A whirlwind tour of C++

Echtzeitsysteme WS 2012/2013

heise@in.tum.de
What you should already know
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- The basic datatypes (e.g. int, float)
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- Basic control flow (e.g. if/else, for, while)
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- What methods and functions are
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- The basic datatypes (e.g. int, float)
- Basic control flow (e.g. if/else, for, while)
- What methods and functions are
- What classes and objects are
What you should already know

- The basic datatypes (e.g. int, float)
- Basic control flow (e.g. if/else, for, while)
- What methods and functions are
- What classes and objects are
- How to use a compiler
Hello C++

Code

```cpp
#include <iostream>

int main()
{
    std::cout << "Hello World" << std::endl;
    return 0;
}
```
Hello C++

Code

```cpp
#include <iostream>

int main()
{
    std::cout << "Hello World" << std::endl;
    return 0;
}
```

Build/Output

```
$ g++ main.cpp
$ ./a.out
Hello World
$
```
Functions

- Reuse and structure code
- Parameters and return value
- C++ allows pass by reference and value
- C++ allows function overloading
#include <iostream>

int fac( int x )
{
    return ( x <= 1 ) ? 1 : x * fac( x - 1 );
}

int main()
{
    std::cout << fac( 5 ) << std::endl;
    return 0;
}
Functions

Code

```cpp
#include <iostream>

int fac( int x )
{
    return ( x <= 1 ) ? 1 : x * fac( x - 1 );
}

int main()
{
    std::cout << fac( 5 ) << std::endl;
    return 0;
}
```

Output

```
$./a.out
120
$ 
```
int fac(int x) {
    return ( x <= 1 ) ? 1 : x * fac(x - 1);
}
Functions

Return type
Function name
Argument 0 type
Argument 0 name

```c
int fac( int x )
{
    return ( x <= 1 ) ? 1 : x * fac( x - 1 );
}
```

arbitrary number of arguments possible

```c
type function( type0 arg0, type1 arg1, ..., typeN argN )
{
    ...
}
```
Functions
Pass by value vs. reference

```cpp
#include <iostream>

void func_value( int x )
{
    x = 10;
}

void func_reference( int& x )
{
    x = 10;
}

int main()
{
    int a = 0;
    func_value( a );
    std::cout << a << std::endl;
    func_reference( a );
    std::cout << a << std::endl;
    return 0;
}
```
Functions

Pass by value vs. reference

```cpp
#include <iostream>

void func_value(int x)
{
    x = 10;
}

void func_reference(int& x)
{
    x = 10;
}

int main()
{
    int a = 0;
    func_value(a);
    std::cout << a << std::endl;
    func_reference(a);
    std::cout << a << std::endl;
    return 0;
}
```

Output

```
$./a.out
0
10
$
```

---

Thursday, November 22, 12
#include <iostream>

void func( int v )
{
    std::cout << "Integer: " << v << std::endl;
}

void func( float v )
{
    std::cout << "Float: " << v << std::endl;
}

int main()
{
    func( 5 );
    func( 1.0f );
    return 0;
}
# Functions

Overloading

```cpp
#include <iostream>

void func( int v )
{
    std::cout << "Integer: " << v << std::endl;
}

void func( float v )
{
    std::cout << "Float: " << v << std::endl;
}

int main()
{
    func( 5 );
    func( 1.0f );
    return 0;
}
```

Output

```bash
$./a.out
Integer: 5
Float: 1
$
Arrays

Declaration

```plaintext
type name[ dimension ];
type name[ dimension1 ][ dimension2 ];
...
```
Arrays

Declaration

- Type
- Name
- Dimension

```plaintext
type name[ dimension ];
type name[ dimension1 ][ dimension2 ];
...
```

Initialization

```plaintext
int array[ 4 ];
array[ 0 ] = 0;
array[ 1 ] = 5;
array[ 2 ] = 8;
array[ 3 ] = 3;
```

```plaintext
int array[ 4 ] = { 3, 7, 9, 2 };
```

```plaintext
int array[] = { 3, 7, 9, 2 };
```
Arrays

- Special initialization for char arrays / strings
- The following char arrays are equivalent

```c
char str[] = "String";
char str2[] = { 'S', 't', 'r', 'i', 'n', 'g', '\0' };
```
Pointers

- A variable name refers to a particular location in memory and stores a value there
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- If you refer to the variable by name then
Pointers

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- If you refer to the variable by name then
  - the memory address is looked up
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- If you refer to the variable by name then
  - the memory address is looked up
  - the value at the address is retrieved or set
Pointers

- A variable name refers to a particular location in memory and stores a value there.
- If you refer to the variable by name then:
  - the memory address is looked up.
  - the value at the address is retrieved or set.
- C++ allows us to perform these steps independently.
Pointers

- A variable name refers to a particular location in memory and stores a value there.
- If you refer to the variable by name then:
  - the memory address is looked up
  - the value at the address is retrieved or set
- C++ allows us to perform these steps independently
  - \&x evaluates to the address of \(x\) in memory
Pointers

- A variable name refers to a particular location in memory and stores a value there.
- If you refer to the variable by name then:
  - the memory address is looked up.
  - the value at the address is retrieved or set.
- C++ allows us to perform these steps independently.
  - `&x` evaluates to the address of `x` in memory.
  - `*( &x )` dereferences the address of `x` and retrieves the value of `x`.
Pointers

- A variable name refers to a particular location in memory and stores a value there.
- If you refer to the variable by name then:
  - the memory address is looked up
  - the value at the address is retrieved or set
- C++ allows us to perform these steps independently:
  - `&x` evaluates to the address of `x` in memory
  - `*( &x )` dereferences the address of `x` and retrieves the value of `x`
  - `*( &x )` is the same thing as `x`
```cpp
#include <iostream>

int main()
{
    int x;
    int* p = &x;

    x = 10;
    std::cout << *p << std::endl;

    *p = 5;
    std::cout << x << std::endl;

    return 0;
}
```
Pointers

#include <iostream>

int main()
{
    int x;
    int* p = &x;
    x = 10;
    std::cout << *p << std::endl;
    *p = 5;
    std::cout << x << std::endl;
    return 0;
}

$./a.out
10
5
$
Pointers

5

0x123

... 0x123 0x124 0x125 0x126 ...

x p
# Pointers

## Example

```cpp
#include <iostream>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while ( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}
```
# Pointers

**Example**

```cpp
#include <iostream>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}
```

```
#include <iostream>
int main()
{
    char* cptr = "bla";
    int len = 0;
    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}
```
Pointers

Example

```cpp
#include <iostream>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}
```

```
#include <iostream>
int main()
{
    char* cptr = "bla";
    int len = 0;
    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
} ```

Thursday, November 22, 12
#include <iostream>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}

Pointers

Example
#include <iostream>

int main()
{
    char* cptr = "bla";
    int len = 0;

    while( *cptr != '\0' ) {
        len++;
        cptr++;
    }
    std::cout << len << std::endl;
}
Pointers

Pointers and arrays

```c
int array[ 5 ];
...
    array ≡ &array[ 0 ]
    *array ≡ array[ 0 ]
*( array + 1 ) ≡ array[ 1 ] ≡ 1[ array ]
...
```

Arithmetic pointer operations modify the address by `sizeof( type )` bytes

```c
#include <iostream>

int main()
{
    char*  x = 0x0;
    float* y = 0x0;

    std::cout << ( void* ) ( x + 1 ) << std::endl;
    std::cout << ( void* ) ( y + 1 ) << std::endl;
}
```
Pointers

- Pointers and arrays

```cpp
int array[5];
...
array ≡ &array[0]
array ≡ array[0]
*(array + 1) ≡ array[1] ≡ 1[ array ]
...
```

- Arithmetic pointer operations modify the address by sizeof(type) bytes

```cpp
#include <iostream>

int main()
{
    char* x = 0x0;
    float* y = 0x0;

    std::cout << (void*) (x + 1) << std::endl;
    std::cout << (void*) (y + 1) << std::endl;
}
```

$ ./a.out
0x1
0x4
$
Pointers

```c
const int* ptr
```

```c
int* const ptr
```

```c
const int* const ptr
```
Pointers

\texttt{const int* ptr}

- Declares a changeable pointer to a constant integer
- Value cannot be changed
- Pointer can be changed to point to a different constant integer

\texttt{int* const ptr}

\texttt{const int* const ptr}
Pointers

const int* ptr

- Declares a changeable pointer to a constant integer
- Value cannot be changed
- Pointer can be changed to point to a different constant integer

int* const ptr

- Declares a constant pointer to a changeable integer
- Value can be changed
- Pointer cannot be changed to point to a different integer

const int* const ptr
Pointers

const int* ptr

- Declares a changeable pointer to a constant integer
- value cannot be changed
- pointer can be changed to point to a different constant integer

int* const ptr

- Declares a constant pointer to a changeable integer
- value can be changed
- pointer cannot be changed to point to a different integer

const int* const ptr

- Neither the value nor the address can be changed
Pointers

- No guarantees that a pointer points to a valid address

```c
int* ptr = 0xdeadbeef;
int* ptr = 0x0;

int* function()
{
   int x;
   return &x;
}

int* p = new int[ 5 ];
delete p;
```
Memory management

- Dynamic memory allocation possible using new/delete

```cpp
...  
int* x = new int;
...  
int* y = new int[ 10 ];
...
float** z;
z = new float*[ 2 ];
z[ 0 ] = new float[ 3 ];
z[ 1 ] = new float[ 4 ];
...
delete x;
delete[] y;
delete[] z[ 0 ];
delete[] z[ 1 ];
delete[] z;
...  
```

- If allocated memory is not correctly freed using delete it is wasted and cannot be reused

- Pointers to deleted memory still contain the address
Classes

- Make the coupling between functions and data explicit
- Allows the definition of new datatypes
- Enhanced reusability and readability
Classes

Visibility
- Class name

```cpp
class name
{
    public:
        ... methods/members ...
    private:
        ... methods/members ...
    protected:
        ... methods/members ...
};
```
Classes

Visibility

Class name

class name
{
    public:
        ... methods/members ...
    
    private:
        ... methods/members ...
    
    protected:
        ... methods/members ...
};

- Public members/methods can be accessed from outside
Classes

- **Visibility**
  - Class name

```cpp
class name
{
    public:
        ... methods/members ...
    private:
        ... methods/members ...
    protected:
        ... methods/members ...
};
```

- Public members/methods can be accessed from outside
- Private/protected members/methods can only be accessed from within the class
```cpp
#include <iostream>

class Complex
{
    public:
        Complex( float r, float i ) { re = r; im = i; }
        void print() { std::cout << "( " << re << " , " << im << " )" << std::endl; }

        float re;
        float im;
};

int main()
{
    Complex c( 1.0f, 0.0f );
    c.print();
    c.re = 2.0f;
    c.print();
}
```
#include <iostream>

class Complex
{
    public:
        Complex( float r, float i ) { re = r; im = i; }

        void print() { std::cout << "( " << re << " , " << im << " )" << std::endl; }

        float re;
        float im;
};

int main()
{
    Complex c( 1.0f, 0.0f );
    c.print();
    c.re = 2.0f;
    c.print();
}
**Classes**

- Special methods for construction and deconstruction (constructor/destructor)

```cpp
#include <iostream>

class Foobar
{
    public:
        Foobar() { std::cout << "ctor" << std::endl; }
        ~Foobar() { std::cout << "dtor" << std::endl; }
};

int main()
{
    Foobar obj;
}
```
Classes

* Special methods for construction and deconstruction (constructor/destructor)

```cpp
#include <iostream>

class Foobar {
    public:
        Foobar() { std::cout << "ctor" << std::endl; }
        ~Foobar() { std::cout << "dtor" << std::endl; }
};

int main()
{
    Foobar obj;
}
```

Output

```
$ ./a.out
ctor
dtor
$.
```
Classes

- Constructor brings the object into a consistent state
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- Deconstructor can be used for cleaning up (especially useful for dynamic memory)
Classes

- Constructor brings the object into a consistent state
- Deconstructor can be used for cleaning up (especially useful for dynamic memory)
- More special methods exist e.g. for copying objects and special operators
Classes

- If pointers to objects are used, then methods/members can be accessed via “->”

```cpp
#include <iostream>

class Blub
{
    public:
        Blub( int x ) { bla = x; }
        int bla;
};

int main()
{
    Blub* x = new Blub( 2 );

    std::cout << ( *x ).bla << std::endl;
    std::cout << x->bla << std::endl;
}
```
Classes

- If pointers to objects are used, then methods/members can be accessed via "->"

```cpp
#include <iostream>

class Blub
{
    public:
        Blub( int x ) { bla = x; }
        int bla;
};

int main()
{
    Blub* x = new Blub( 2 );

    std::cout << ( *x ).bla << std::endl;
    std::cout << x->bla << std::endl;
}
```

Output

```
$./a.out
2
2
2
$.
```
Questions?