KDAB

Members through a looking glass

Meeting C++ Online

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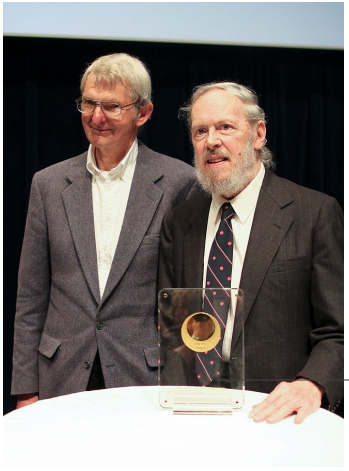
About me

- KDAB senior software engineer
  Software Experts in Qt, C++ and 3D / OpenGL
- Author of the "Functional Programming in C++" book *available in English, Chinese, Korean, Russian, Polish*
- Trainer / consultant
- KDE developer
- University lecturer

COMPOSITION

Composition



Doug McIlroy and Dennis Ritchie

Composition

```
tr -cs A-Za-z '\n' |
    tr A-Z a-z |
    sort |
    uniq -c |
    sort -rn |
    sed ${1}q
```

Composition

- Make each program do one thing well. To do a new job, build afresh rather than complicate old programs by adding new ”features”.
- Expect the output of every program to become the input to another, as yet unknown, program. Don’t clutter output with extraneous information. Avoid stringently columnar or binary input formats. Don’t insist on interactive input.

  ...

Doug McIlroy, Bell System Technical Journal, 1978

Composition

Software design is about composition.

Tony Van Eerd @tvaneerd · Jul 22

9 times out of 10, a for-loop should either be the only code in a function, or the only code in the loop should be a function (or both).

```
int f()
{
  for (...)
  {
    ....
  }
}
```

or

```
for(x...)
  g(x);
```

avoid code outside the loop and inside the loop in the same function.

6 5 39

Functions

```
write(std::string) -> …
to_string(something_t) -> std::string

write(to_string(something);
```

Functions

```
auto compose(auto f, auto g)
{
    return [f, g](auto &&...args) {
        return f(g(FWD(args)...));
    }
}
```

MEMBERS

Pointers to member functions

```
write(std::string) -> …
something_t::to_string() -> std::string

write(&something_t::to_string(something);
```

Pointers to member functions

```
&something_t::to_string : something_t -> std::string
```

Pointers to member functions

```
auto compose(auto f, auto g)
{
    return [f, g](auto &&...args) {
        return std::invoke(f,
                    std::invoke(g, FWD(args)...));
    }
}
```

Pointers to member functions

```
accumulate(appartments, …
           &appartment_t::monthly_payment);
```

Pointers to member functions

```
accumulate(appartments, …
           compose(&tenant_t::monthly_payment,
                   &appartment_t::tenant));
```

Pointers to member objects

```
&something_t::m_full_name
```

Pointers to member objects

```
&something_t::m_full_name :
    something_t -> std::string
```

Pointers to member objects

```
&something_t::m_full_name :
    something_t -> std::string
    (something_t, std::string) -> something_t
```

UNITE

Pairing up

Getters and setters

Note: Not really OOP...

Pairing up

Getters and **updaters**

Note: Not really OOP...

Pairing up

```
view : object_t -> value_t

update : object_t, (value_t -> value_t) -> object_t
```

Pairing up

```
template <typeame Object, typename Value,
          typename View, typename Update>
class typed_property {
    …




};
```

Pairing up

```
template <typeame Object, typename Value,
          typename View, typename Update>
class typed_property {
public:
    using object_t = Object;
    using value_t = Value;

private:
    View m_view;
    Update m_update;
};
```

Pairing up

```
decltype(auto) view(const object_t &object) const
{
    return std::invoke(m_view, object);
}
```

Pairing up

```
decltype(auto) update(object_t &&object, auto updateFn) const
{
    return std::invoke(m_update, std::move(object), updateFn);
}
```

Pairing up

```
decltype(auto) set(object_t &&object, auto value) const
{
    return std::invoke(m_update, std::move(object),
        [_value = std::move(value)] (auto&&) {
            return _value;
        };
    );
}
```

Pairing up

```
operator()(const object_t&)
```
calls view

```
operator()(object_t&&, update_function)
operator()(object_t&&, value_t)
```
calls update
calls set

Pairing up

```
namespace detail
{
template<typename T, typename M>
struct member_splitter_result {
    using object_t = T;
    using member_ptr_t = M;
};

template<typename T, typename M>
member_splitter_result<T, M> member_splitter_helper(M(T::*m));

template<typename MPtr>
using member_traits =
    decltype(member_splitter_helper(std::declval<MPtr>()));
} // namespace detail
```

Pairing up

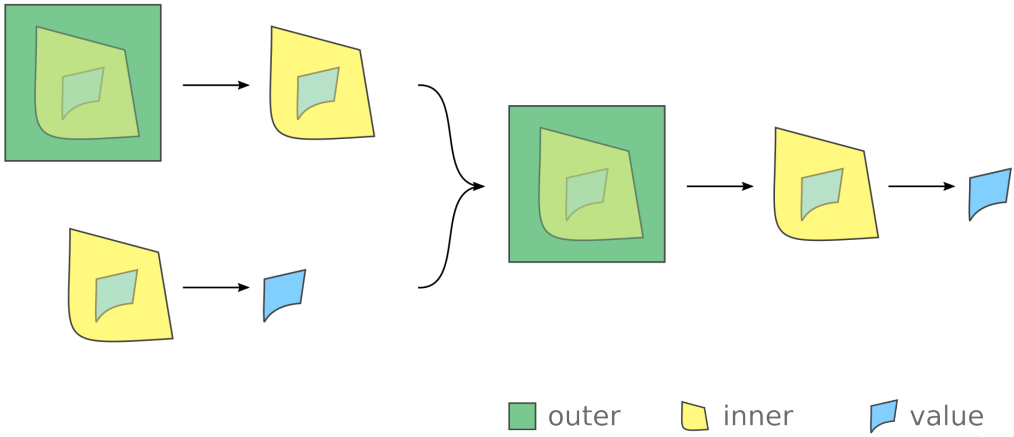
```
template<typename MemberPtr>
auto member(MemberPtr member)
{
    using object_t = …; using member_value_t = …;

    auto update = [member](object_t &&object, auto &&updateFn) -> object_t&&
    {
        auto &field = std::invoke(member, object);
        field = std::invoke(updateFn, std::move(field));
        return std::move(object);
    };

    return typed_property<
        object_t, member_value_t,
        MemberPtr, decltype(update)>(member, std::move(update));
}
```

Back to composition

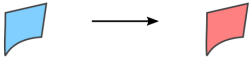
How can we compose properties?

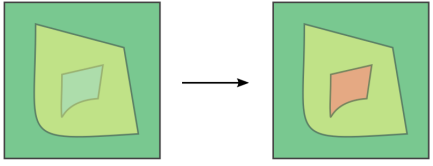
- View
- Update

Back to composition

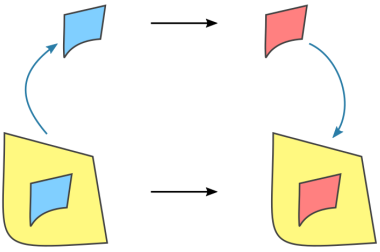


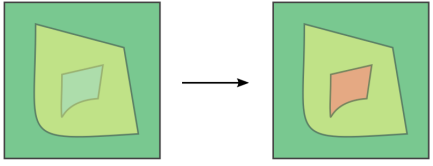
Back to composition



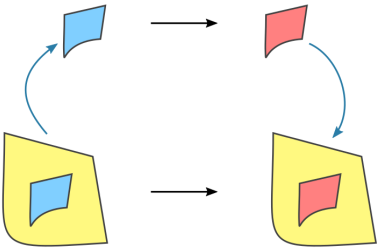


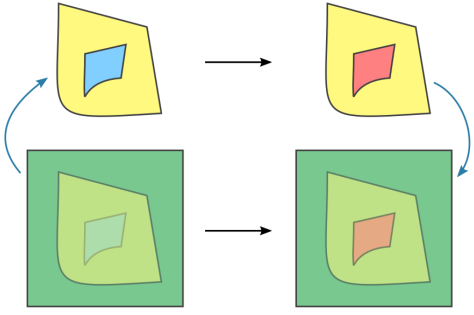
Back to composition





Back to composition

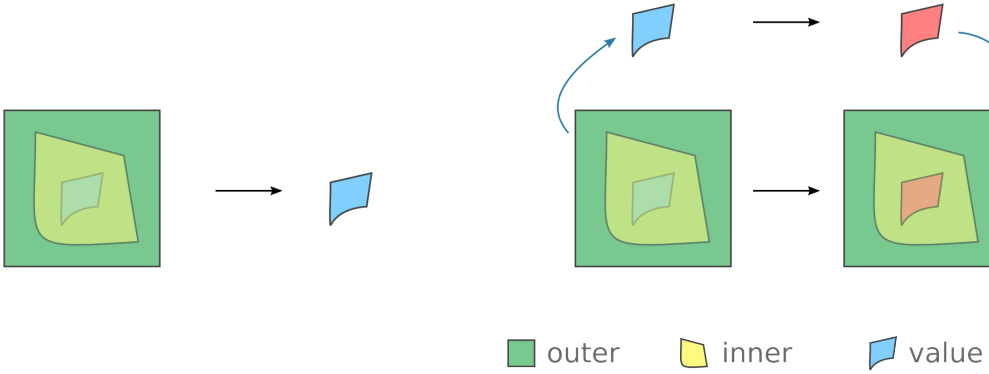




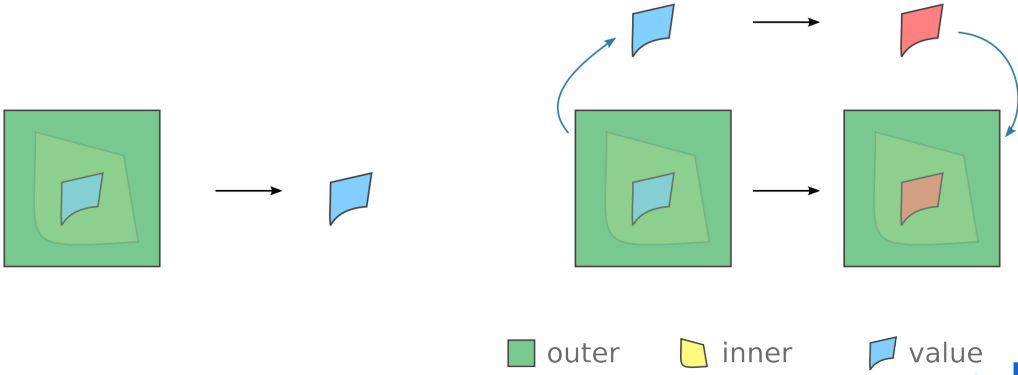
Back to composition

```
auto compose_update =
    [ _left = left.update_function()
    ,  _right = right.update_function()
    ](outer_object_t outerValue, auto innerUpdateFn) {
        auto outerUpdateFunction =
            [_left, innerUpdateFn](inner_object_t innerValue) {
                return std::invoke(_left, std::move(innerValue),
                                   innerUpdateFn);
            };
        return std::invoke(_right, std::move(outerValue),
                           std::move(outerUpdateFunction));
    };
```

Back to composition



Back to composition



Back to composition

```
auto monthly =
    fn::tenant >> fn::monthly_payment;

accumulate(
    appartments, 0.0, std::plus{}, monthly);
```

Back to composition

```
auto monthly =
    fn::tenant >> fn::monthly_payment;

accumulate(
    appartments, 0.0, std::plus{}, monthly);

new_appartment = monthly(
    std::move(old_appartment), increase_20_percent);
```

ABSTRACTION

But, what is composition?

- Functions
- Properties

...

But, what is composition?

```
f: object_t -> optional<value_t>;
g: value_t -> optional<inner_t>;

compose(g, f): object_t -> optional<inner_t>;
```

But, what is composition?

```
f: object_t -> vector<value_t>;
g: value_t -> vector<inner_t>;

compose(g, f): object_t -> vector<inner_t>;
```

But, what is composition?

```
building_t::appartments   : building_t -> vector<appartment_t>;
appartment_t::tenant      : appartment_t -> tenant_t;
tenant_t::monthly_payment : tenant_t -> double

auto payments = fn::appartments
             >> fn::tenant
             >> fn::monthly_payment;
accumulate(payments(building), 0.0);
```

But, what is composition?

```
building_t::appartments    : building_t -> vector<appartment_t>;
appartment_t::tenants      : appartment_t -> vector<tenant_t>;
tenant_t::monthly_payments : tenant_t -> vector<double>

auto payments = fn::appartments
             >> fn::tenants
             >> fn::monthly_payments;
accumulate(payments(building), 0.0);
```

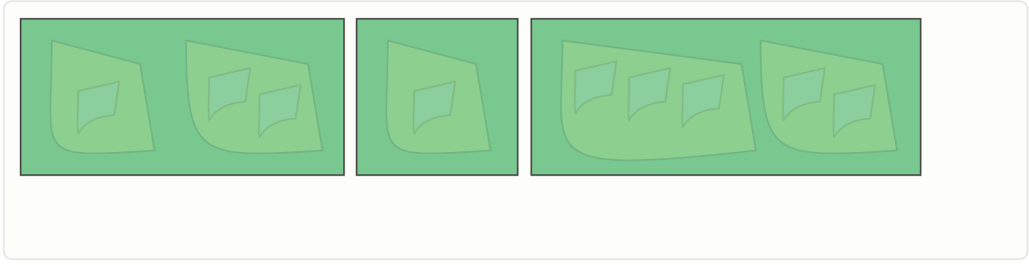
But, what is composition?

```
building_t::appartments    : building_t -> vector<appartment_t>;
appartment_t::tenants      : appartment_t -> vector<tenant_t>;
tenant_t::monthly_payments : tenant_t -> vector<double>

auto payments = fn::appartments
             >> fn::tenants
             >> fn::monthly_payments;
auto expensive_building =
    payments(std::move(building), increase_20_percent);
```

Focus

Focus

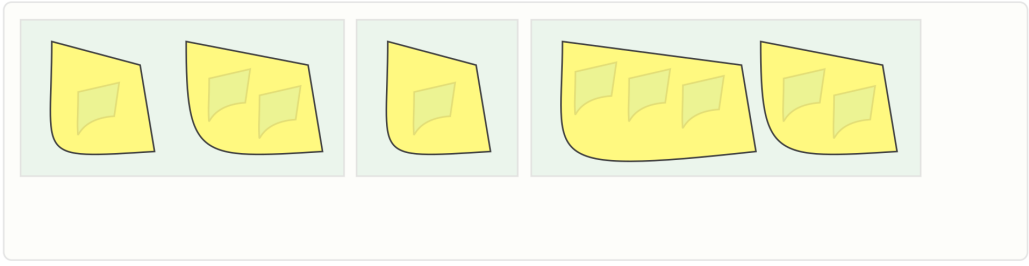
`fn::appartments`



building appartment tenant monthly_payment

Focus

```
fn::appartments
>> fn::tenants
```



building appartment tenant monthly_payment

Focus

```
fn::appartments
>> fn::tenants
>> fn::monthly_payments
```

building appartment tenant monthly_payment

Focus

```
accumulate(payments(building), ...)
```

building appartment tenant monthly_payment

Focus

```
auto expensive_building =
     payments(std::move(building), …)
```

building appartment tenant monthly_payment

Composition in the future

```
f: object_t -> future<value_t>;
g: value_t -> future<inner_t>;

compose(g, f): object_t -> future<inner_t>;
```

Composition in the future

```
building_t::appartments    : building_t -> future<appartment_t>;
appartment_t::tenants      : appartment_t -> future<tenant_t>;
tenant_t::monthly_payments : tenant_t -> future<double>

auto payments = fn::appartments
             >> fn::tenants
             >> fn::monthly_payments;
not_really_accumulate(payments(building), 0.0);
```

Wrap

- Core-language support is great, but…
- Refactoring
- Easily expanded to filtering, optional values, …
- Nice for building GUIs

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cukic.co/to/fp-in-cpp

Functional Programming in C++