C++ Programming I

Refresher

C++ Programming
FS 2020

Dr. P. Arnold &
Dr. A. Schneider
Bern University of Applied Sciences

Agenda

- Variables

Agenda

- Variables
- Data Types

Agenda

- Variables
- Data Types
- Keywords

Agenda

- **Variables**
- **Data Types**
- **Keywords**
- **Compiling & Linking**
  - The Development Cycle
  - Linking Order
  - Include Guards

Variables

Variables

Declaration, Initialisation and Definition

```
// Declaration
int x; // of variable int
int getValue(); // of function prototype

// Definition
int x; // same as declaration
int getValue(){ /* Definition */ } // without ';'

// Initialisation is optional, but it's
// often a good programming practice
int x = 42; // refers to the "assignment" of a value

// initialization does not mean much for functions
```

- The variable type attribute tells the compiler the nature of data the variable can store, and the compiler reserves the necessary space for it
- The variable name is a friendly replacement for the address in the memory
- Use `camelCase` naming convention for variables
- Naming conventions differs for objects, functions etc.

> Naming variables appropriately is important for writing good, understandable, and maintainable code!

Data Types

Fundamental C++ Variable Types

Data Type Ranges

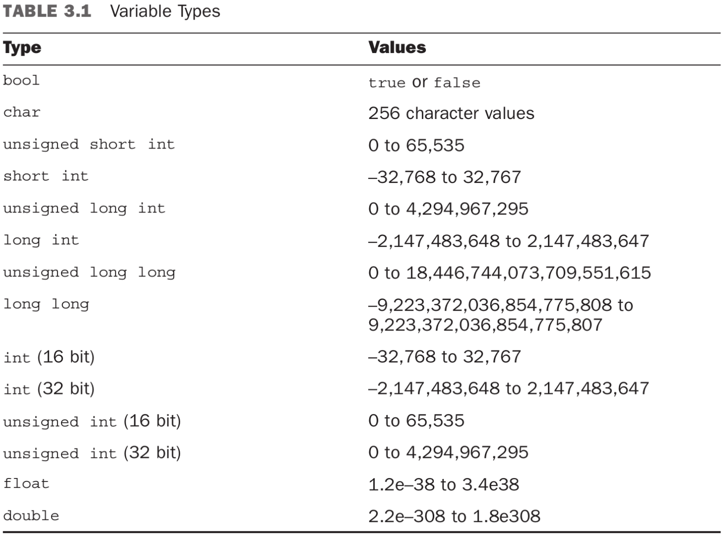


TABLE 3.1 Variable Types

Type	**Values**
`bool`	`true` or `false`
`char`	256 character values
`unsigned short int`	0 to 65,535
`short int`	–32,768 to 32,767
`unsigned long int`	0 to 4,294,967,295
`long int`	–2,147,483,648 to 2,147,483,647
`unsigned long long`	0 to 18,446,744,073,709,551,615
`long long`	–9,223,372,036,854,775,808 to 9,223,372,036,854,775,807
`int` (16 bit)	–32,768 to 32,767
`int` (32 bit)	–2,147,483,648 to 2,147,483,647
`unsigned int` (16 bit)	0 to 65,535
`unsigned int` (32 bit)	0 to 4,294,967,295
`float`	1.2e–38 to 3.4e38
`double`	2.2e–308 to 1.8e308

- Select correct data type according your needs!

Fundamental Types in C++

Determining the size of variables using `sizeof`

```cpp
#include <iostream>
using namespace std;

int main()
{
   cout << "Size of char : " << sizeof(char) << endl;
   cout << "Size of int : " << sizeof(int) << endl;
   cout << "Size of short int : " << sizeof(short int) << endl;
   cout << "Size of long int : " << sizeof(long int) << endl;
   cout << "Size of float : " << sizeof(float) << endl;
   cout << "Size of double : " << sizeof(double) << endl;
   cout << "Size of wchar_t : " << sizeof(wchar_t) << endl;

   return 0;
}

// Output changes with compiler, hardware and OS
Size of char :         1
Size of int :          4
Size of short int :    2
Size of long int :     8
Size of float :        4
Size of double :       8
```

struct packing: sum of bytes must even with __Attribut__((packed)) --> get real byte value

1 byte = 8 bit

C++ 11 introduced fixed-width integer types! Include `<cstdint>` to use e.g. 8-bit signed and unsigned integers (`int8_t, uint8_t`)

Fundamental Types in C++

Limits

```cpp
    std::cout << "char : "
              << int (std::numeric_limits<char>::min()) << ".."
              << int (std::numeric_limits<char>::max()) << "\n" ;

    std::cout << "int : "
              << std::numeric_limits<int>::min () << ".."
              << std::numeric_limits<int>::max() << "\n";

    std::cout << "short int : "
              << std::numeric_limits<short int>::min() << ".."
              << std::numeric_limits<short int>::max() << "\n";

    std::cout << "long int : "
              << std::numeric_limits<long int>::min () << ".."
              << std::numeric_limits<long int>::max () << "\n";

    std::cout << "float : "
              << std::numeric_limits<float>::min () << ".."
              << std::numeric_limits<float>::max () << "\n";

    std::cout << "double : "
              << std::numeric_limits<double>::min () << ".."
              << std::numeric_limits<double>::max () << "\n";

    std::cout << "wchar_t : "
              << std::numeric_limits<wchar_t>::min () << ".."
              << std::numeric_limits<wchar_t>::max ();
```

Fundamental Types in C++

Limits

```
char :      -128..127
int :       -2147483648..2147483647
short int : -32768..32767
long int :  -9223372036854775808..9223372036854775807
float :      1.17549e-38..3.40282e+38
double :     2.22507e-308..1.79769e+308
wchar_t :   -2147483648..2147483647
```

- Size of type in bytes.

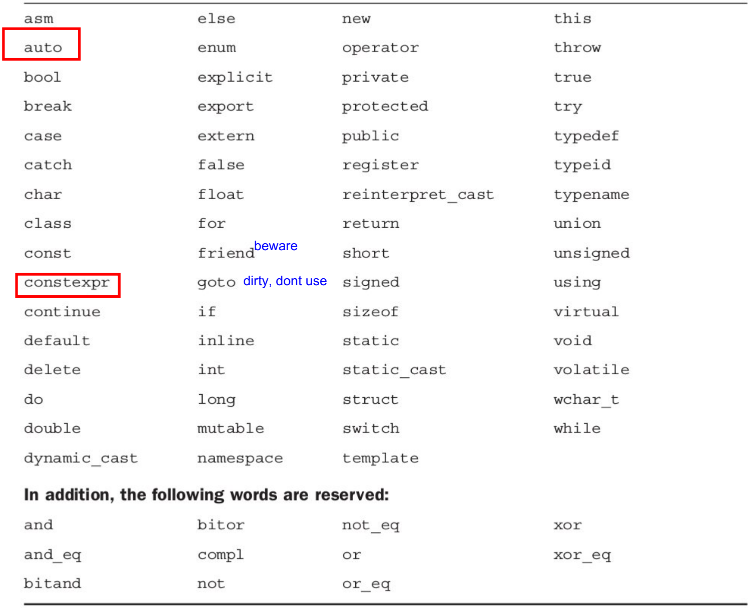
Tip:

Include <limits> from the standard library

Keywords

Major Keywords

reserved by C++



asm
auto
bool
break
case
catch
char
class
const
constexpr
continue
default
delete
do
double
dynamic_cast

else
enum
explicit
export
extern
false
float
for
friend beware
goto dirty, dont use
if
inline
int
long
mutable
namespace

new
operator
private
protected
public
register
reinterpret_cast
return
short
signed
sizeof
static
static_cast
struct
switch
template

this
throw
true
try
typedef
typeid
typename
union
unsigned
using
virtual
void
volatile
wchar_t
while

In addition, the following words are reserved:

and
and_eq
bitand

bitor
compl
not

not_eq
or
or_eq

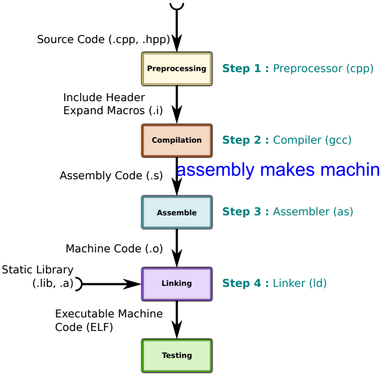
xor
xor_eq

Compiling & Linking

Compilation Process

g++ Build Steps. *Use `–save–temps` to store the "temporary" intermediate files*

1. Syntax check (checks spelling, removes comment), converts macros and include headers



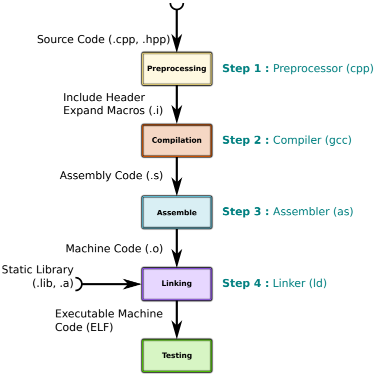
assembly makes machine code

Compilation Process

g++ Build Steps. *Use `–save–temps` to store the "temporary" intermediate files*

1. Syntax check (checks spelling, removes comment), converts macros and include headers

2. Compiles the source code to assembly code



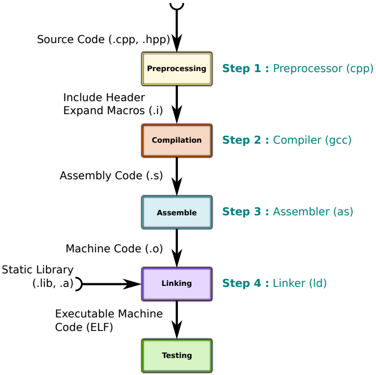
Compilation Process

g++ Build Steps. *Use `-save-temps` to store the "temporary" intermediate files*

1. Syntax check (checks spelling, removes comment), converts macros and include headers

2. Compiles the source code to assembly code

3. Generates machine code which is not linked



Compilation Process

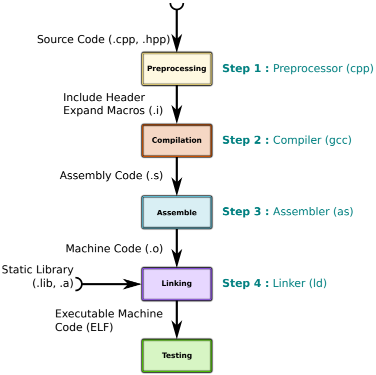
g++ Build Steps. *Use `-save-temps` to store the "temporary" intermediate files*

1. Syntax check (checks spelling, removes comment), converts macros and include headers

2. Compiles the source code to assembly code

3. Generates machine code which is not linked

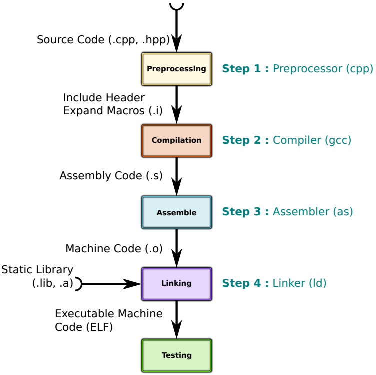
4. Link project and static library objects to an ELF file



Compilation Process

g++ Build Steps. *Use `-save-temps` to store the "temporary" intermediate files*

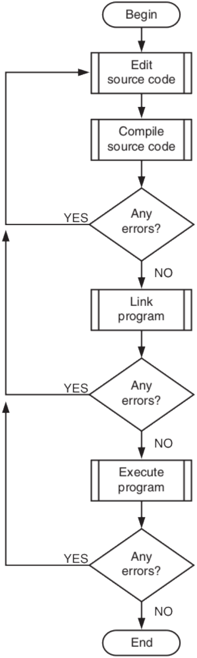
1. Syntax check (checks spelling, removes comment), converts macros and include headers
2. Compiles the source code to assembly code
3. Generates machine code which is not linked
4. Link project and static library objects to an ELF file
5. Program test by user or test-system on real/emulated hardware



Development Cycles

Errors

- Typing mistakes result in compiling errors (syntax errors)
  Syntax errors are the simplest sort of errors. To avoid such errors read the C++ manual and you will be fine.

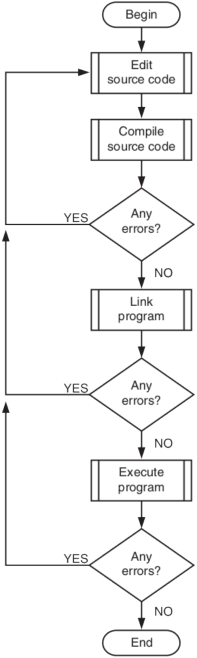


Development Cycles

Errors

- Typing mistakes result in compiling errors (syntax errors)
  Syntax errors are the simplest sort of errors. To avoid such errors read the C++ manual and you will be fine.

- In-existent references result in linking errors
  Linking errors happen due to missing linker configurations or missing libraries



Development Cycles

Errors

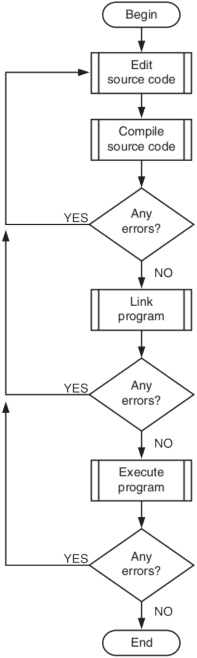
- Typing mistakes result in compiling errors (syntax errors)
  Syntax errors are the simplest sort of errors. To avoid such errors read the C++ manual and you will be fine.

- In-existent references result in linking errors
  Linking errors happen due to missing linker configurations or missing libraries

- Wrong behaviour are logical errors (visible only when testing)
  Beginners often think "a code which compiles is free of errors"! TRAP... Only tested code has a change of having just a few miss functionality. ***Never forget testing!***

compiler tests line by line

static code analyzer checks function and links
unit tester, runtime tester, wall grinde open source



Compiling an Linking

Order of Compilation

```cpp
void ping(int n_times)
{
    std::cout << "ping: " << n_times << std::endl;
    if(n_times > 0)
    {
        pong(--n_times);
    }
}

void pong(int n_times)
{
    std::cout << "pong: " << n_times << std::endl;
    if(n_times > 0)
    {
        ping(--n_times);
    }
}
```

- Do you see a problem?

Compiling an Linking

Order of Compilation

```
void ping(int n_times)
{
    std::cout << "ping: " << n_times << std::endl;
    if(n_times > 0)
    {
        pong(--n_times);
    }
}

void pong(int n_times)
{
    std::cout << "pong: " << n_times << std::endl;
    if(n_times > 0)
    {
        ping(--n_times);
    }
}
```

- Do you see a problem?
- This code wont compile! Why?

Compiling an Linking

Order of Compilation

```
void ping(int n_times)
{
    std::cout << "ping: " << n_times << std::endl;
    if(n_times > 0)
    {
        pong(--n_times);
    }
}

void pong(int n_times)
{
    std::cout << "pong: " << n_times << std::endl;
    if(n_times > 0)
    {
        ping(--n_times);
    }
}
```

- Do you see a problem?
- This code wont compile! Why?
- `pong` not declared when compiling `ping`

Compiling an Linking

Forward Declaration

just decleration

```
// forward declaration
void ping(int n_times);
void pong(int n_times);

void ping(int n_times)
{
    std::cout << "ping: " << n_times << std::endl;
    if(n_times > 0)
    {
        pong(--n_times);
    }
}

void pong(int n_times)
{
    std::cout << "pong: " << n_times << std::endl;
    if (n_times > 0)
    {
        ping(--n_times);
    }
}
```

- Use forward declaration!

Compiling an Linking

Seperate Implementation - Header File

```
#ifndef PINGPONG_H
#define PINGPONG_H

void ping(int n_times);
void pong(int n_times);

#endif // PINGPONG_H
```

- Declaration of function `ping` and `pong`
- Visible to the user
- Note the include guards

Compiling an Linking

Seperate Implementation - Source

```
#include "iostream"
#include "pingpong.h"

void ping(int n_times)
{
    std::cout << "ping: " << n_times << std::endl;
    if(n_times > 0)
    {
        pong(--n_times);
    }
}

void pong(int n_times)
{
    std::cout << "pong: " << n_times << std::endl;
    if(n_times > 0)
    {
        ping(--n_times);
    }
}
```

- Definition of function `ping` and `pong`
- Can be hidden from the user!
- Can be a binary file

Compiling an Linking

Seperate Implementation

```cpp
#include <iostream>
#include "pingpong.h"

int main ( )
{
    std::cout << "Lets play!" << std::endl;
    ping(10);

    std::cout << "Next round..." << std::endl;
    pong(5);

    return 0;
}
```

- Functions are included: `#include pingpong.h`
- What is the output? (Demo)

Note

Include system libraries with <SysLib.h> and user libraries with “UserLib.h”

Include Guard

Macro

```
#ifndef INCLUDEHEADER1_H
#define INCLUDEHEADER1_H

#include "includeHeader2.h"


#endif // INCLUDEHEADER1_H
```

preprocessorr checks if exists

```
#ifndef INCLUDEHEADER2_H
#define INCLUDEHEADER2_H

#include "includeHeader1.h"

#endif // INCLUDEHEADER2_H
```

- Multiple includes is a problem of recursive nature for the preprocessor
- One of the most frequently used macro-based functionality in C++
- PingPongGame **Demo**

Thank You

Questions

???