2>::type>::type`, if it exists; if not, there is no member type.

# std::common_type

```
template<class U, class V>

struct common_type<U, V> : common_type_2_impl<std::decay_t<U>, std::decay_t<V>> { };
```

- If applying `std::decay` to at least one of T1 and T2 produces a different type, the member type names the same type as `std::common_type<std::decay<T1>::type, std::decay<T2>::type>::type`, if it exists; if not, there is no member type.

# std::common_type

```
template<class AlwaysVoid, class U, class V, class... Args>
struct common_type_multi_impl { };


template< class U, class V, class... Args>
struct common_type_multi_impl<std::void_t<common_type<U, V>>, U, V, Args...>
       : common_type<typename common_type<U,V>::type,Args...> { };
```

# std::common_type

```
template<class AlwaysVoid, class U, class V, class... Args>
struct common_type_multi_impl { };


template< class U, class V, class... Args>
struct common_type_multi_impl<std::void_t<common_type<U, V>>, U, V, Args...>
       : common_type<typename common_type<U,V>::type,Args...> { };
```

# std::common_type

```
template<class AlwaysVoid, class U, class V, class... Args>
struct common_type_multi_impl { };


template< class U, class V, class... Args>
struct common_type_multi_impl<std::void_t<common_type<U, V>>, U, V, Args...>
       : common_type<typename common_type<U,V>::type,Args...> { };
```

# std::common_type

```
template<class AlwaysVoid, class U, class V, class... Args>
struct common_type_multi_impl { };


template< class U, class V, class... Args>
struct common_type_multi_impl<std::void_t<common_type<U, V>>, U, V, Args...>
       : common_type<typename common_type<U,V>::type,Args...> { };
```

# std::common_type

```
template<class AlwaysVoid, class U, class V, class... Args>
struct common_type_multi_impl { };


template< class U, class V, class... Args>
struct common_type_multi_impl<std::void_t<common_type<U, V>>, U, V, Args...>
       : common_type<typename common_type<U,V>::type,Args...> { };
```

# std::common_type

```
template<class U, class V, class... Args>

struct common_type<U, V, Args...> : common_type_multi_impl<void, U, V, Args...> {};
```

# For what?

# For what?

```
template<class T1, class T2, class T3>
auto multi_conditional(const T1& t1, const T2& t2, const T3& t3) {
   /*conditions, hard logic...*/
       return t1;
   /*conditions, hard logic...*/
       return t2;
   /*conditions, hard logic...*/
       return t3;
}
```

# For what?

```
template<class T1, class T2, class T3>
auto multi_conditional(const T1& t1, const T2& t2, const T3& t3) {
   /*conditions, hard logic...*/
       return t1;
   /*conditions, hard logic...*/
       return t2;
   /*conditions, hard logic...*/
       return t3;
}
```

```
int main() {
   multi_conditional(5,'c',5u);
}
```

# For what?

```
template<class T1, class T2, class T3>
auto multi_conditional(const T1& t1, const T2& t2, const T3& t3) {
   /*conditions, hard logic...*/
       return t1;
   /*conditions, hard logic...*/
       return t2; //inconsistent deduction for auto return type: ‘int’ and then ‘char’
   /*conditions, hard logic...*/
       return t3; //inconsistent deduction for auto return type: ‘int’ and then ‘unsigned int’
}
```

```
int main() {
   multi_conditional(5,'c',5u);
}
```

# For what?

```
template<class T1, class T2, class T3>
auto multi_conditional(const T1& t1, const T2& t2, const T3& t3) -> std::common_type_t<T1,T2,T3> {
   /*conditions, hard logic...*/
       return t1;
   /*conditions, hard logic...*/
       return t2;
   /*conditions, hard logic...*/
       return t3;
}
```

```
int main() {
   multi_conditional(5,'c',5u);
}
```

# Order matters!

```
struct T1 {
   operator int();
};


struct T2 {
   operator T1();
};
```

# Order matters!

```
struct T1 {

   operator int();

};


struct T2 {

   operator T1();

};
```

```
int main() {

   std::common_type_t<T2,T1,int> var;

   std::common_type_t<T2,int,T1> var;
}
```

# Order matters!

```
struct T1 {

   operator int();

};


struct T2 {

   operator T1();

};
```

```
int main() {
   // T2 -> T1 -> int
   std::common_type_t<T2,T1,int> var; // int

   std::common_type_t<T2,int,T1> var;
}
```

# Order matters!

```
struct T1 {

   operator int();

};


struct T2 {

   operator T1();

};
```

```
int main() {
   // T2 -> T1 -> int
   std::common_type_t<T2,T1,int> var; // int
   // T2 ?? int ?? T1
   std::common_type_t<T2,int,T1> var; // fail
}
```