Algorithm & Container

IN MODERN C++

Containers

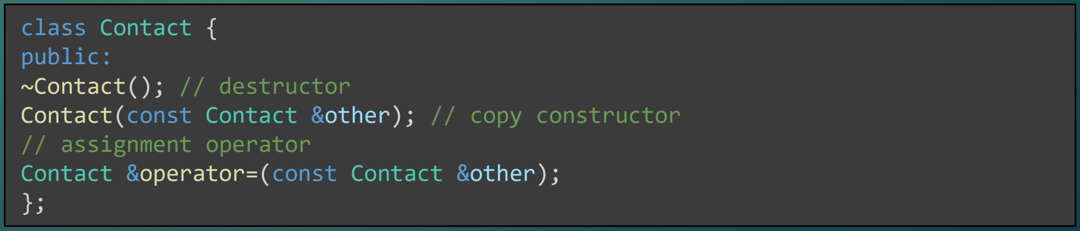
- General pourpose template based data structure
- Organize data following different criteria
- Almost always equally or more efficent than user written structure
- Almost always safer than user written structure
- Safe By Design

Type of containers

- vector memory managed unordered array of data
- map key-value based container. Higher insert operation time but lower data finding time respect to vector or list.
- list collection of non-contigous memory data.
- set holder of unique objects.
- array std version of the standard array.

Storing classes in containers

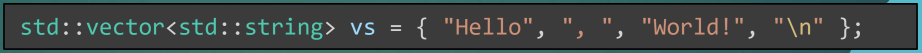
- *Class must be CopyAssignable and CopyConstructible:*
  - *If copy constructor or assignment operator is not provided C++ will provide one (uses member copying*
- *If no constructors provided*
  - *Empty default constructor provided by C++*
- *Keys in associative(e.g. std::map) also need to be comparable*
  - *Provide an operator< overload*
  - *Or provide a comparison function as template parameter*



```
class Contact {
public:
~Contact(); // destructor
Contact(const Contact &other); // copy constructor
// assignment operator
Contact &operator=(const Contact &other);
};
```

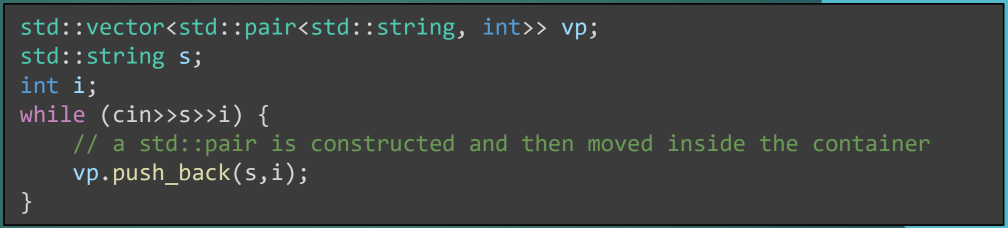
Changes since c++ 98

- *Initializer lists*



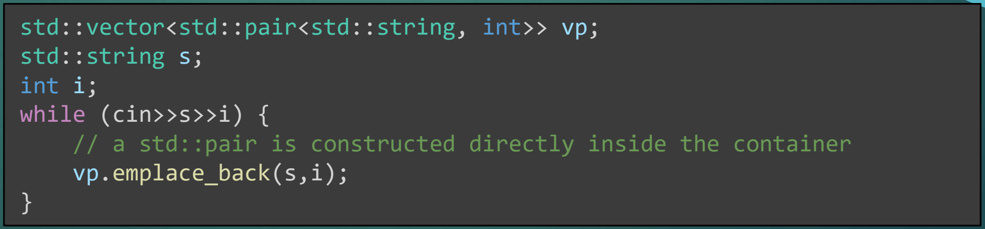
```
std::vector<std::string> vs = { "Hello", ", ", "World!", "\n" };
```

- *Rvalue push_back*



```
std::vector<std::pair<std::string, int>> vp;
std::string s;
int i;
while (cin>>s>>i) {
    // a std::pair is constructed and then moved inside the container
    vp.push_back(s,i);
}
```

- *emplace_back*

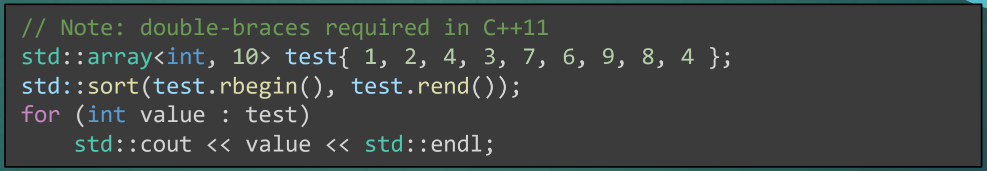


```
std::vector<std::pair<std::string, int>> vp;
std::string s;
int i;
while (cin>>s>>i) {
    // a std::pair is constructed directly inside the container
    vp.emplace_back(s,i);
}
```

- *Unordered associative container(O(1) lookup, insertion and removal)*

Std::array

- Standard container API, usable in algorithms
- Wrapper around C-style arrays
  - Constant size Data
  - Has automatic storage, no dynamic allocation



```
// Note: double-braces required in C++11
std::array<int, 10> test{ 1, 2, 4, 3, 7, 6, 9, 8, 4 };
std::sort(test.rbegin(), test.rend());
for (int value : test)
    std::cout << value << std::endl;
```

Modernization example

```cpp
std::vector<std::string> v;
v.push_back("one");
v.push_back("two");
v.push_back("three");
std::string item1 = v[1]; // "two"
for (int i = 0; i < v.size(); i++)
{
    std::string &item = v.at(i);
    item += "_suffix";
}
item1 = v[1]; // "two_suffix"
```

```cpp
std::vector<std::string> v = {"one", "two", "three"};
auto item1 = v[1]; // "two"
for (auto& item : v) {
    item += "_suffix";
}
item1 = v[1]; // "two_suffix"
```

Algorithm

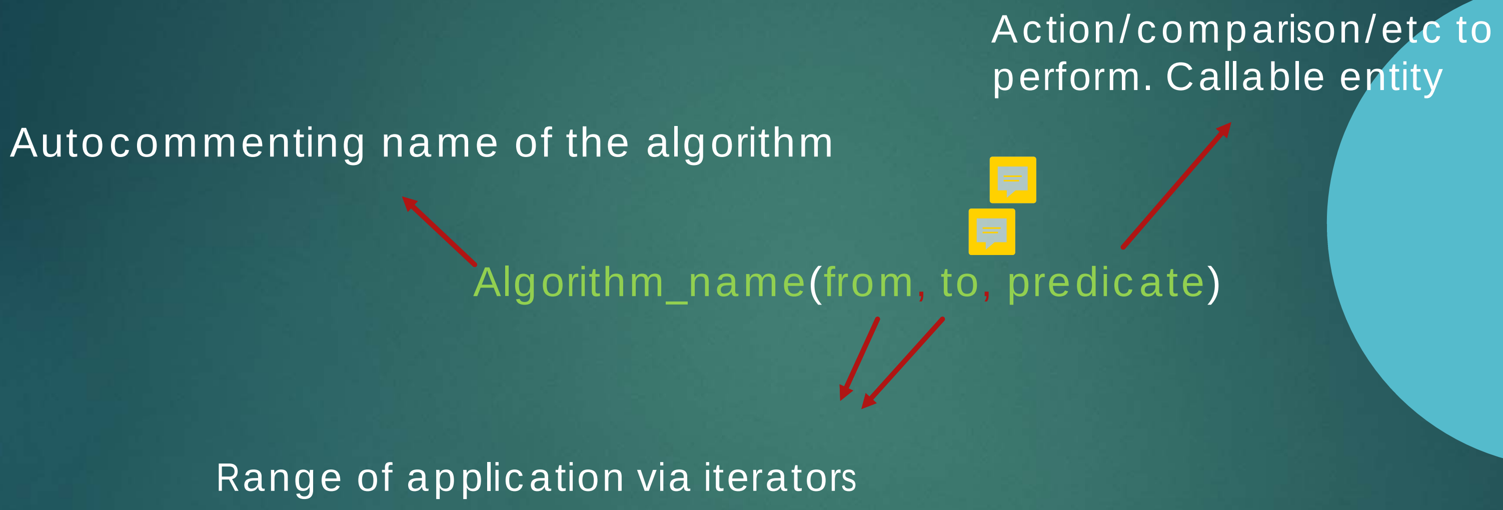
Don’t do things your way if there is an algorithm that do them

do not reinvent the wheel

Advantage

- Algorithm are out of the box safe by design operation that can be applied on containers.
- Self commenting code
- Error free, can be excluded in debugging session

Basic structure



Action/comparison/etc to perform. Callable entity

Autocommenting name of the algorithm

```
Algorithm_name(from, to, predicate)
```

Range of application via iterators

Common algorithm

all_of/none_of

any_of

for_each

find/find_if/find_if_not/find_first_of

count/count_if

copy/copy_if

swap

remove/remove_if

replace/replace_if

generate

transform

unique

…

Check it out:

https://en.cppreference.com/w/cpp/algorithm

Example 1

```
std::vector<int> collection = {3, 6, 12, 6, 9, 12};

// Are all numbers divisible by 3?
bool divby3 = std::all_of(begin(collection), end(collection), [](int x) { return x % 3 == 0; });
// divby3 equals true, because all numbers are divisible by 3

// Is any number divisible by 2?
bool divby2 = std::any_of(begin(collection), end(collection), [](int x) { return x % 2 == 0; });
// divby2 equals true because 6, 12 divisible by 2

// Is no number divisible by 6?
bool divby6 = std::none_of(begin(collection), end(collection), [](int x) { return x % 6 == 0; });
// divby6 equals false because 6, 12 divisible by 6
```

Example 2

```
// C++98
std::vector<int> collection;
collection.push_back(2); collection.push_back(4); collection.push_back(4);
collection.push_back(1); collection.push_back(1); collection.push_back(3);
for(int i = 0; i<collection.size(); i++) {
    collection[i] += 26;
}
```

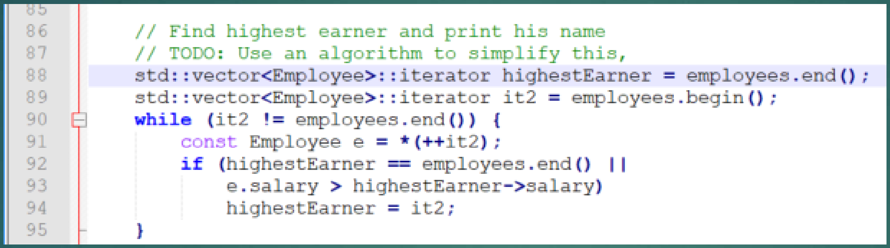
```
// C++11
std::vector<int> collection = {2,4,4,1,1,3};
for(auto& el:collection) {
    el +=26;
}
```

```
// C++11, using algorithm
std::vector<int> collection = {2,4,4,1,1,3,9};
std::for_each(begin(collection), end(collection), [] (int &x){x += 26;});
```

Example 3

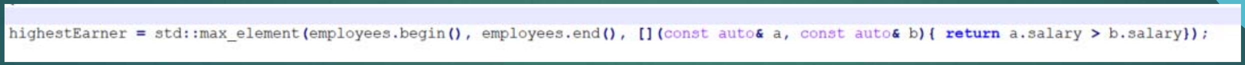
Find max element

C++98



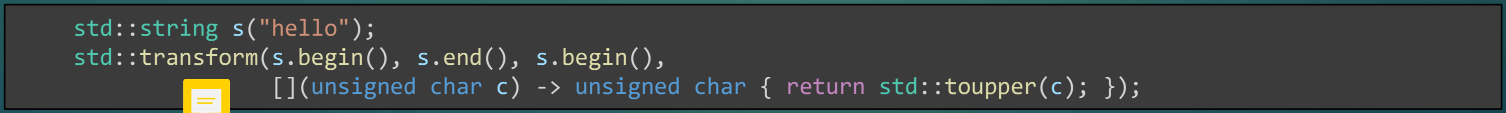
```cpp
// Find highest earner and print his name
// TODO: Use an algorithm to simplify this,
std::vector<Employee>::iterator highestEarner = employees.end();
std::vector<Employee>::iterator it2 = employees.begin();
while (it2 != employees.end()) {
    const Employee e = *(++it2);
    if (highestEarner == employees.end() ||
        e.salary > highestEarner->salary)
        highestEarner = it2;
}
```

C++11



```cpp
highestEarner = std::max_element(employees.begin(), employees.end(), [](const auto& a, const auto& b){ return a.salary > b.salary});
```

Transform



```cpp
std::string s("hello");
std::transform(s.begin(), s.end(), s.begin(),
               [](unsigned char c) -> unsigned char { return std::toupper(c); });
```

Conclusion

Do you think you need a for loop to do stuff in a container?

Think again.

Use an algorithm