Tutorial 3

Praktikum Pemrograman Berbasis Objek

Asisten IF2210 2022/2023

Outline

1. Generic Function
2. Generic Class
3. Exception
4. C++ Standard Template Library

1. Generic Function

Generic Function

- **Generic Function** adalah fungsi yang **dapat dibuat dari template**, sehingga dapat membuat suatu **algoritma generik** yang dapat bekerja untuk **tipe data / nilai apapun sesuai konstrain**.

Tujuan Generic Function / Class

- Tidak perlu mendefinisikan hal yang sama berkali-kali
- Keep your code DRY
- Abstraksi

Contoh Fungsi: maxElmt (Tanpa Generic)

```
int maxElmt(int* arr, int N)
// mengembalikan elemen terbesar pada array
// Array arr memiliki elemen sebanyak N
// Diasumsikan N > 0
{
    int max_result = arr[0];
    for (int i = 1; i < N; i++) {
        if (arr[i] > max_result) {
            max_result = arr[i];
        }
    }
    return max_result;
}
```

Contoh Fungsi: maxElmt (Generic)

```
template<class T>
T maxElmt(T* arr, int N)
// mengembalikan elemen terbesar pada array
// Array arr memiliki elemen sebanyak N
// Diasumsikan N > 0
{
    T max_result = arr[0];
    for (int i = 1; i < N; i++) {
        if (arr[i] > max) {
            max_result = arr[i];
        }
    }
    return max_result;
}
```

2. Generic Class

Generic Class

- **Generic Class** adalah kelas yang dapat didefinisikan dari **sebuah template**, sehingga **tidak perlu** membuat ulang implementasi kelas yang sama untuk **tipe data / nilai yang berbeda**.

Generic Class Example: Vector2

- Vector ini adalah representasi dari vektor yang sudah dipelajari di fisika maupun matematika.
- Catatan: bedakan dengan STL vector milik C++ yang pada dasarnya merupakan array dinamis

Definisi Vector2 (Kelas tanpa Generic)

```cpp
class Vector2 {
private:
    int* elements;

public:
    Vector2() {
        this->elements = new int[2];
        this->elements[0] = 0;
        this->elements[1] = 0;
    }

    Vector2(const Vector2& other) {
        this->elements = new int[2];
        this->elements[0] = other.elements[0];
        this->elements[1] = other.elements[1];
    }

    ~Vector2() {
        delete[] this->elements;
    }
```

```cpp
int& operator[](int idx) {
    return this->elements[idx];      Yonas Adiel, 2 years
}

Vector2 operator+(const Vector2& other) {
    Vector2 result;
    result.elements[0] = elements[0] + other.elements[0];
    result.elements[1] = elements[1] + other.elements[1];
    return result;
}

Vector2 operator-(const Vector2& other) {
    Vector2 result;
    result.elements[0] = elements[0] - other.elements[0];
    result.elements[1] = elements[1] - other.elements[1];
    return result;
}
```

Definisi Vector2 (Kelas tanpa Generic)

```cpp
bool operator<(const Vector2& other) {
    if (elements[0] != other.elements[0]) {
        return elements[0] < other.elements[0];
    }
    return elements[1] < other.elements[1];
}

bool operator>(const Vector2& other) {
    if (elements[0] != other.elements[0]) {
        return elements[0] > other.elements[0];
    }
    return elements[1] > other.elements[1];
}
```

```cpp
friend std::ostream& operator<<(ostream& os, Vector2 vector) {
    os << "<";
    os << vector.elements[0];
    os << ",";
    os << vector.elements[1];
    os << ">";
    return os;
}

friend std::istream& operator>>(istream& is, Vector2& vector) {
    return is >> vector.elements[0] >> vector.elements[1];
}
```

Generic Class Example: Vector2

- Terdapat 2 kekurangan dari vector ini:
  - Elemen vector harus berupa integer
  - Vector hanya memiliki panjang 2
- Kabar baiknya, dua kekurangan ini dapat diselesaikan dengan membuat generic class dari Vector!

Definisi Vector Generic (Vector di ruang N)

```cpp
class Vector2 {
private:
    int* elements;

public:
    Vector2() {
        this->elements = new int[2];
        this->elements[0] = 0;
        this->elements[1] = 0;
    }

    Vector2(const Vector2& other) {
        this->elements = new int[2];
        this->elements[0] = other.elements[0];
        this->elements[1] = other.elements[1];
    }

    ~Vector2() {
        delete[] this->elements;
    }
```

Sebelum

```cpp
template<class T, int N>
class Vector {
private:
    T* elements;

public:
    Vector() {
        this->elements = new T[N];
    }

    Vector(const Vector<T, N>& other) {
        this->elements = new T[N];
        for (int i = 0; i < N; i++) {
            this->elements[i] = other.elements[i];
        }
    }

    ~Vector() {
        delete[] this->elements;
    }
```

Sesudah

Definisi Vector Generic

```
int& operator[](int idx) {
    return this->elements[idx];      Yonas Adiel, 2 years
}

Vector2 operator+(const Vector2& other) {
    Vector2 result;
    result.elements[0] = elements[0] + other.elements[0];
    result.elements[1] = elements[1] + other.elements[1];
    return result;
}

Vector2 operator-(const Vector2& other) {
    Vector2 result;
    result.elements[0] = elements[0] - other.elements[0];
    result.elements[1] = elements[1] - other.elements[1];
    return result;
}
```

Sebelum

```
T& operator[](int idx) {
    return this->elements[idx];
}

Vector<T, N> operator+(const Vector<T, N>& other) {
    Vector<T, N> result;
    for (int i = 0; i < N; i++) {
        result.elements[i] = elements[i] + other.element
    }
    return result;
}

Vector<T, N> operator-(const Vector<T, N>& other) {
    Vector<T, N> result;
    for (int i = 0; i < N; i++) {
        result.elements[i] = elements[i] - other.element
    }
    return result;
}
```

Sesudah

Definisi Vector Generic

```cpp
bool operator<(const Vector2& other) {
    if (elements[0] != other.elements[0]) {
        return elements[0] < other.elements[0];
    }
    return elements[1] < other.elements[1];
}

bool operator>(const Vector2& other) {
    if (elements[0] != other.elements[0]) {
        return elements[0] > other.elements[0];
    }
    return elements[1] > other.elements[1];
}
```

Sebelum

```cpp
bool operator<(const Vector<T, N>& other) {
    for (int i = 0; i < N; i++) {
        if (this->elements[i] != other.elements[i]) {
            return this->elements[i] < other.elements[i];
        }
    }
    return false; // vector sama
}

bool operator>(const Vector<T, N>& other) {
    for (int i = 0; i < N; i++) {
        if (this->elements[i] != other.elements[i]) {
            return this->elements[i] > other.elements[i];
        }
    }
    return false; // vector sama
}
```

Sesudah

Definisi Vector Generic

```
friend std::ostream& operator<<(ostream& os, Vector2 vector) {
    os << "<";
    os << vector.elements[0];
    os << ",";
    os << vector.elements[1];
    os << ">";
    return os;
}

friend std::istream& operator>>(istream& is, Vector2& vector) {
    return is >> vector.elements[0] >> vector.elements[1];
}
```

Sebelum

```
friend ostream& operator<<(ostream& os, const Vector<T, N>& vector) {
    os << "<";
    for (int i = 0; i < N; i++) {
        os << vector.elements[i];
        if (i != N - 1) {
            os << ",";
        }
    }
    os << ">";
    return os;
}

friend istream& operator>>(istream& is, Vector<T, N>& vector) {
    for (int i = 0; i < N; i++) {
        is >> vector.elements[i];
    }
    return is;
}
```

Sesudah

Contoh Program Utama Vector Generic

```cpp
#include "Vector.hpp"
#include <iostream>

int main() {
    Vector<int, 4> v1, v2;
    cout << "Masukkkan vektor 4 elemen: ";
    cin >> v1;

    v2[0] = -1;
    v2[1] = -2;
    v2[2] = -3;
    v2[3] = -4;
    cout << v1 << " + " << v2 << " = " << v1 + v2 << endl;
    cout << v1 << " - " << v2 << " = " << v1 - v2 << endl;
}
```

```
Masukkkan vektor 4 elemen: 9 5 2 3
<9,5,2,3> + <-1,-2,-3,-4> = <8,3,-1,-1>
<9,5,2,3> - <-1,-2,-3,-4> = <10,7,5,7>
```

3. Exception

Exception

- Dalam C++, Exception melambangkan behavior yang tidak diharapkan
- Dengan adanya exception, kita dapat menangani behaviour yang tidak diharapkan tersebut sesuai kehendak kita.

Exception

- Sebagai contoh, bagaimana jika pada akses indeks di Vector, indeksnya *out of bound*?
- Exception dilakukan dengan menuliskan **throw <suatu objek>;**

Contoh Throw Exception pada Vector Generic

```
T& operator[](int idx) {
    if (idx < 0 || N <= idx) {
        throw "Invalid index";
    }
    return this->elements[idx];
}
```

```
int main() {
    Vector<int, 4> v;

    v[5] = 7;

    cout << "Baris ini tidak dieksekusi" << endl;

    return 0;
}
```

```
terminate called after throwing an instance of 'char const*'
Aborted (core dumped)
```

Di sini, kita melempar exception berupa constant array of char.

Exception menyebabkan program berjalan tidak sempurna dan exit dengan kode bukan 0

Contoh Catch Exception pada Vector Generic

```
T& operator[](int idx) {
    if (idx < 0 || N <= idx) {
        throw "Invalid index";
    }
    return this->elements[idx];
}
```

```
int main() {
    Vector<int, 4> v;

    try {
        v[5] = 7;
        cout << "Baris ini tidak dieksekusi" << endl;
    } catch (const char* err) {
        cout << "Error: " << err << endl;
    }

    cout << "Baris ini dieksekusi" << endl;

    return 0;
}
```

```
Error: Invalid index
Baris ini dieksekusi
```

Di sini, error yang dilempar (throw), ditangkap (catch) oleh program utama.

Program juga berhenti sempurna

Object as Exception

```
class VectorIndexOutOfBoundException {
private:
    int idxAccessed;
    int numOfElements;
public:
    VectorIndexOutOfBoundException(int idxAccessed, int numOfElements) {
        this->idxAccessed = idxAccessed;
        this->numOfElements = numOfElements;
    }
    void printMessage() {
        cout << "Error: you are trying to access index " << idxAccessed;
        cout << " but the vector only have " << numOfElements;
        cout << " elements." << endl;
    }
};
```

Atau, kamu juga bisa menerima exception berupa object

Contoh Object as Exception

```
T& operator[](int idx) {
    if (idx < 0 || N <= idx) {
        VectorIndexOutOfBoundException e(idx, N);
        throw e;
    }
    return this->elements[idx];
}
```

```
int main() {
    Vector<int, 4> v;

    try {
        v[5] = 7;
        cout << "Baris ini tidak dieksekusi" << endl;
    } catch (VectorIndexOutOfBoundException err) {
        err.printMessage();
    }

    cout << "Baris ini dieksekusi" << endl;

    return 0;
```

```
Error: you are trying to access index 5 but the vector only have 4 elements.
Baris ini dieksekusi
```

Di sini, error yang dilempar (throw), ditangkap (catch) oleh program utama.

Program juga berhenti sempurna

Exception

- Perhatikan kalau kita harus menuliskan tipe data exception yang akan ditangkap.
- Artinya, kita juga perlu menangkap banyak exception jika yang dilempar memiliki tipe berbeda-beda

```
try {
    // doing something dangerous
} catch (Exception1 e) {
    // do something
} catch (Exception2 e) {
    // do something
} catch (Exception3 e) {
    // do something
}
```

Exception

- Atau...
- Bisa juga kita menerima banyak bentuk dari exception

Exception

- Atau...
- Bisa juga kita menerima banyak bentuk dari exception
- Ingat slide ini?

Polymorphism

- Secara harfiah berarti banyak bentuk, diserap dari bahasa yunani
- Konsep ini menyatakan bahwa kelas anak bisa berlaku seperti kelas *parent*-nya

Contoh Polymorphism

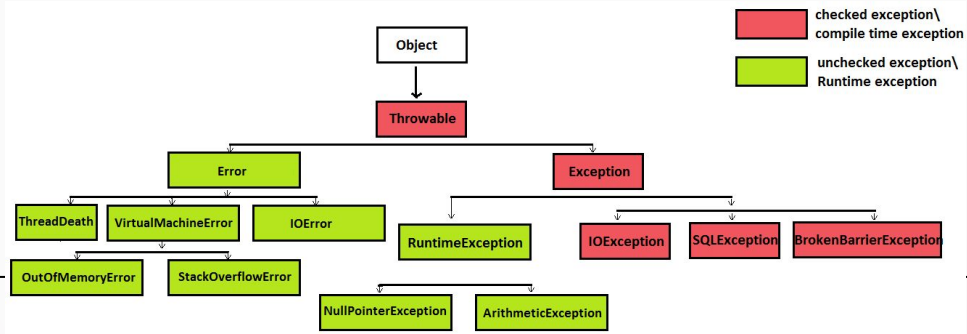
```
void waterPlant(Plant *v) {
    v->absorbWater(1.5);
    v->photosynthesis();
}

int main() {
    Weed weed;
    waterPlant(&weed);
}
```

Output:

```
Nyam nyam makan cahaya
```

Exception

- Idenya, kita dapat membuat sebuah kelas **Exception** yang memiliki **banyak kelas anak**.
- Kita dapat membuat member seperti **printMessage**, **getMessage**, atau lainnya yang dapat dipanggil oleh kode yang melakukan **catch** pada exception
- Contoh kode tidak diberikan, dapat dicoba sendiri di rumah



4. STL / Standard Template Library

STL / Standard Template Library

- C++ menyediakan banyak standard template library, yakni Algoritma (sort, search), Container (list, vector), Iterator, dan fungsi-fungsi lainnya.
- Untuk menggunakannya, perlu meng-include header, misal
- **#include <vector>** atau **#include <algorithm>**

Contoh Container

- vector: array dinamis
- stack
- queue
- deque: stack sekaligus queue
- list: linked list
- priority_queue
- set
- map
- pair / tuple

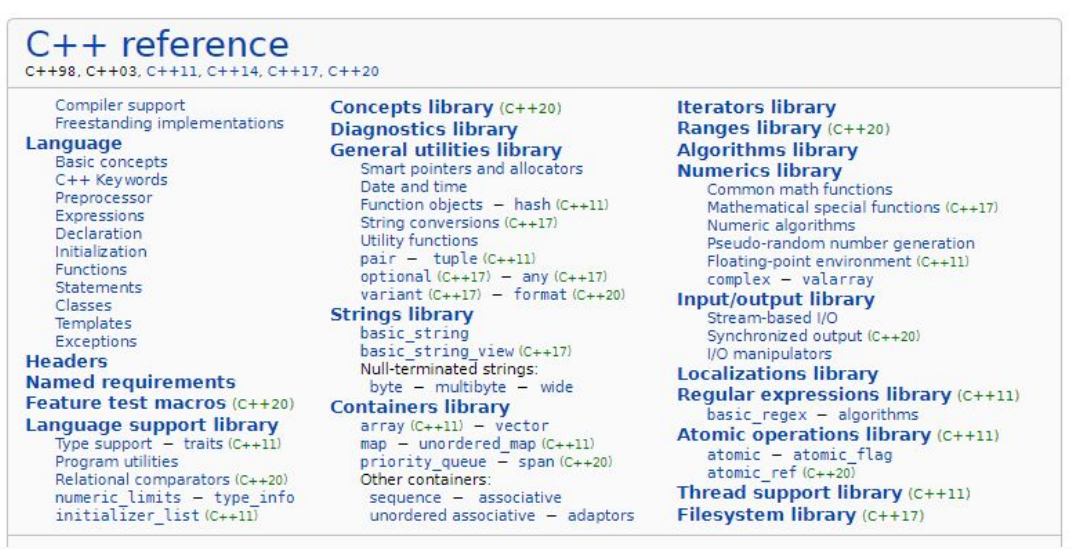
```cpp
int main() {
    vector<int> v;  // seperti array, tapi ukuran dinamis
    v.push_back(4); // v = 4
    v.push_back(2); // v = 4 2
    v.pop_back();   // v = 4

    map<string, int> m;
    m["abc"] = 1;
    m["def"] = 2;
    cout << m["abc"] << endl; // writes 1

    queue<int> q;
    q.push(4); // q = 4
    q.push(2); // q = 4 2
    q.pop();   // q = 2, returns 4

    return 0;
}
```

Contoh Algoritma

```
int main() {
    ...

    sort(a, a + n); // mengurutkan array a berukuran n
    sort(v.begin(), v.end()); // mengurutkan vector v

    find(v.begin(), v.end(), 3); // menemukan nilai 3 di vector v

    binary_search(v.begin(), v.end(), 3); // memeriksa keberadaan nilai 3 di vector terurut

    return 0;
}
```

Contoh STL lain

- Ada banyak, pelajari sendiri ya.. :)



C++ reference

C++98, C++03, C++11, C++14, C++17, C++20

- Compiler support
- Freestanding implementations

Language

- Basic concepts
- C++ Keywords
- Preprocessor
- Expressions
- Declaration
- Initialization
- Functions
- Statements
- Classes
- Templates
- Exceptions

Headers

Named requirements

Feature test macros (C++20)

Language support library

- Type support – traits (C++11)
- Program utilities
- Relational comparators (C++20)
- numeric_limits – type_info
- initializer_list (C++11)

Concepts library (C++20)

Diagnostics library

General utilities library

- Smart pointers and allocators
- Date and time
- Function objects – hash (C++11)
- String conversions (C++17)
- Utility functions
- pair – tuple (C++11)
- optional (C++17) – any (C++17)
- variant (C++17) – format (C++20)

Strings library

- basic_string
- basic_string_view (C++17)
- Null-terminated strings:
  byte – multibyte – wide

Containers library

- array (C++11) – vector
- map – unordered_map (C++11)
- priority_queue – span (C++20)
- Other containers:
  sequence – associative
  unordered associative – adaptors

Iterators library

Ranges library (C++20)

Algorithms library

Numerics library

- Common math functions
- Mathematical special functions (C++17)
- Numeric algorithms
- Pseudo-random number generation
- Floating-point environment (C++11)
- complex – valarray

Input/output library

- Stream-based I/O
- Synchronized output (C++20)
- I/O manipulators

Localizations library

Regular expressions library (C++11)

- basic_regex – algorithms

Atomic operations library (C++11)

- atomic – atomic_flag
- atomic_ref (C++20)

Thread support library (C++11)

Filesystem library (C++17)

Sekian.

Ditunggu praktikum dan tutorial berikutnya.