Übung zu Betriebssystembau

C++ Crashkurs

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From: Linus Torvalds
Subject: Re: Compiling C++ kernel module + Makefile
Date: Mon, 19 Jan 2004 22:46:23 -0800 (PST)

On Tue, 20 Jan 2004, Robin Rosenberg wrote:
>
> This is the "We've always used COBOL^H^H^H^H" argument.

In fact, in Linux we did try C++ once already, back in 1992.

It sucks. Trust me - writing kernel code in C++ is a BLOODY STUPID IDEA.

The fact is, C++ compilers are not trustworthy. They were even worse in 1992, but some fundamental facts haven't changed:

- the whole C++ exception handling thing is fundamentally broken. It's _especially_ broken for kernels.
- any compiler or language that likes to hide things like memory allocations behind your back just isn't a good choice for a kernel.
- you can write object-oriented code (useful for filesystems etc) in C, _without_ the crap that is C++.

In general, I'd say that anybody who designs his kernel modules for C++ is either
(a) looking for problems
(b) a C++ bigot that can't see what he is writing is really just C anyway
(c) was given an assignment in CS class to do so.

Feel free to make up (d).

Linus

C++: As Close as Possible to C, but no Closer

Andrew Koenig and Bjarne Stroustrup, The C++ Report. July 1989

Erste Schritte

einfaches ANSI C ist (fast) valides C++

```
01 #include <stdio.h>
02
03
04 int main() {
05     const char * str = "Informatik";
06     int n = 4;
07     printf("%s %d\n", str, n);
08     return 0;
09 }
```

Erste Schritte

```
01 #include <cstdio>
02
03
04 int main() {
05     const char * str = "Informatik";
06     int n = 4;
07     printf("%s %d\n", str, n);
08     return 0;
09 }
```

```
01 #include <iostream>
02
03
04 int main() {
05 	const char * str = "Informatik";
06 	int n = 4;
07 	std::cout << str << ' ' << n << std::endl;
08 	return 0;
09 }
```

```
01 #include <iostream>
02
03
04 int main() {
05     const std::string str = "Informatik";
06     int n = 4;
07     std::cout << str << ' ' << n << std::endl;
08     return 0;
09 }
```

```
01 #include <iostream>
02 using namespace std;
03
04 int main() {
05     const string str = "Informatik";
06     int n = 4;
07     cout << str << ' ' << n << endl;
08     return 0;
09 }
```

Namensräume

```
01 namespace Foo {
02     int getNum() {
03         return 23;
04     }
05 }
06
07 namespace Bar {
08     int getNum() {
09         return 42;
10     }
11 }
12
13 std::cout << Foo::getNum() << std::endl
14           << Bar::getNum() << std::endl;
```

Referenzen

```
01 int foo = 23;
02 int& bar = foo;
03 std::cout << bar << std::endl; // Ausgabe: 23
04
05 bar = 42;
06 std::cout << foo << std::endl; // Ausgabe: 42
```

Referenzen

```
01 int foo = 23;
02 int& bar = foo;
03 std::cout << bar << std::endl; // Ausgabe: 23
04
05 bar = 42;
06 std::cout << foo << std::endl; // Ausgabe: 42
```

Unterschied zu Zeiger

- Initialisierung bei Definition
- kann nicht geändert werden
- kann nicht `NULL` sein

Referenzen als Funktionsparameter

Konstante Referenzparameter

```
01  void dump(std::ostream &os, const Complex &c) {
02      os << c.real << " + " << c.img << "i\n";
03  }
```

Referenzen als Funktionsparameter

Konstante Referenzparameter

```
01 void dump(std::ostream &os, const Complex &c) {
02     os << c.real << " + " << c.img << "i\n";
03 }
```

Nicht-konstante Referenzparameter

```
01 void inc(int& i) { i++; }
02
03 int foo = 23;
04 inc(foo);
05
06 std::cout << foo << std::endl; // Ausgabe: 24
```

Standardparameter

```
01 void inc(int& i, int n = 1) {
02       i += n;
03 }
04
05 int foo = 23;
06 inc(foo);
07
08 std::cout << foo << std::endl; // Ausgabe: 24
09
10 inc(foo, 2);
11
12 std::cout << foo << std::endl; // Ausgabe: 26
```

Überladen von Funktionen

```
01 bool isZero(int i){
02     return i == 0;
03 }
04
05 bool isZero(double i){
06     const double eps = 0.00001;
07     return i < eps && i > -eps;
08 }
```

Überladen von Funktionen

```
01 bool isZero(int i){
02     return i == 0;
03 }
04
05 bool isZero(double i){
06     const double eps = 0.00001;
07     return i < eps && i > -eps;
08 }
```

Overload resolution ist nicht trivial!

Strukturen & Klassen

```
01
02 struct Disp {
03     char val;
04     int x, y;
05 };
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     struct Disp p;
06     p.val = 'X';
07     p.x = 2;
08     p.y = 0;
09     cout << p.val << endl;
10 }
11 // Geht in C++ nicht:
12 // struct Disp p = {
13 //     .val = 'X',
14 //     .x = 2,
15 //     .y = 0
16 // }
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp() {
07         val = 'X';
08         this->x = 2;
09         this->y = 0;
10     }
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p;
06     cout << p.val << endl;
07 }
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0) {
07         val = c;
08         this->x = x;
09         this->y = y;
10     }
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p('X', 2);
06     cout << p.val << endl;
07 }
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0) {
07         val = c;
08         this->x = x;
09         this->y = y;
10     }
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{'X', 2};
06     cout << p.val << endl;
07 }
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0)
07       : val(c), x(x), y(y) {}
08 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{'X', 2};
06     cout << p.val << endl;
07 }
```

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0)
07       : val(c), x(x), y(y) {}
08
09     Disp(int p) : val('X'),
10         x(p % 80), y(p / 80) {}
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{2};
06     cout << p.val << endl;
07 }
```

Strukturen & Klassen

disp.h:

```
01
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0)
07       : val(c), x(x), y(y) {}
08
09     Disp(int p)
10       : Disp('X', p % 80, p / 80)
             {}
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{2};
06     cout << p.val << endl;
07 }
```

disp.h:

```
01 int count = 0;
02 struct Disp {
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0)
07       : val(c), x(x), y(y) {
08         count++;
09     }
10
11     Disp(int p)
12       : Disp('X', p % 80, p / 80)
             {}
13
14     ~Disp() { count--; }
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{2};
06     cout << p.val << "-"
07          << count << endl;
08 }
```

disp.h:

```
01 struct Disp {
02      static int count;
03      char val;
04      int x, y;
05
06      Disp(char c, int x=0, int y
            =0)
07        : val(c), x(x), y(y) {
08          count++;
09      }
10
11      Disp(int p)
12        : Disp('X', p % 80, p / 80)
              {}
13
14      ~Disp() { count--; }
15 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05      Disp p{2};
06      cout << p.val << "-"
07           << Disp::count << endl;
08 }
09
10 int Disp::count = 0;
```

disp.h:

```
01 struct Disp {
02     static int count;
03     char val;
04     int x, y;
05
06     Disp(char c, int x=0, int y
           =0);
07
08     Disp(int p)
09       : Disp('X', p % 80, p / 80)
             {}
10
11     ~Disp();
12 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{2};
06     cout << p.val << "-"
07          << Disp::count << endl;
08 }
09
10 int Disp::count = 0;
11
12 Disp::Disp(char c, int x, int y)
13   : val(c), x(x), y(y) {
14     count++;
15 }
16 Disp::~Disp() { count--; }
```

disp.h:

```
01 struct Disp {
02   private:
03     static int count;
04     char val;
05     int x, y;
06
07   public:
08     Disp(char c, int x=0, int y
         =0);
09     Disp(int p);
10     ~Disp();
11 };
```

disp.cc:

```
01 #include "disp.h"
02 using namespace std;
03
04 void func() {
05     Disp p{2};
06     // Übersetzerfehler bei:
07     cout << p.val << endl;
08 }
09
10 int Disp::count = 0;
11
12 Disp::Disp(char c, int x, int y)
13   : val(c), x(x), y(y) {
14     count++;
15 }
16 Disp::~Disp() { count--; }
```

Unterschied Standardsichtbarkeit

`public` bei `struct` (und `union`)

`private` bei `class`

```
struct Foo {
  Foo(int i) { ... };
  test() { ... };
};
```

```
Foo foo1{23};
foo1.test();  // OK
```

```
Foo foo2(23);
foo2.test();  // OK
```

```
struct Bar {
  Bar() { ... };
  test() { ... };
};
```

```
Bar bar0;
bar0.test();  // OK
```

```
Bar bar1{};
bar1.test();  // OK
```

```
Bar bar2();
bar2.test();  // Fehler
```

```
struct Foo {
  Foo(int i) { ... };
  test() { ... };
};
```

```
struct Bar {
  Bar() { ... };
  test() { ... };
};
```

```
Bar bar0;
bar0.test();  // OK
```

```
Foo foo1{23};
foo1.test();  // OK
```

```
Bar bar1{};
bar1.test();  // OK
```

```
Foo foo2(23);
foo2.test();  // OK
```

```
Bar bar2();
bar2.test();  // Fehler
```

error: request for member ‘test’ in ‘bar2’,
which is of non-class type ‘Bar()’

```cpp
struct Foo {
  Foo(int i) { ... };
  test() { ... };
};

Foo foo1{23};
foo1.test();  // OK

Foo foo2(23);
foo2.test();  // OK
```

```cpp
struct Bar {
  Bar() { ... };
  test() { ... };
};

Bar bar0;
bar0.test();  // OK

Bar bar1{};
bar1.test();  // OK

Bar bar2();
bar2.test();  // Fehler
```

```
error: request for member ‘test’ in ‘bar2’,
       which is of non-class type ‘Bar()’
```

→ **Häufiger, „most vexing parse“ genannter Fehler!**

Vererbung

Syntax: `class` **`Abgeleitet:`** *`Vererbungsart`* **`Basis`**

Vererbung

Syntax: `class` **`Abgeleitet`**`:` *`Vererbungsart`* **`Basis`**

```
01 class Foo {
02         int n;
03     protected:
04         int f1(int i){
05                 return i * n;
06         }
07 };
```

Vererbung

Syntax: `class` **`Abgeleitet`**`:` *`Vererbungsart`* **`Basis`**

```
01 class Foo {
02         int n;
03     protected:
04         int f1(int i){
05             return i * n;
06         }
07 };
```

```
01 class Bar : Foo {
02     public:
03         int n;   // eigene Var
04         int f2(int i){
05             return f1(i) * n;
06         }
07 };
```

Vererbung

Syntax: `class` **`Abgeleitet`**`:` *`Vererbungsart`* **`Basis`**

```
01 class Foo {
02       int n;
03    protected:
04       int f1(int i){
05             return i * n;
06       }
07 };
```

```
01 class Bar : Foo {
02    public:
03       int n;   // eigene Var
04       int f2(int i){
05             return f1(i) * n;
06       }
07 };
```

Vererbungsart	Elemente aus **Basis**
public	public und protected bleiben *Standard wenn* **`Abgeleitet`** *eine Struktur ist*
protected	public und protected werden zu protected
private	public und protected werden zu private *Standard wenn* **`Abgeleitet`** *eine Klasse ist*

Mehrfachvererbung

```
01 class FooBaz: public Foo, protected Baz
02 {
03     // ...
04 }
```

Mehrfachvererbung

```
01 class FooBaz: public Foo, protected Baz
02 {
03     // ...
04 }
```

Falls `Foo` und `Baz` selbe Basisklasse haben → Diamond-Problem

Virtuelle Methoden

Auswahl der **Methode**

nicht-virtuell zur Übersetzungszeit anhand des statischen Typs

virtuell zur Laufzeit anhand des „tatsächlichen“ Typs

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() { cout << "Foo::f1" << endl; };
04     virtual void f2() { cout << "Foo::f2" << endl; };
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() { cout << "Bar::f2" << endl; }
10     void f3() { cout << "Bar::f3" << endl; }
11 };
12 class Baz : public Foo {
13   public:
14     void f1() { cout << "Baz::f1" << endl; }
15     void f3() { cout << "Baz::f3" << endl; }
16 };
```

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() { cout << "Foo::f1" << endl; };
04     virtual void f2() { cout << "Foo::f2" << endl; };
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() override { cout << "Bar::f2" << endl; }
10     void f3() override { cout << "Bar::f3" << endl; }
11 };
12 class Baz : public Foo {
13   public:
14     void f1() { cout << "Baz::f1" << endl; }
15     void f3() override { cout << "Baz::f3" << endl; }
16 };
```

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() {...};
04     virtual void f2() {...};
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() override {...}
10     void f3() override {...}
11 };
12 class Baz : public Foo {
13   public:
14     void f1() {...}
15     void f3() override {...}
16 };
```

```
01 Foo foo;
02 // Nicht erlaubt
03 // Übersetzerfehler
```

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() {...};
04     virtual void f2() {...};
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() override {...}
10     void f3() override {...}
11 };
12 class Baz : public Foo {
13   public:
14     void f1() {...}
15     void f3() override {...}
16 };
```

```
01 Bar bar;
02 bar.f1();
03 // "Foo::f1"
04 bar.f2();
05 // "Bar::f2"
06 bar.f3();
07 // "Bar::f3"
```

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() {...};
04     virtual void f2() {...};
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() override {...}
10     void f3() override {...}
11 };
12 class Baz : public Foo {
13   public:
14     void f1() {...}
15     void f3() override {...}
16 };
```

```
01 Bar bar;
02 bar.f1();
03 // "Foo::f1"
04 bar.f2();
05 // "Bar::f2"
06 bar.f3();
07 // "Bar::f3"
```

```
01 Baz baz;
02 baz.f1();
03 // "Baz::f1"
04 baz.f2();
05 // "Foo::f2"
06 baz.f3();
07 // "Baz::f3"
```

Virtuelle Methoden

```
01 class Foo {
02   public:
03     void f1() {...};
04     virtual void f2() {...};
05     virtual void f3() = 0;
06 };
07 class Bar : public Foo {
08   public:
09     void f2() override {...}
10     void f3() override {...}
11 };
12 class Baz : public Foo {
13   public:
14     void f1() {...}
15     void f3() override {...}
16 };
```

```
01 Foo * foo = &bar;
02 foo->f1();
03 // "Foo::f1"
04 foo->f2();
05 // "Bar::f2"
06 foo->f3();
07 // "Bar::f3"
```

```
01 foo = &baz;
02 foo->f1();
03 // "Foo::f1"
04 foo->f2();
05 // "Foo::f2"
06 foo->f3();
07 // "Baz::f3"
```

Operatorüberladung & Freundschaft

```
01 class Complex {
02   int real, img;
03  public:
04   Complex(int real, int img) : real(real), img(img) { }
05
06   Complex operator+(const Complex &o) {
07     return Complex{real + o.real, img + o.img};
08   }
09
10   friend Complex operator-(Complex l, Complex r);
11 };
12
13 Complex operator-(Complex l, Complex r) {
14   return Complex{l.real - r.real, l.img - r.img};
15 }
16
17 std::cout << Complex{4,2} - Complex{2,1} << std::endl;
```

Operatorüberladung – wofür in StuBS?

Streamoperatoren (z.B. `cout`, abgeleitet von `ostream`)

```
01 std::cout << "Die Antwort ist " << std::hex << 66 << std::endl;
```

Operatorüberladung – wofür in STUBS?

Streamoperatoren (z.B. `cout`, abgeleitet von `ostream`)

```
01 std::cout << "Die Antwort ist " << std::hex << 66 << std::endl;
```

Äquivalent in STUBS: `OutputStream`

```
OutputStream&  OutputStream :: operator<< (bool b) {…}
```

- `OutputStream&` – Rückgabewert
- `OutputStream` – Namespace
- `operator<<` – Überladung
- `(bool b)` – Parameter
- `{…}` – Rumpf

Operatorüberladung – wofür in StuBS?

Streamoperatoren (z.B. `cout`, abgeleitet von `ostream`)

```
01 std::cout << "Die Antwort ist " << std::hex << 66 << std::endl;
```

Äquivalent in StuBS: `OutputStream`

$$\underbrace{\texttt{OutputStream\&}}_{\text{Rückgabewert}}\ \underbrace{\texttt{OutputStream}}_{\text{Namespace}}::\underbrace{\texttt{operator<<}}_{\text{Überladung}}\underbrace{\texttt{(bool b)}}_{\text{Parameter}}\ \underbrace{\texttt{\{...\}}}_{\text{Rumpf}}$$

Manipulatoren:

```
OutputStream& hex(OutputStream&){...}
```

Casting & Typkonvertierungen

const_cast	static_cast	dynamic_cast	reinterpret_cast

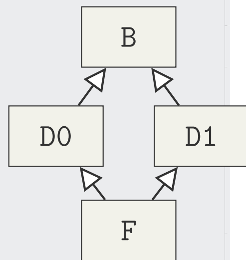
Hinzufügen oder Entfernen der Attribute `const` oder `volatile`

```
01 const int *x = get();
02 int* y = const_cast<int*>(x);
```

Casting & Typkonvertierungen

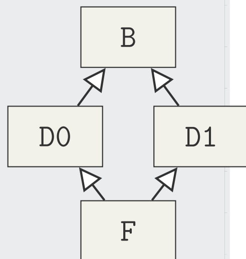
const_cast | **static_cast** | dynamic_cast | reinterpret_cast

```
01 D0 d{};
02 B *x = &d;
03 D0 *a = static_cast<D0*>(x); ✓
04 D1 *b = static_cast<D1*>(x); ϟ
05 // Laufzeit: Undef. Verhalten
06 D1 *c = static_cast<D1*>(a); ϟ
07 // Compiler: invalid static_cast from
08 // type 'D1*' to type 'D0*'
```



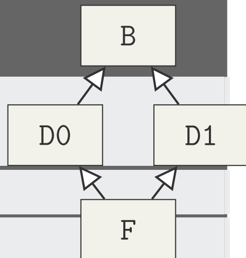
const_cast | **static_cast** | dynamic_cast | reinterpret_cast

```
01 F f{};
02 B *x = &f;
03 D0 *a = static_cast<D0*>(x); ✓
04 D1 *b = static_cast<D1*>(x); ✓
05 // Okay: F erbt von D0 und D1
06
07 D1 *c = static_cast<D1*>(a); ϟ
08 // Compiler: invalid static_cast from
09 // type 'D1*' to type 'D0*'
```



const_cast | static_cast | **dynamic_cast** | reinterpret_cast

Typprüfung zur Laufzeit (nur polymorphe Klassen):




```
01 D0 d{};
02 B *x = &d;
03 D0 *a = dynamic_cast<D0*>(x); ✓
04 D1 *b = dynamic_cast<D1*>(x); ϟ nullptr
```

Casting & Typkonvertierungen

const_cast	static_cast	dynamic_cast	reinterpret_cast

„Reinterpretieren“ der Bitwerte

```
01 char *x = reinterpret_cast<char*>(0xb8000);
```

Casting & Typkonvertierungen

`const_cast`	`static_cast`	`dynamic_cast`	`reinterpret_cast`

„Reinterpretieren“ der Bitwerte

```
01 char *x = reinterpret_cast<char*>(0xb8000);
```

C-style casts (`int x=(int) malloc(42)`) auch in C++ möglich, trotzdem **nicht verwenden**

Learning by Doing:
Aufgabe 0 (C++ Streams)