

Department I - C Plus Plus

Modern and Lucid C++ Advanced for Professional Programmers

Week 7 – Bonus: Tags for Value Types

Thomas Corbat / Felix Morgner
Rapperswil / St. Gallen, 04.04.2024
FS2024



```
struct Speed {  
    constexpr explicit Speed(double kmh)  
        : kmh { kmh } {}  
    double kmh;  
};
```

```
Speed v{1.0}; //Unit?
```

- **Problem: Literal values lack a dimension**

- Can result in hard to detect bugs
- Especially when they are implicitly convertible

```
struct Speed {  
    constexpr Speed(double value) {...}  
};  
  
auto isFasterThanWalking(Speed speed) -> bool;
```

```
ASSERT(isFasterThanWalking(10.0));  
ASSERT(isFasterThanWalking(2.8));  
ASSERT(isFasterThanWalking(6.2));
```

- **Possible Approach: Add factory functions for disambiguation**

- Tedious to call in many places
- Difficult to extend (Open Closed Principle is violated)

```
struct Speed {  
    static auto fromKmh(double value) -> Speed;  
    static auto fromMph(double value) -> Speed;  
    static auto fromMps(double value) -> Speed;  
private:  
    Speed(double value);  
};  
  
auto isFasterThanWalking(Speed speed) -> bool;
```

```
ASSERT(isFasterThanWalking(Speed::fromKmh(10.0)));  
ASSERT(isFasterThanWalking(Speed::fromMph(2.8)));  
ASSERT(isFasterThanWalking(Speed::fromMps(6.2)));
```

- Create a tag type for the unit

```
struct Kph;  
struct Mph;  
struct Mps;
```

- Create a quantity type template for speed

```
template <typename Unit>  
struct Speed {  
    constexpr explicit Speed(double value)  
        : value{value}{};  
    constexpr explicit operator double() const {  
        return value;  
    }  
private:  
    double value;  
};
```

- Add a speedCast function

```
template<typename Target, typename Source>
constexpr auto speedCast(Speed<Source> const& source) -> Speed<Target> {
    return Speed<Target>{ ConversionTraits<Target, Source>::convert(source) };
}
```

- Create a ConversionTraits class template

```
template<typename Target, typename Source>
struct ConversionTraits {
    constexpr static auto convert(Speed<Source> sourceValue) -> Speed<Target> =
delete;
};
```

- **Specialize ConversionTraits class template**

```
template <typename Same>
struct ConversionTraits<Same, Same> {
    constexpr static auto convert(Speed<Same> sourceValue) -> Speed<Same> {
        return sourceValue;
    }
};

static constexpr double mphToKphFactor { 1.609344 };
template<>
struct ConversionTraits<tags::Kph, tags::Mph> {
    constexpr static auto convert(Speed<tags::Mph> sourceValue) -> Speed<tags::Kph> {
        return Speed<tags::Kph>{static_cast<double>(sourceValue) * mphToKphFactor};
    }
};
//...
```

```
template <typename Unit>
auto isFasterThanWalking(Speed<Unit> speed) -> bool {
    return velocity::speedCast<Kph>(speed) > Speed<Kph>{5.0};
}
```

- **Requires comparison operations, i.e >**
 - They can be implemented using boost
- **Arbitrary Speed objects can be compared with an == operator template**

```
template <typename LeftTag, typename RightTag>
constexpr auto operator==(Speed<LeftTag> const & lhs,
                          Speed<RightTag> const & rhs) -> bool {
    return lhs == speedCast<LeftTag>(rhs);
}
```