Optymalizacje c++11

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Plan prezentacji

- std::move() i rvalue referencje
- Uniwersalne referencje
- Noexcept
- Optymalizacje Struktur danych

rvalue referencje

- obiekty tymczasowe - nienazwane
- obiekty które nam nie są potrzebne
- wszystko co nie posiada adresu

rvalue referencje

```
std::string foo(std::string&& s)
{
    return s;
}
int main()
{
    foo(std::string("Warsaw"));
    foo("C++");
    foo(foo("Group"));
}
```

rvalue referencje

```
std::string foo(std::string&& s)
{
    return s;
}

int main()
{
    std::string a(" :( ");
    foo(a);  //error: cannot bind std::string lvalue to std::string&&
}
```

std::move()

```
std::string foo(std::string&& s)
{
    return s;
}

int main()
{
    std::string a(" :) ");
    foo(std::move(a));  // fine
}
```

std::move()

```
struct Foo {
    Foo(std::string&& temp) : a_(temp)   // Copies temp to a_!
    {
    }
    std::string a_;
};
int main() {
    std::string c("42");
    Foo foo(std::move(c));
    Foo foo2("42");
}
```

std::move()

```
struct Foo {
    Foo(std::string&& temp) : a_(std::move(temp))  // fine, everything is moved
    {
    }
    std::string a_;
};
int main() {
    std::string c("42");
    Foo foo(std::move(c));
    Foo foo2("42");
}
```

std::move()

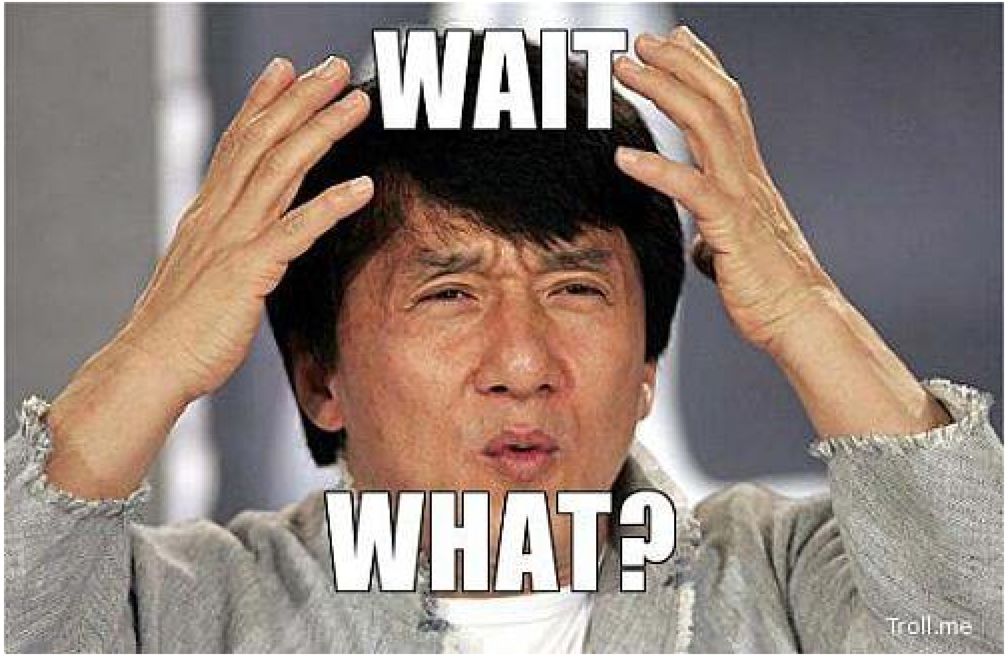
```
template< class T >
typename std::remove_reference<T>::type&& move( T&& t )
{
    return static_cast<remove_reference<decltype(arg)>::type&&>(arg);
}
```

std::move() **nie przenosi** żadnych obiektów.

Jedyne co robi to podmienia typ wyrażenia

Uniwersalne referencje

```
template <typename T>
void foo(T&& t)
{
}
int main()
{
    foo("123");

    std::string a("abc");
    foo(a);
}
```



universal reference

```
template <typename T>
void foo(T&& t)
{
}
int main()
{
    foo(std::string("123")); // calls foo(std::string&&)

    std::string a("abc");
    foo(a);                  //cals foo(std::string&)
}
```

- A& & becomes A&
- A& && becomes A&
- A&& & becomes A&
- A&& && becomes A&&

perfect forwarding

```
struct Foo {
    template <typename T>
    Foo(T&& t) : s_(std::forward<T> (t))
    {
    }
    std::string s_;
};
int main() {
    Foo f("fdafds");

    std::string b("fdas");
    Foo f2(b);
}
```

```
template<class S>
S&& forward(typename remove_reference<S>::type& a) noexcept
{
        return static_cast<S&&>(a);
}
```

std::forward “zachowuje” początkowy typ.

string&& -> string&&

string& -> string&

universal reference

```
struct ConstExtraParamArgs
{
        typedef std::string                                          ExtraParamValueType;
        typedef std::vector<ExtraParamValueType>      ExtraParamValuesContainer;

    ConstExtraParamArgs(ExtraParamValueType key = "",
                       std::string separator = "",
                       std::string recursiveOtherName = "",
                       size_t limit = 0,
                       bool recursive = false,
                       ExtraParamValuesContainer predefinedValues=ExtraParamValuesContainer());
     … //te same pola co w konstruktorze
};
```

universal reference

```
class ExtraParamArgs {
    typedef const ConstExtraParamArgs                       PointerElementType;
public:
    typedef std::shared_ptr<PointerElementType>        ConstExtraParamArgsPtr;
    ExtraParamArgs() : index(0),
            constExtraParamArgsPtr_(std::make_shared<PointerElementType>())
    { }
    template <typename... Args>
    ExtraParamArgs(size_t index, Args... args)
        : index(index),
          constExtraParamArgsPtr_(std::make_shared<PointerElementType>(std::forward<Args>(args)...))
    { }
    size_t index;
private:
    ConstExtraParamArgsPtr constExtraParamArgsPtr_;
};
```

universal reference

Universalne referencje nie zawsze działają

```
foo({0, 1, 2})
```

5.cc:11:18: error: no matching function for call to ‘foo(<brace-enclosed initializer list>)’

```
    foo({0, 1, 2});
              ^
```

5.cc:6:6: note: template argument deduction/substitution failed:

5.cc:11:18: note: couldn't deduce template parameter ‘T’

```
   foo({0, 1, 2})
```

ale takie coś się skompiluje:

```
auto v = {0, 1, 2};  // type v to std::initializer_list<int>
foo(std::move(v));
```

```
template <typename T>
void foo(T&& t) {
    std::vector<int> v(t);
}
```

reference vs value

```
struct Foo {
    Foo(std::string s) : s_(std::move(s))
    {
    }

    std::string s_;
};
int main() {
    Foo f("fdafds"); // 0 copies
    std::string b("fdas");
    Foo f2(b); // 1 copy
    Foo x(std::move(b)); //0 copies
}
```

Jeśli typ który przekazujesz

- posiada konstruktor przenoszący oraz
- kopia zostanie wykonana tak czy siak

Wtedy powinieneś pobierać parametry przez wartość.

W przeciwnym wypadku powinna to być referencja

std::move()

```
std::vector<std::string> v;
void make_something(const std::string s)
{
      //stuff
    v.push_back(std::move(s));
}

int main() {
    make_something("123");
}
```

Skompiluje się i spowoduje dodatkową kopie.

string nie powiada konstruktora push_back(const string&&)

zostanie wybrany push_back(const string&)

to move or not to move?

```
std::vector<std::string> foo(std::string s)
{
   std::vector <std::string> v;
   v.push_back(std::move(s));
   return v;
}
int main()
{
   auto v = foo("hmm");
}
```

URVO i NRVO

(Named/Unnamed) **Return Value Optimization** to powszechnie stosowana optymalizacja mająca na celu uniknięcie kopiowania zwracanej wartości.

Polega ona na stworzeniu tymczasowego obiektu **w miejsce** obiektu do którego przypisywana jest zwracana wartość.

Jest ona wyjątkiem w regule “**as-if**”, która mówi że kod po optymalizacjach musi produkować takie same rezultaty co przed optymalizacjami.

URVO i NRVO - jak to działa

```
struct Foo {
    Foo(int a, int b);
    void some_method();
};
void do_something_with(Foo&);
Foo rbv() {
    Foo y = Foo(42, 73);
    y.some_method();
    do_something_with(y);
    return y;
}
void caller() {
    Foo x = rbv();
}
```

```
// Pseudo-code
void Foo_ctor(Foo* this, int a, int b) {
  // ...
}
void caller() {
    struct Foo x;
    // Note: x is not initialized here!
    rbv(&x);
}
```

URVO i NRVO - jak to działa

```
// Pseudo-code
void Foo_ctor(Foo* this, int a, int b) {
  // ...
}
void caller() {
    struct Foo x;
    // Note: x is not initialized here!
    rbv(&x);
}
```

```
// Pseudo-code
void rbv(void* put_result_here) {
    Foo_ctor((Foo*)put_result_here, 42, 73);
    Foo_some_method(*(Foo*)put_result_here);
    do_something_with((Foo*)put_result_here);

    return;
}
```

URVO i NRVO ex.

```
struct Foo {
        Foo() {
            std::cout << "Foo()" << std::endl;
        }
        Foo(const Foo&) {
            std::cout << "Foo(const Foo&)" << std::endl;
        }
        Foo(Foo&&) {
            std::cout << "Foo(Foo&&)" << std::endl;
        }
        ~Foo() {
            std::cout << "~Foo()" << std::endl;
        }
        void someMethod() {
            std::cout << "some method" << std::endl;
        }
};
```

```
Foo bar(bool p) {
    return Foo(); //URVO
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:

Foo()

end

~Foo()

to move or not to move?

```
Foo bar(bool p) {
    return Foo(); //URVO
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:
Foo()
end
~Foo()

```
Foo bar(bool p) {
    return std::move(Foo()); //no URVO!
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:
Foo()
Foo(Foo&&)
~Foo()
end
~Foo()

URVO i NRVO ex.

```cpp
Foo bar(bool p) {
    Foo a;
    a.someMethod();
    return a; //NRVO
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:

Foo()
some method
end
~Foo()

```cpp
Foo bar(bool p) {
    Foo a;
    a.someMethod();
    return std::move(a);
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:

Foo()
some method
Foo(Foo&&)
~Foo()
end
~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    Foo a;
    if (p)
        return a;
    else {
        a.someMethod();
        return a;
    }
}
```

```
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out: ./prog

Foo()
some method
end
~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    if (p)
        return Foo();
    else {
        Foo a;
        a.someMethod();
        return a;
    }
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

odpalamy: ./**prog**

gcc-4.8.2 out:

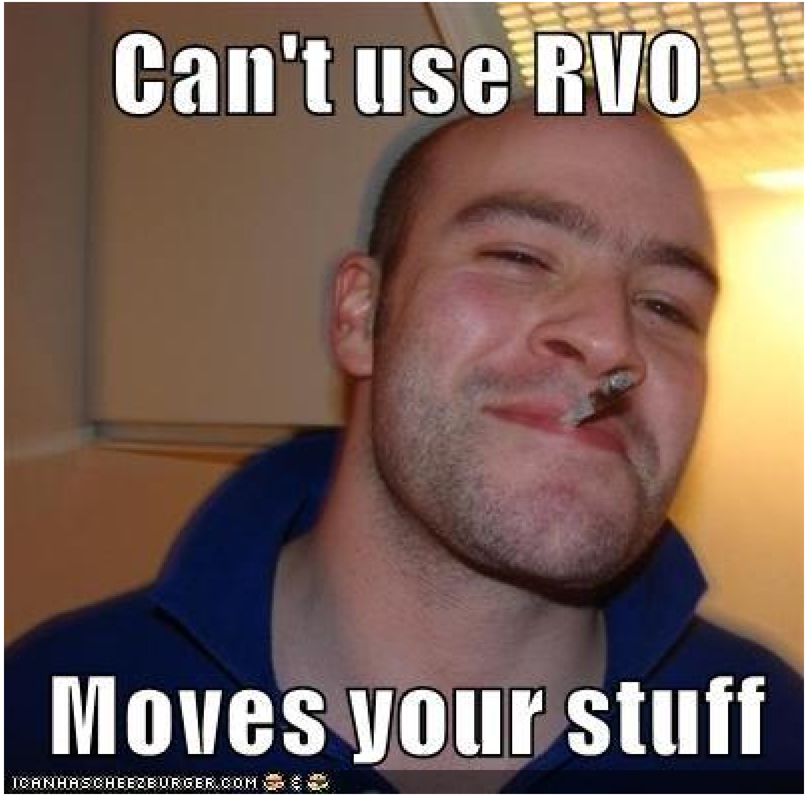
```
Foo()
some method
Foo(Foo&&)
~Foo()
end
~Foo()
```

clang-3.5 out:

```
Foo()
some method
end
~Foo()
```

URVO i NRVO ex.

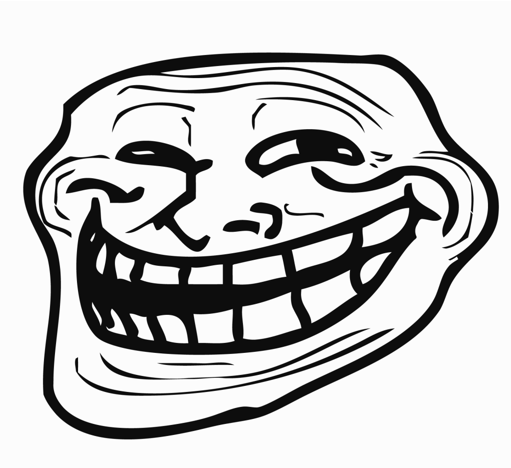
When the criteria for elision of a copy operation are met or would be met save for the fact that the source object is a function parameter, and the object to be copied is designated by an lvalue, overload resolution to select the constructor for the copy is first performed as if the object were designated by an rvalue.



URVO i NRVO ex.

```
    //Dodajmy te 2 konstruktory
    Foo(const std::initializer_list<int>&) {
        cout << "Foo(initializer_list &)" << endl;
    }
    Foo(std::initializer_list<int>&&) {
        cout << "Foo(initializer_list &&)" << endl;
    }

Foo bar(bool p) {
    return {};
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:
Foo()
end
~Foo()



URVO i NRVO ex.

```
Foo bar(bool p) {
    return {1, 2, 3};
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    cout << "end" << endl;
}
```

out:

Foo(initializer_list &&)
end
~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    auto v = {1, 2, 3};
    return v;
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    cout << "end" << endl;
}
```

out:

Foo(initializer_list &)
end
~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    auto v = {1, 2, 3};
    return std::move(v); // :(
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    cout << "end" << endl;
}
```

out:

Foo(initializer_list &&)

end

~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    if (p)
        return {1, 2, 3};
    else {
        Foo a;
        return a;
    }
}
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

clang out: ./prog

Foo()

end

~Foo()

clang out: ./prog 123

Foo(initializer_list &&)

end

~Foo()

gcc out: ./prog 123

Foo(initializer_list &&)

end

~Foo()

gcc out: ./prog

Foo()

Foo(Foo&&)

~Foo()

end

~Foo()

URVO i NRVO ex.

```
Foo bar(bool p) {
    Foo a;
    a.someMethod();
    Foo b;
    if (p)
        return b;
    else
        return a;
}
```

```
int main(int argc, char* argv[]) {
    Foo f = bar(argc > 1);
    std::cout << "end" << std::endl;
}
```

out:

```
Foo()
some method
Foo()
Foo(Foo&&)
~Foo()
~Foo()
end
~Foo()
```

URVO i NRVO podsumowanie

- Nie używaj “return std::move(...)” - nawet jeśli kompilatorowi nie uda się użyć RVO to przeniesie obiekty za Ciebie, chyba że:
- zwraczasz obiekt o innym typie niż który zwraca funkcja. Wtedy powinieneś użyć return std::move(...);
- Staraj się wszędzie zwracać obiekt o tej samej nazwie (dokładnie ten sam).
- Na wszelki wypadek upewnij się że zwracany obiekt ma konstruktor przenoszący.

noexcept

```
void maybe();
void foo() throw();
void bar() noexcept;
```

The difference between unwinding the call stack and possibly unwinding it has a surprisingly large impact on code generation. In a noexcept function, optimizers need not keep the runtime stack in an unwindable state if an exception would propagate out of the function, nor must they ensure that objects in a noexcept function are destroyed in the inverse order of construction should an exception leave the function. The result is more opportunities for optimization, not only within the body of a noexcept function, but also at sites where the function is called. Such flexibility is present only for noexcept functions. Functions with “throw()” exception specifications lack it, as do functions with no exception specification at all.

An implementation shall not reject an expression merely because when executed it throws or might throw an exception that the containing function does not allow.

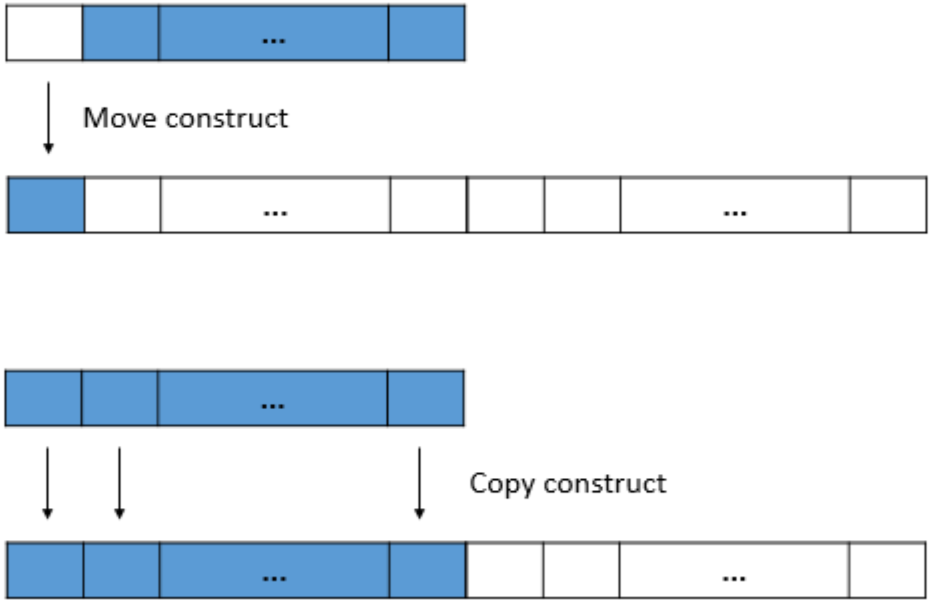
noexcept

```
struct Foo {
    Foo() {
        cout << "Foo()" << endl;
    }
    Foo(const Foo&) {
        cout << "Foo(const Foo&)" << endl;
    }
    Foo(Foo&&) {
        cout << "Foo(Foo&&)" << endl;
    }
    ~Foo() {
        cout << "~Foo()" << endl;
    }
};
```

```
int main()
{
    std::vector<Foo> v;
    for (int i = 0 ; i < 3; i++)   {
        cout << "wkladam " << endl;
        v.emplace_back();
    }
    cout << "koniec" << endl;
}
```

```
wkladam
Foo()               #1
wkladam
Foo()               #2
Foo(const Foo&)     #1'
~Foo()              #1
wkladam
Foo()               #3
Foo(const Foo&)     #1''
Foo(const Foo&)     #2''
~Foo()              #1'
~Foo()              #2'
koniec
~Foo()              #1''
~Foo()              #2''
~Foo()              #3''
```

noexcept



move_if_noexcept()

```
template <class T>
  typename conditional < is_nothrow_move_constructible<T>::value ||
                         !is_copy_constructible<T>::value,
                         T&&, const T& >::type
 move_if_noexcept(T& arg) noexcept;
```

castuje na rvalue jeśli jeden z warunków jest spełniony

- konstruktor przenoszący jest noexcept
- nie istnieje konstruktor kopiujący

noexcept

```
struct Foo {
    Foo() {
        cout << "Foo()" << endl;
    }
    Foo(const Foo&) {
        cout << "Foo(const Foo&)" << endl;
    }
    Foo(Foo&&) noexcept {
        cout << "Foo(Foo&&)" << endl;
    }
    ~Foo() {
        cout << "~Foo()" << endl;
    }
};
```

```
int main()
{
    std::vector<Foo> v;
    for (int i = 0 ; i < 3; i++)   {
        cout << "wkladam " << endl;
        v.emplace_back();
    }
    cout << "koniec" << endl;
}
```

```
wkladam
Foo()           #1
wkladam
Foo()           #2
Foo(Foo&&)      #1'
~Foo()          #1
wkladam
Foo()           #3
Foo(Foo&&)      #1''
Foo(Foo&&)      #2''
~Foo()          #1'
~Foo()          #2'
koniec
~Foo()          #1''
~Foo()          #2''
~Foo()          #3''
```

noexcept

```
struct Foo {
    Foo() {
        cout << "Foo()" << endl;
    }
    Foo(const Foo&) {
        cout << "Foo(const Foo&)" <<
endl;
    }
    Foo(Foo&&) = default;
    ~Foo() {
        cout << "~Foo()" << std::endl;
    }
};
```

An inheriting constructor (12.9) and an implicitly declared special member function (Clause 12) have an *exception-specification*. If `f` is an inheriting constructor or an implicitly declared default constructor, copy constructor, **move constructor**, destructor, copy assignment operator, or move assignment operator, its implicit *exception-specification* specifies the type-id `T` if and only if `T` is allowed by the *exception-specification* of a function directly invoked by `f`'s implicit definition; `f` allows all exceptions if any function it directly invokes allows all exceptions, and `f` has the *exception-specification* `noexcept(true)` if every function it directly invokes allows no exceptions.

noexcept(expresion)

```
template <class T1, class T2>
struct pair {
    void swap(pair& p) noexcept(noexcept(swap(first, p.first)) &&
                                noexcept(swap(second, p.second)));
};
```

```
std::cout << std::boolalpha << noexcept(Foo(std::move(f))) << std::endl;
```

noexcept podsumowanie

- Używaj noexcept w celach dokumentacyjnch,
- Generując defaultowe konstruktory używaj “ = default”,
- Jeśli definiujesz własne konstruktory oznaczaj je noexcept jeśli nie rzucają wyjątkami
- ZAWSZE używaj noexcept zamiast throw()

moving containers

```
std::vector<std::string> data;
std::vector<std::string> cache;
    // some inserting to both
std::copy(cache.begin(), cache.end(), std::back_inserter(data));
data.insert(data.end(), cache.begin(), cache.end());

std::move(cache.begin(), cache.end(), std::back_inserter(data));

data.insert(data.end(),
                  std::make_move_iterator(cache.begin()),
                  std::make_move_iterator(cache.end()));
```

Bezsensowne optymalizacje

- inline’owanie funkcji na własną rękę - **bo call taki drogi**
- ++i zamiast i++ - **bo oszczędza kopii**
- przesunięcia bitowe zamiast dzielenia/mnożenia/modulo przez stałe potęgi 2
- wyciąganie end() do zmiennej
- używanie **register**
- int& - używanie dziwnych type_traitsów aby używać sygnatur bez referencji dla POD w przypadku szablonów

Kompilator OP

```
int64_t getValue(int n) {
    int64_t result = 0;
    for (int i = 1 ; i <= n ; i++)
            result += i;
    return result;
}
```

```
int main(int argc, char* argv[]) {
    assert(argc == 3);
    int n = atoi(argv[1]);
    int64_t value = strtoll(argv[2], NULL, 10);
    for (int i = 1; i <= n ; i++) {
        if (getValue(i) == value)
            std::cout << i << std::endl;
    }
}
```

./wzor 1000000000 500000000500000000
clang ~ 2s
g++ ~ 32 lata

set vs unordered_set

set vs unordered_set

posortowane dane i pamięć vs szybkość

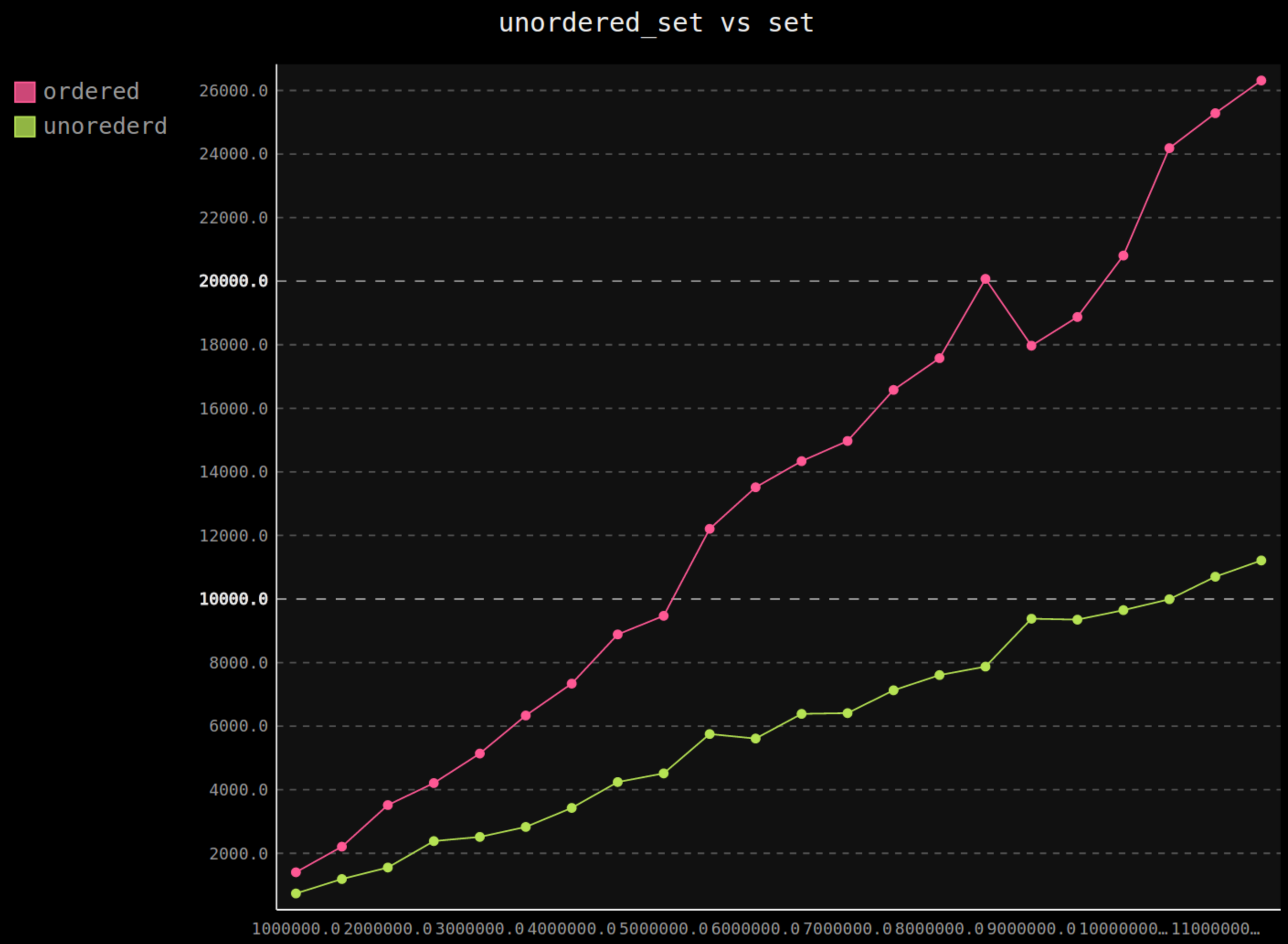
set vs unordered_set

```
int64_t benchSet(int size)
{
    std::set<int64_t> secior;
    for (int i = 0 ; i < size ; i++)
        secior.insert(mt());

    int64_t result = 0;
    for (auto& entry : secior)
        result += entry;
    return result;
}
```

```
random_device rd;
mt19937 mt(rd());
```

set vs unordered_set

```
int64_t benchUnorderedSet(int size) {
    std::unordered_set<int64_t> secior;
    for (int i = 0 ; i < size ; i++)
        secior.insert(mt());

    std::vector <int64_t> v(secior.begin(), secior.end());
    std::sort(v.begin(), v.end());
    int64_t result = 0;
    for (auto& entry : v)
        result += entry;
    return result;
}
```

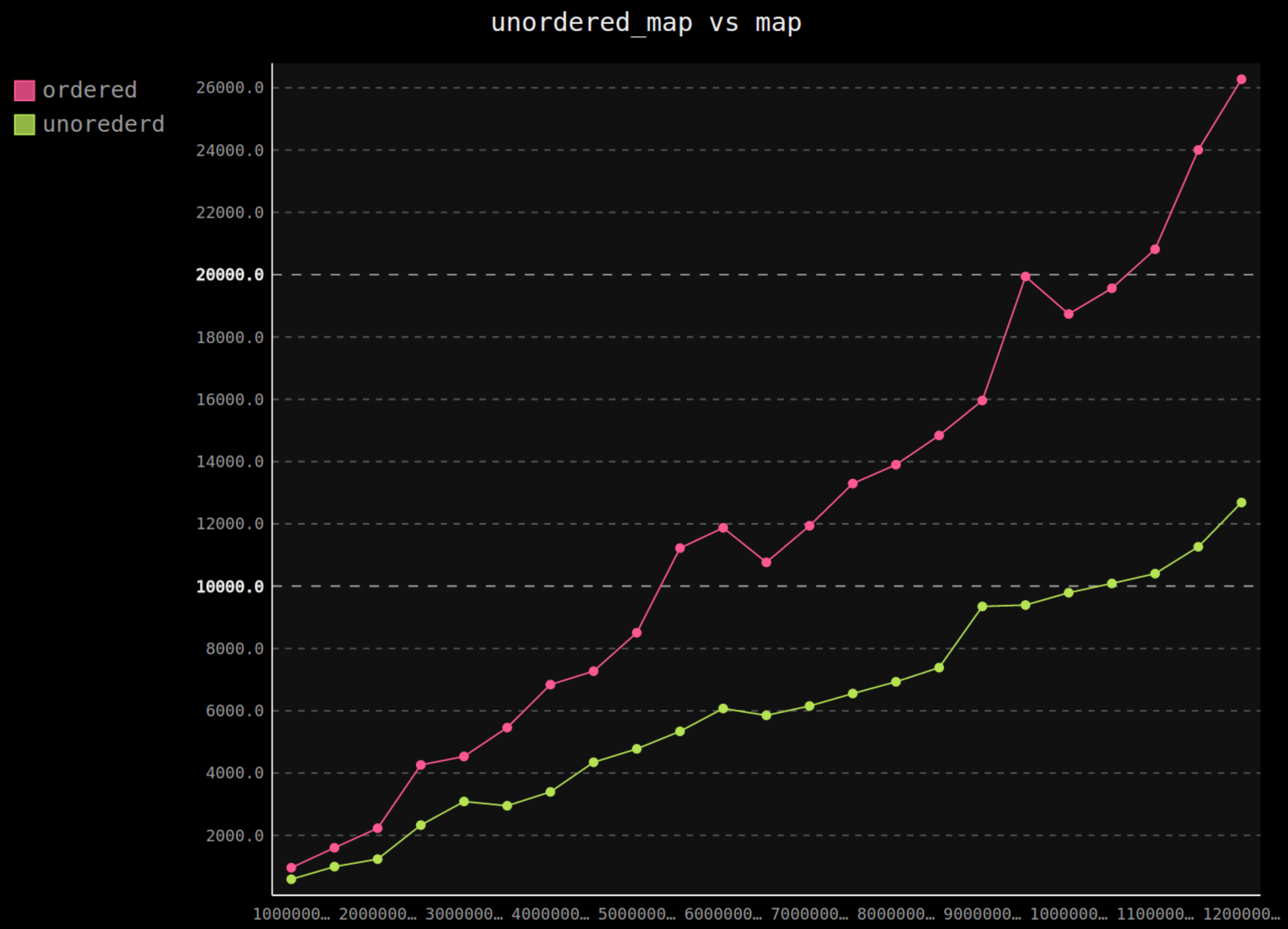

unordered_set vs set
ordered
unorederd
26000.0
24000.0
22000.0
20000.0
18000.0
16000.0
14000.0
12000.0
10000.0
8000.0
6000.0
4000.0
2000.0
1000000.0
2000000.0
3000000.0
4000000.0
5000000.0
6000000.0
7000000.0
8000000.0
9000000.0
10000000…
11000000…

map vs unordered_map

```
int64_t benchMap(int size) {
    std::map<int64_t, int64_t> mapcior;
    for (int i = 0 ; i < size ; i++)
        mapcior[mt()] = i;

    int64_t result = 0;
    for (auto& entry : mapcior)
        result += entry.second;
    return result;
}
```

map vs unordered_map

```
int64_t benchUnorderdMap(int size) {
    std::unordered_map<int64_t, int64_t> mapcior;
    for (int i = 0 ; i < size ; i++)
        mapcior[mt()] = i;

    std::vector <std::pair<int64_t, int64_t> > v(mapcior.begin(), mapcior.end());
    std::sort(v.begin(), v.end());
    int64_t result = 0;
    for (auto& entry : v)
        result += entry.second;
    return result;
}
```

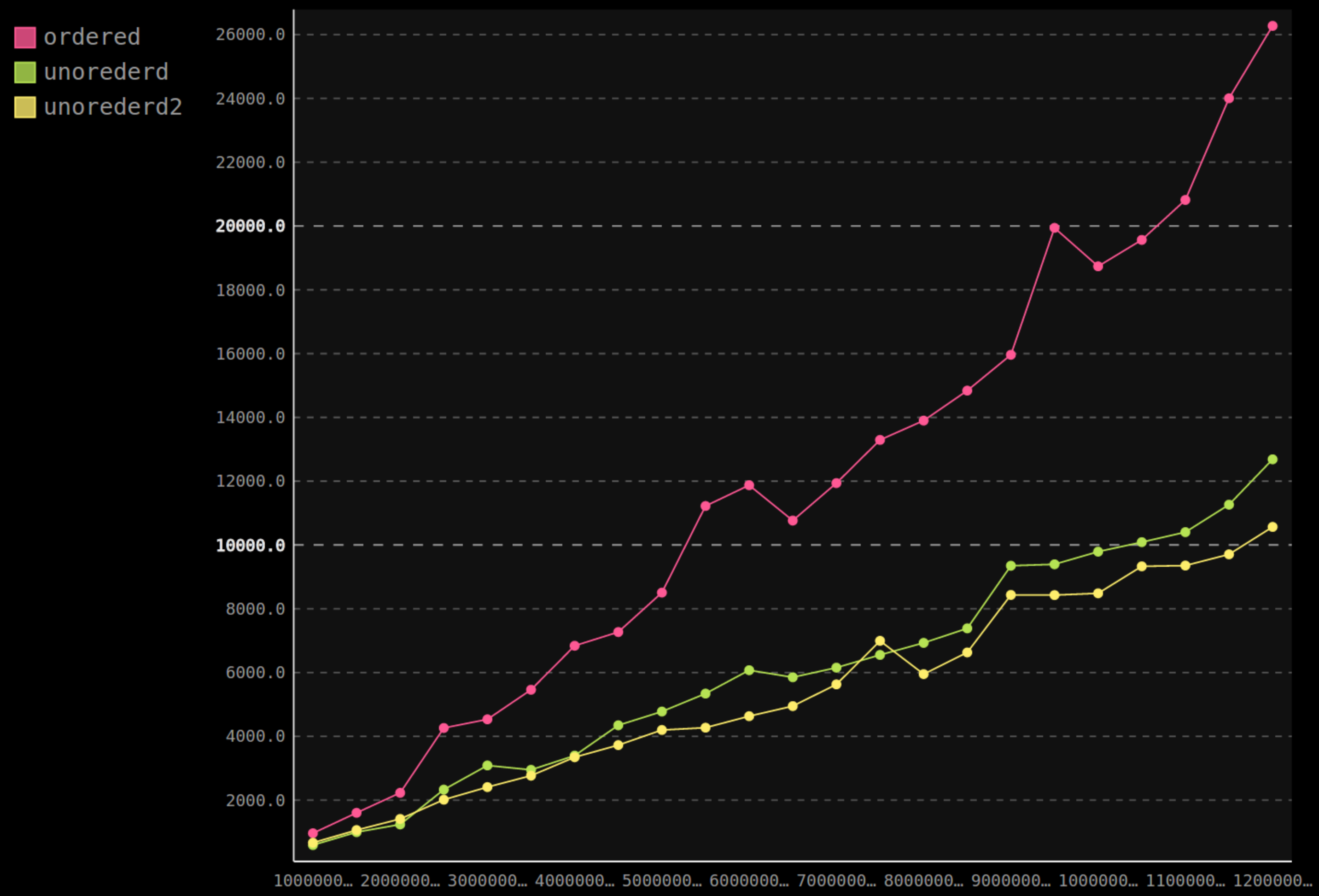


unordered_map vs map
ordered
unorederd
26000.0
24000.0
22000.0
20000.0
18000.0
16000.0
14000.0
12000.0
10000.0
8000.0
6000.0
4000.0
2000.0
1000000…
2000000…
3000000…
4000000…
5000000…
6000000…
7000000…
8000000…
9000000…
1000000…
1100000…
1200000…

map vs unordered_map

```
int64_t benchUnorderdMap(int size) {
    std::unordered_map<int64_t, int64_t> mapcior;
    for (int i = 0 ; i < size ; i++)
        mapcior[mt()] = i;

    std::vector <int64_t> v;
    v.reserve(mapcior.size());
    for (auto& entry : mapcior)
        v.push_back(entry.second);

    std::sort(v.begin(), v.end());
    int64_t result = 0;
    for (int64_t value : v)
        result += value;
    return result;
}
```

unordered_map vs map



powrót do kopii

Potyczki algorytmiczne 2014

zadanie Fiolki

```
template <typename SetType>
struct ListJoinSets
{
    ListJoinSets(const vector<set<SetType> >& sets)
        : sets_(sets) { ... }

private:
    ...
    vector<set<SetType> >sets_;
};
```

```
template <typename SetElementType>
struct ListJoinSets
{
    ListJoinSets(vector<set<SetType> >& sets)
        : sets_(sets)
    ...
private:
    ...
    vector<set<SetElementType> >   &sets_;
};
```

powrót do kopii

Potyczki algorytmiczne 2014

zadanie Fiolki

Rezultat

10/10 pkt **vs** **8/10 pkt**

Ale te referencje są wolne!

Copy vs Ref vs Move

```
template <typename Container>
int benchHelper(const Container& container, int64_t reads) { // (Container container, ..) w ver 2
    random_device rd;
    mt19937 mt(rd());
    int value = 0;
    while (reads > 0) {
        for (const auto& val: container) {
            if (get(val) <= mt())
                value++;
            reads--;
        }
    }
    return value;
}
```

```
int64_t get(int64_t val) { return val; }

template <typename T>
int64_t get(const T& t) { return t.second; }
```

Copy vs Ref vs Move

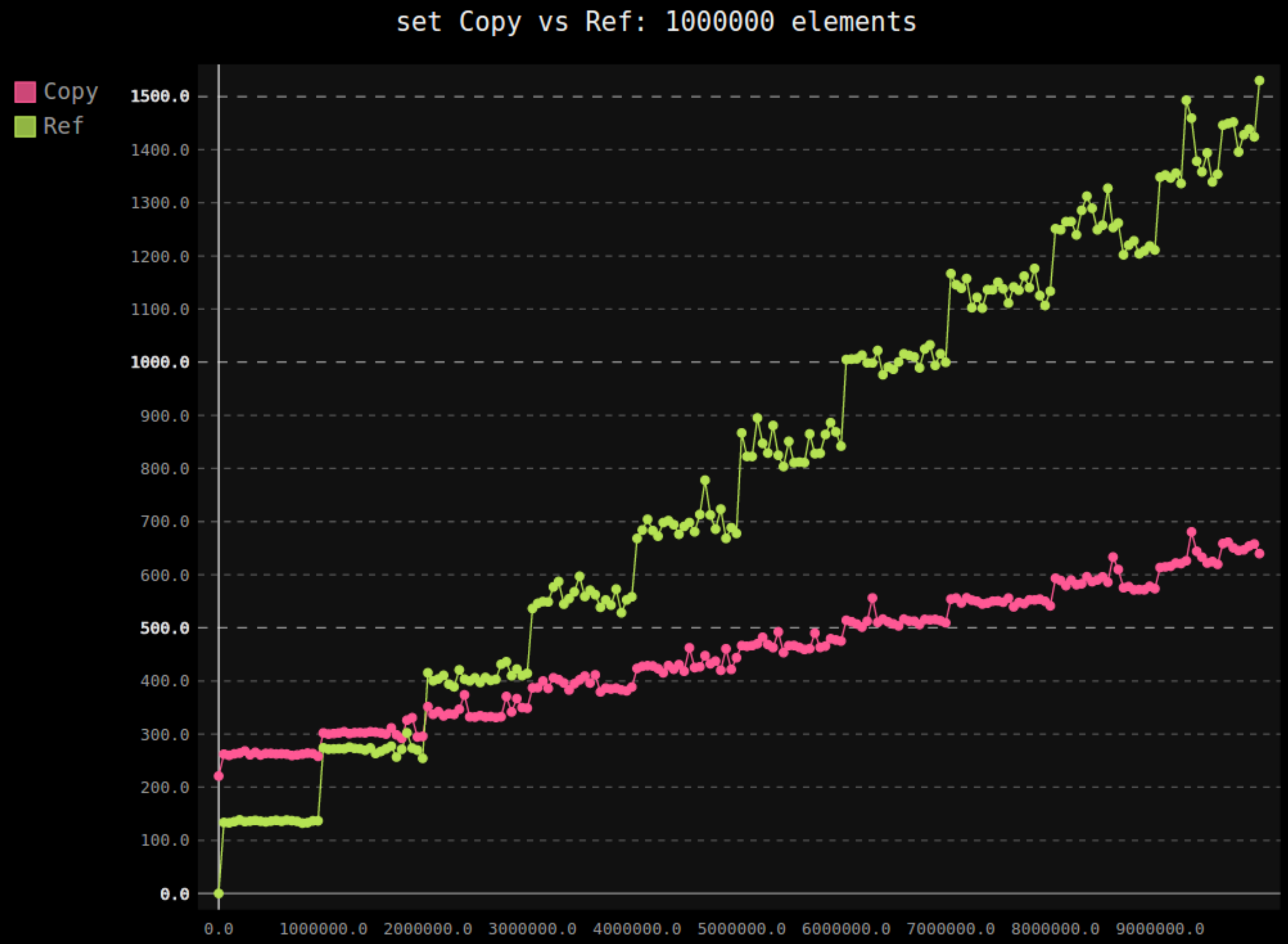
```
int bench(const set<int64_t> &secior, int64_t reads) {
    return benchHelper(secior, reads);
}
int bench(const unordered_set<int64_t> &secior, int64_t reads) {
    return benchHelper(secior, reads);
}
```

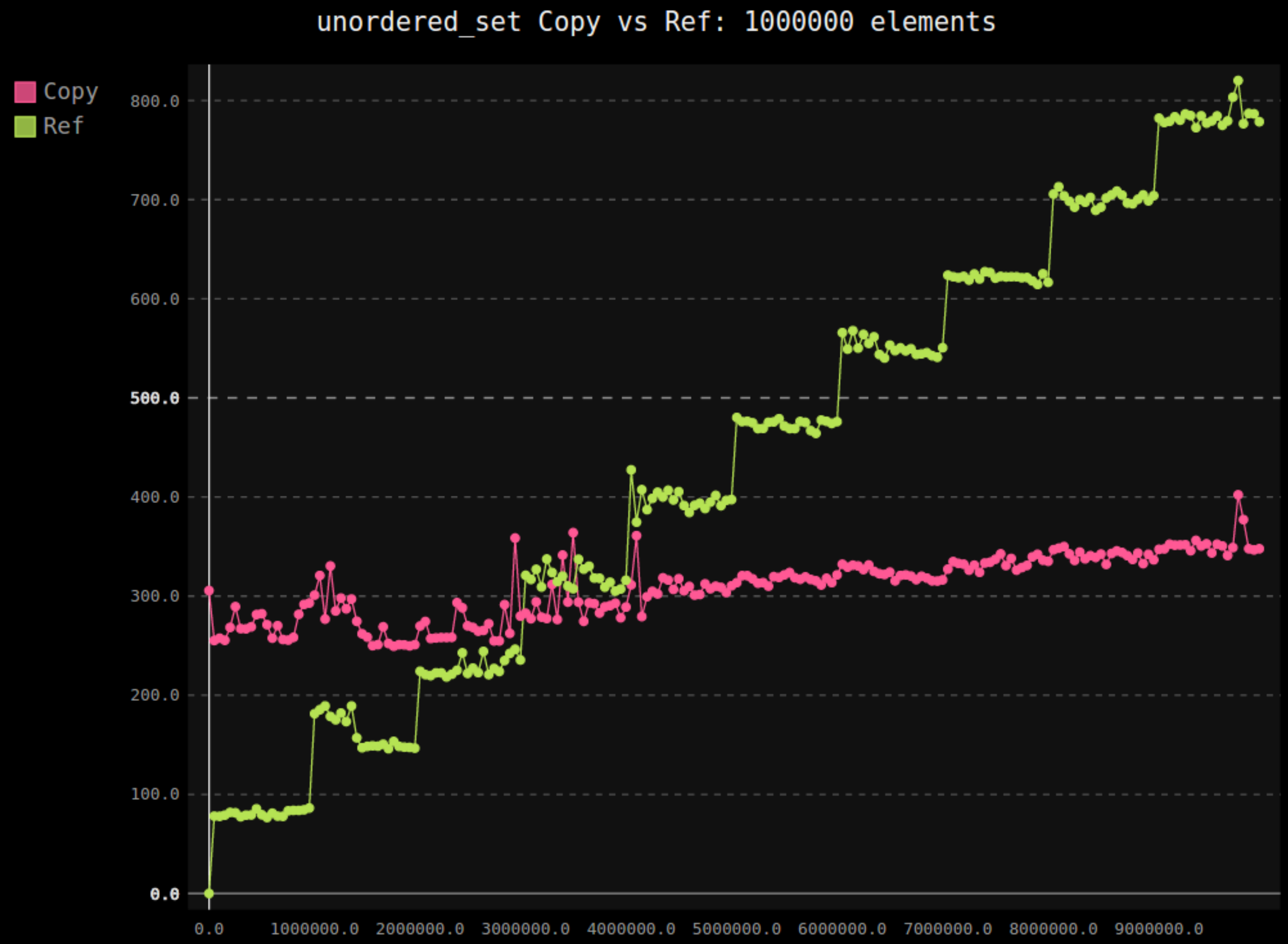
vs

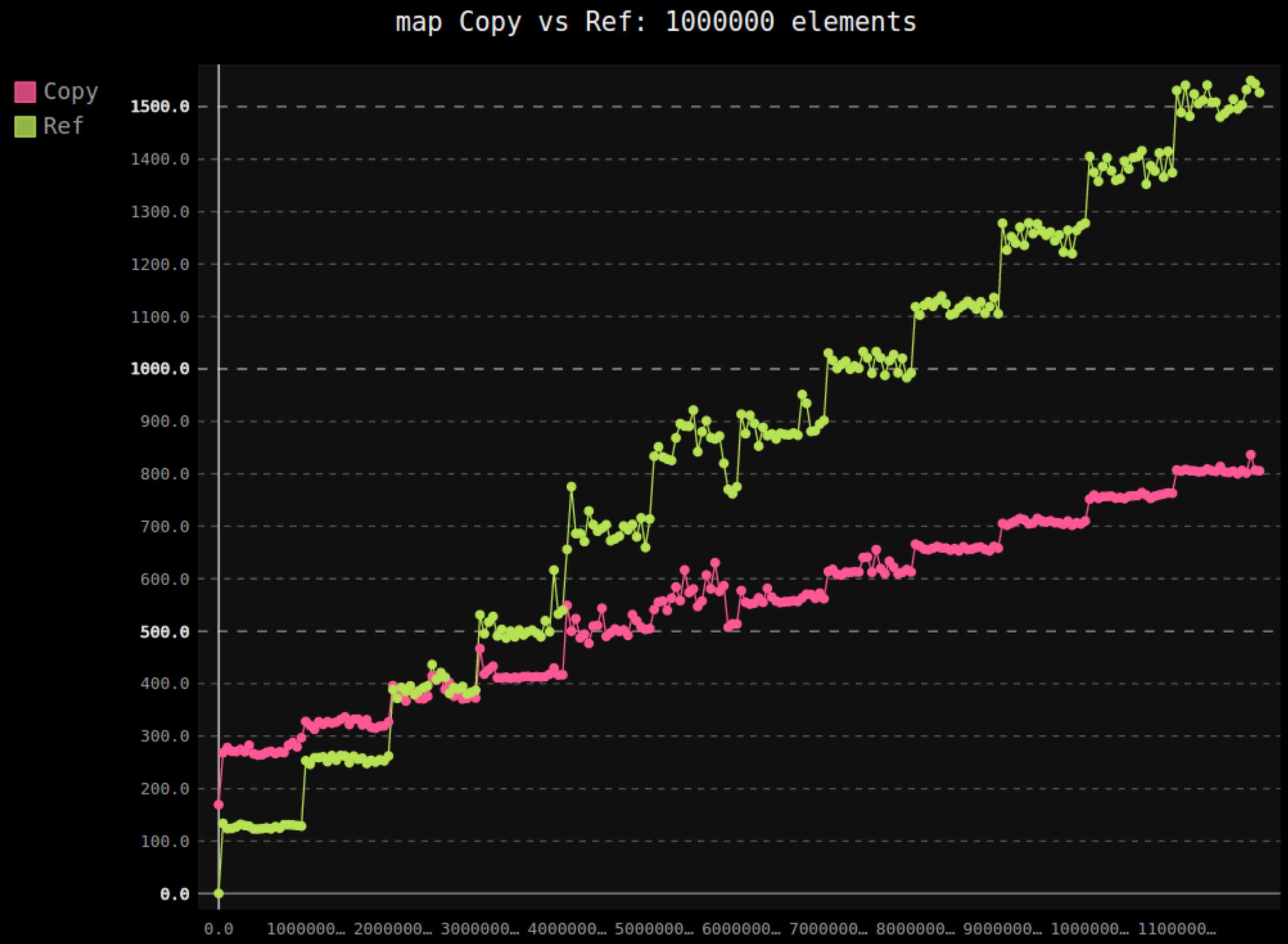
```
int bench(std::set<int64_t> secior, int64_t reads) {
    return benchHelper(move(secior), reads);
}
int bench(std::unordered_set<int64_t> secior, int64_t reads) {
    return benchHelper(move(secior), reads);
}
```

Copy vs Ref vs Move

```
template <typename Container>
void benchSet(int size, int readsCount) {
    Container secior;
    for (int i = 0 ; i < size ; i++)
        secior.insert(mt());

    auto now = system_clock::now();
    bench(secior, readsCount);
    auto duration = chrono::duration_cast<chrono::milliseconds>(
                                          system_clock::now() - now).count();
    cout << duration << endl;
}
```

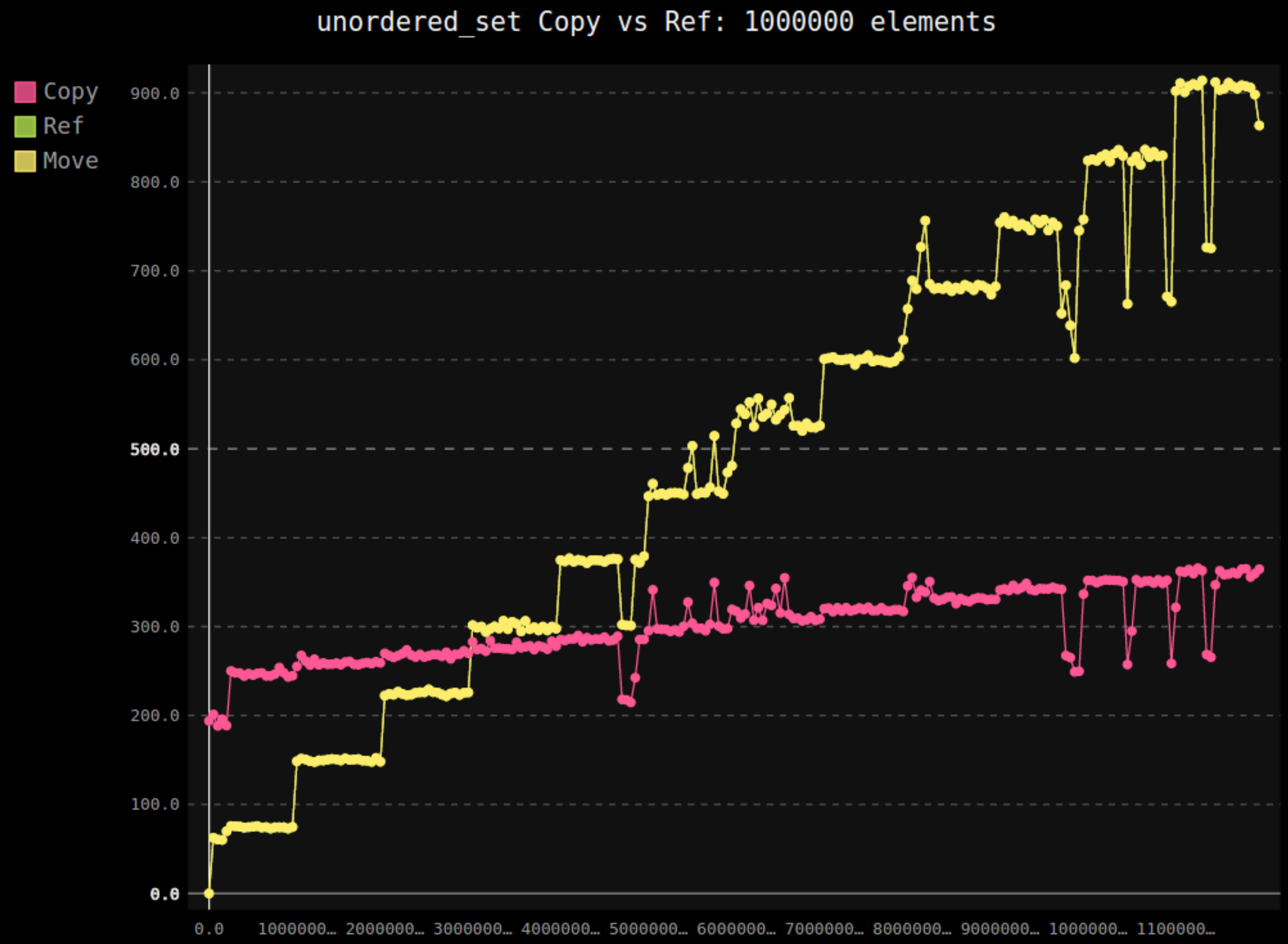

set Copy vs Ref: 1000000 elements
Copy
Ref
1500.0
1400.0
1300.0
1200.0
1100.0
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
1000000.0
2000000.0
3000000.0
4000000.0
5000000.0
6000000.0
7000000.0
8000000.0
9000000.0


unordered_set Copy vs Ref: 1000000 elements
Copy
Ref
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
1000000.0
2000000.0
3000000.0
4000000.0
5000000.0
6000000.0
7000000.0
8000000.0
9000000.0

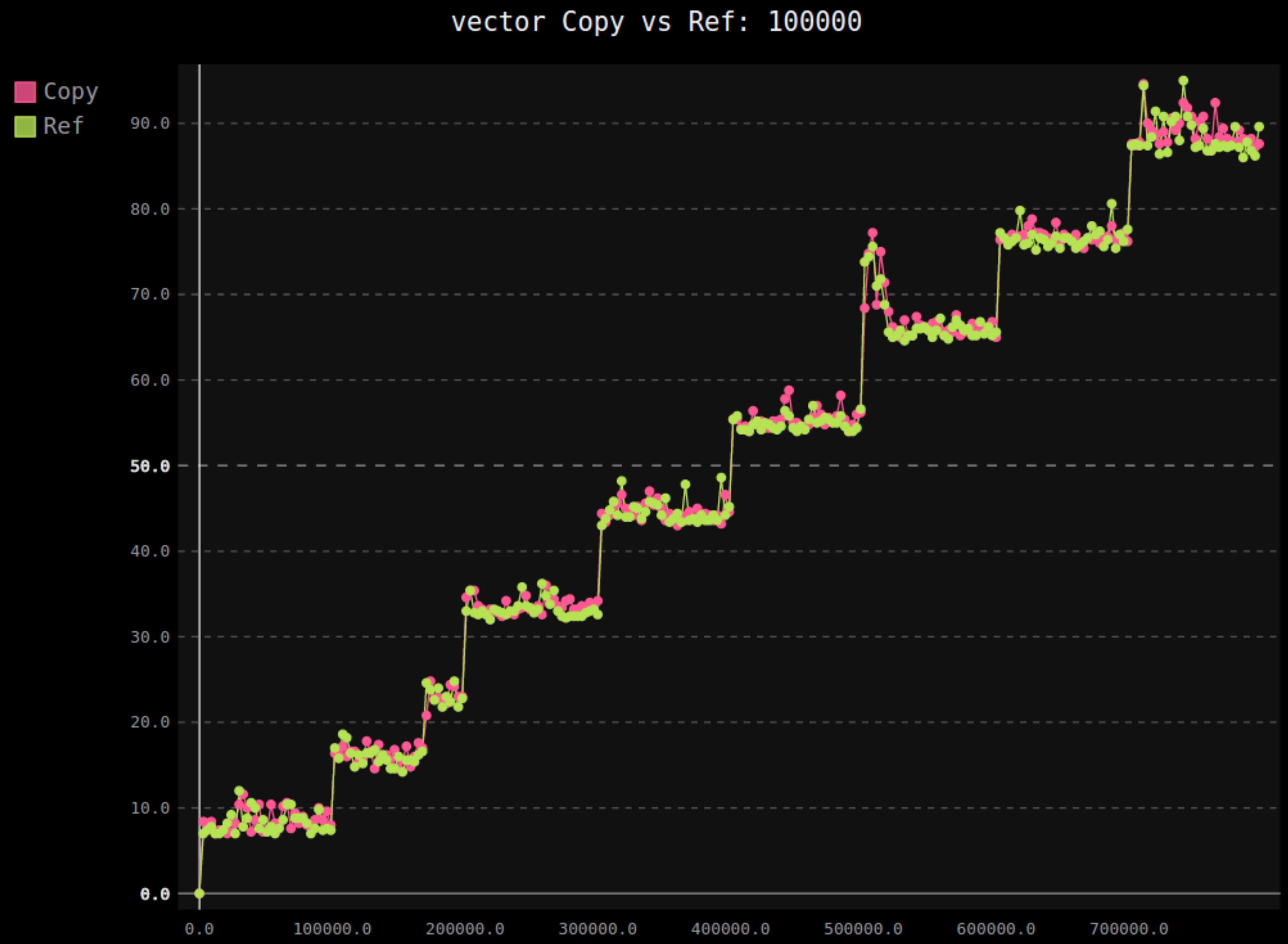

map Copy vs Ref: 1000000 elements
Copy
Ref
1500.0
1400.0
1300.0
1200.0
1100.0
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
1000000…
2000000…
3000000…
4000000…
5000000…
6000000…
7000000…
8000000…
9000000…
1000000…
1100000…

Copy vs Ref vs Move

Co się stanie jeśli przeniesiemy obiekt?



unordered_set Copy vs Ref: 1000000 elements
Copy
Ref
Move
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
1000000…
2000000…
3000000…
4000000…
5000000…
6000000…
7000000…
8000000…
9000000…
1000000…
1100000…



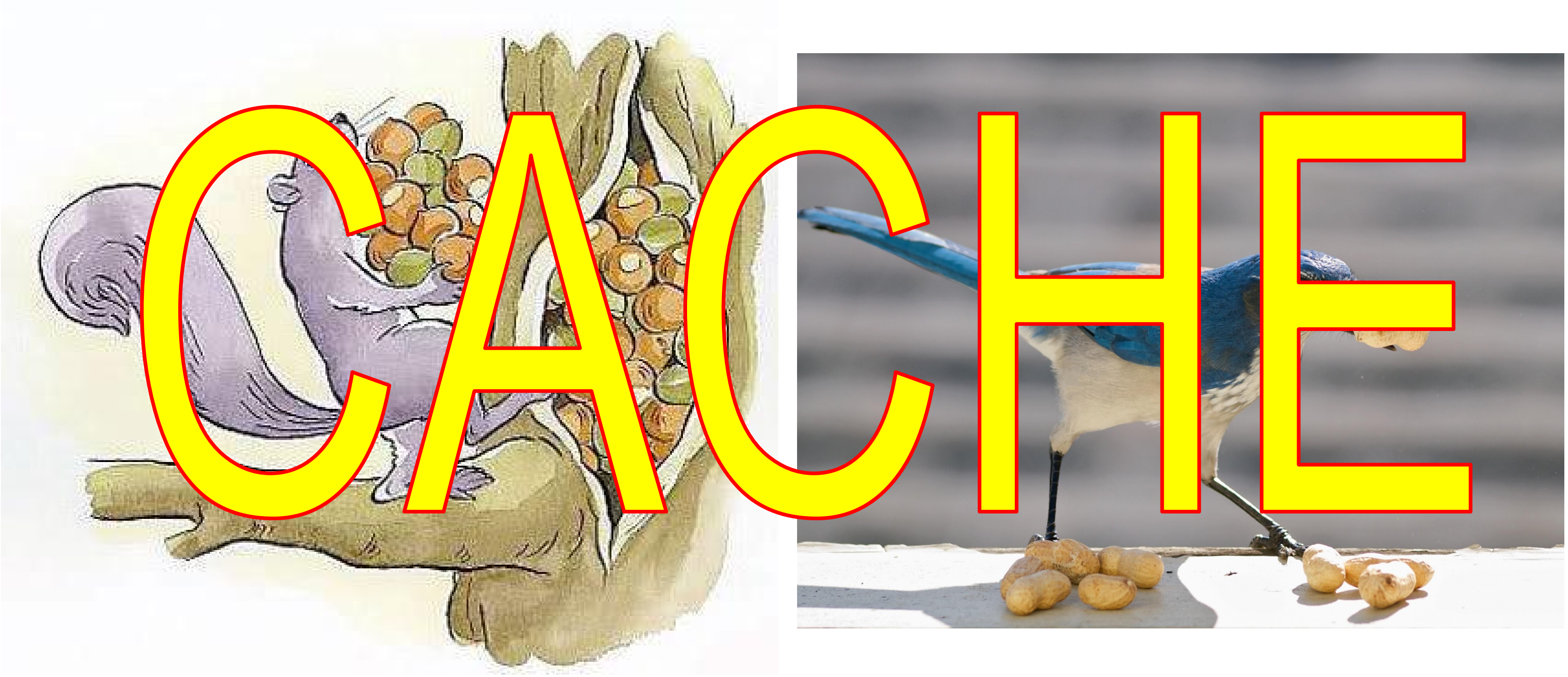
vector Copy vs Ref: 100000
Copy
Ref
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0.0
100000.0
200000.0
300000.0
400000.0
500000.0
600000.0
700000.0

Copy vs Ref vs Move

Ale te referencje są wolne!

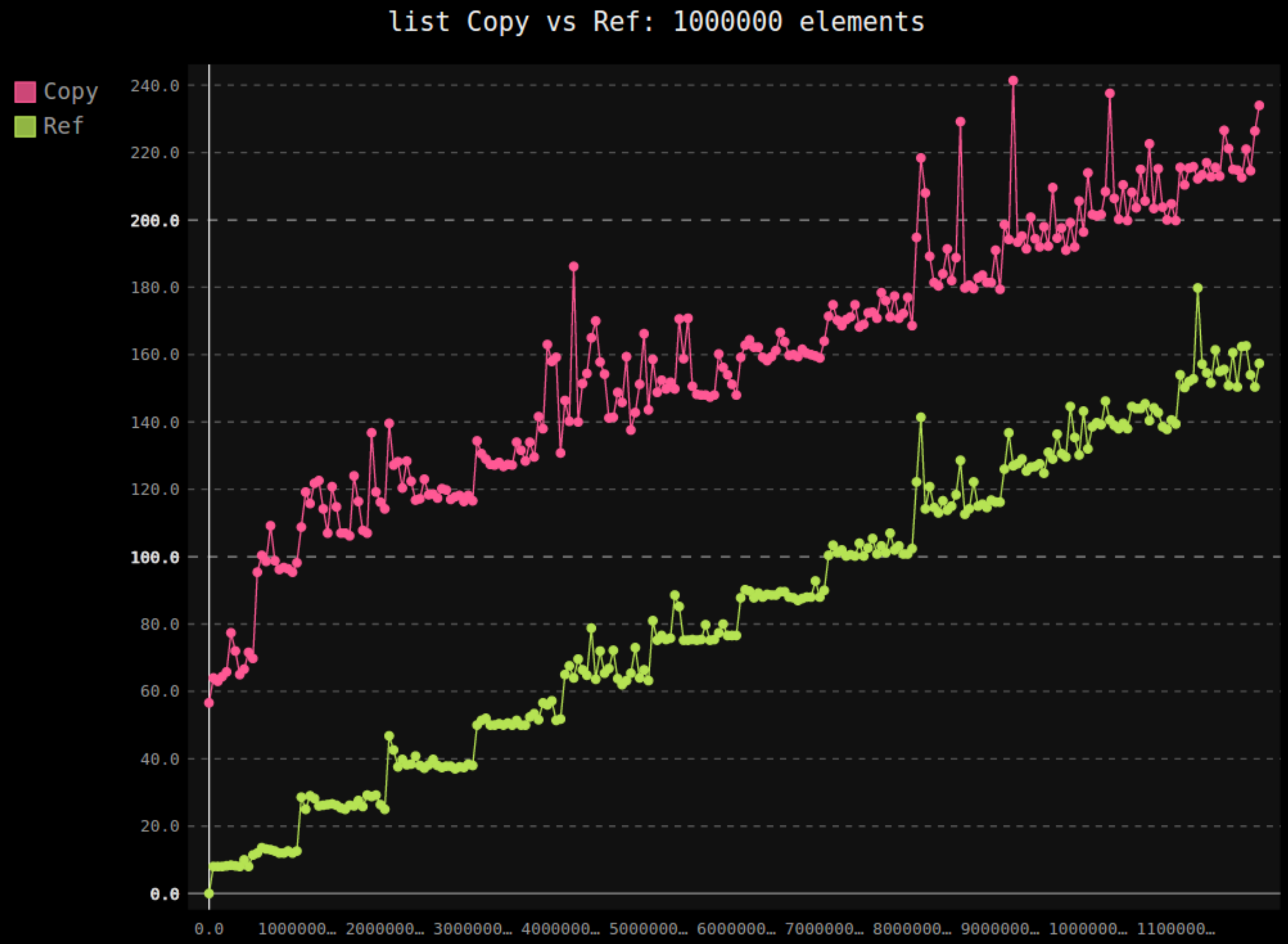
Wniosek: jakaś magia dzieje się podczas kopiowania

hint:



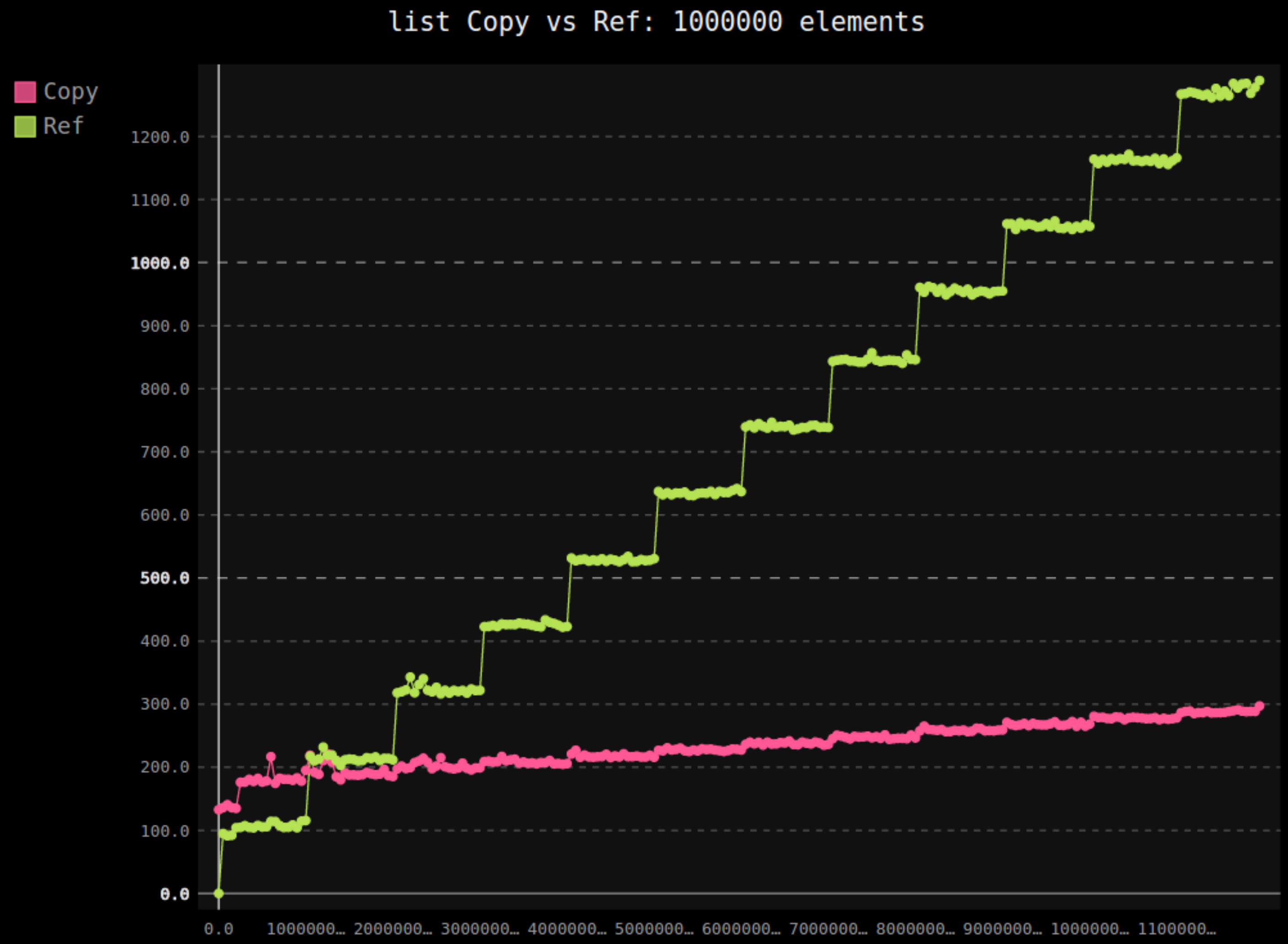
Copy vs Ref vs Move

```
void benchList(int size, int64_t readsCount) {
    list<int64_t> liscior;
    for (int i = 0 ; i < size ; i++)
        if (i % 2)
            liscior.push_back(mt());
        else
            liscior.push_front(mt());

    auto now = system_clock::now();
    bench(liscior, readsCount);
    auto duration = chrono::duration_cast<chrono::milliseconds>(
                                system_clock::now() - now).count();
    cout << duration << endl;
}
```


list Copy vs Ref: 1000000 elements
Copy
Ref
240.0
220.0
200.0
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
0.0
1000000…
2000000…
3000000…
4000000…
5000000…
6000000…
7000000…
8000000…
9000000…
1000000…
1100000…

Copy vs Ref vs Move

```
void benchList(int size, int64_t readsCount) {
    list<int64_t> liscior;
    for (int i = 0 ; i < size ; i++)
        if (i % 2)
            liscior.push_back(mt());
        else
            liscior.push_front(mt());
    liscior.sort();
    auto now = system_clock::now();
    bench(liscior, readsCount);
    auto duration = chrono::duration_cast<chrono::milliseconds>(
                                system_clock::now() - now).count();
    cout << duration << endl;
}
```


list Copy vs Ref: 1000000 elements
Copy
Ref
1200.0
1100.0
1000.0
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
0.0
1000000…
2000000…
3000000…
4000000…
5000000…
6000000…
7000000…
8000000…
9000000…
1000000…
1100000…

Copy vs Ref vs Move

```
void benchList(int size, int64_t readsCount) {
    list<int64_t> liscior;
    for (int i = 0 ; i < size ; i++)
        if (i % 2)
            liscior.push_back(mt());
        else
            liscior.push_front(mt());
    liscior.sort(); // random_shuffle of memory
    auto now = system_clock::now();
    bench(liscior, readsCount);
    auto duration = chrono::duration_cast<chrono::milliseconds>(
                                system_clock::now() - now).count();
    cout << duration << endl;
}
```

Copy vs Ref vs Move

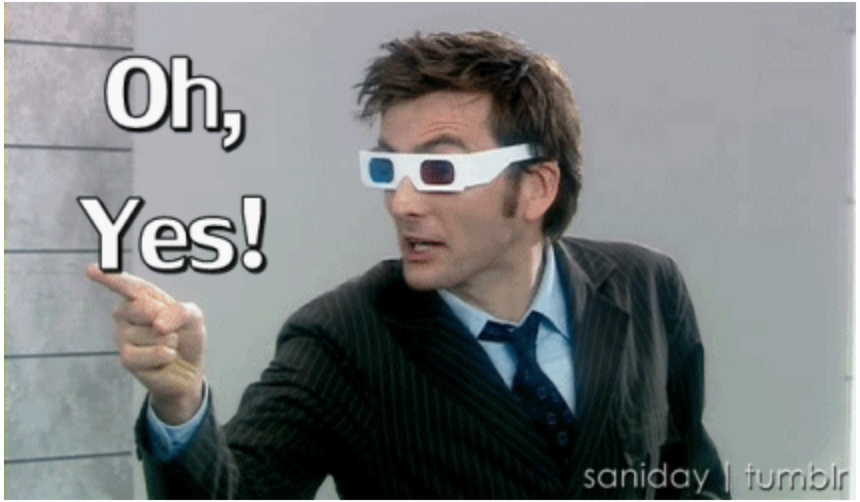
Skopiowanie całego kontenera defragmentuje pamięć.

Obiekty na które wskazują bliskie sobie wskaźniki układają się blisko siebie.

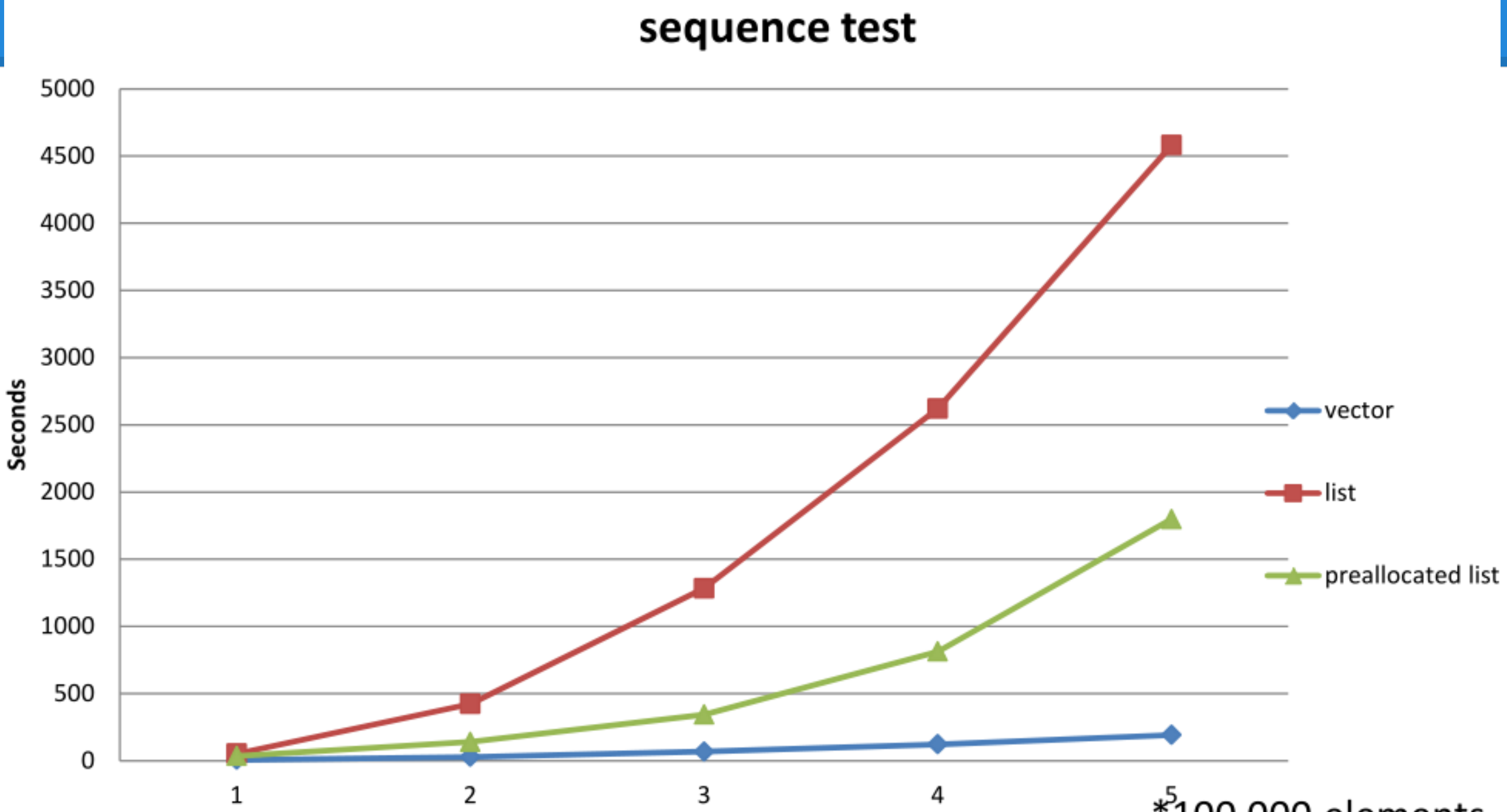
less cache misses, performance boost

powrót do kopii

Czy istnieje taki case gdzie optymalniej jest kopiować niż przenosić lub brać przez referencję?



Vector vs. List



*100,000 elements

Vector as default

Używaj wektora kiedy potrzebujesz:

- Sekwencji danych bez określonej kolejności
- “statycznego seta/mapy” - write, sort, find
- małej mapy ze wszystkimi operacjami
- tablicy asocjacyjnej indeksowanej numerycznie z zakresu [0, 10^7]

```cpp
template <typename T>
class AutoStretchingVector : public std::vector<T> {
    typedef std::vector<T>  Self;
public:
    using typename Self::value_type;
    using typename Self::reference;
    using typename Self::const_reference;
    using typename Self::size_type;
    using typename Self::iterator;
    using typename Self::const_iterator;

    using Self::Self;

    reference get(size_type index)
    {
        if (Self::size() <= index)
            Self::resize(index + 1);
        return Self::operator[](index);
        assertYouDidntBreakIt_(); //have to call it to be instantiated
    }
private:
    static void assertYouDidntBreakIt_();
};
```

```cpp
template <typename T>
inline void AutoStretchingVector<T>::
assertYouDidntBreakIt_()
{
    static_assert(sizeof(std::vector<T>) ==
                        sizeof(AutoStretchingVector<T>),
                    "Don't add any data to this class!");
}

AutoStretchingVector<
            AutoStretchingVector<
                AutoStretchingVector <int>
            > > matrix;

matrix.get(i).get(j).get(k) = 42;

get(get(get(matrix, i), j), k) = 42; // function instead of method
```

Dziękuję za uwagę!

źródła

http://thbecker.net/articles/rvalue_references/section_08.html

http://isocpp.org/wiki/faq/ctors#return-by-value-optimization

http://aristeia.com/EC++11-14/noexcept%202014-03-31.pdf

http://stackoverflow.com/questions/20517259/why-vector-access-operators-are-not-specified-as-noexcept

http://channel9.msdn.com/Events/GoingNative/GoingNative-2012/Keynote-Bjarne-Stroustrup-Cpp11-Style

Effective Modern c++ - Scott Meyers