Übung zu Betriebssysteme

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++

Erste Schritte

```c
#include <stdio.h>


int main() {
    const char * str = "Informatik";
    int n = 4;
    printf("%s %d\n", str, n);
    return 0;
}
```

Erste Schritte

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

int main() {
    const string str = "Informatik";
    int n = 4;
    cout << str << ' ' << n << endl;
    return 0;
}
```

Referenzen

```
int foo = 23;
int& bar = foo;
std::cout << bar << std::endl; // Ausgabe: 23

bar = 42;
std::cout << foo << std::endl; // Ausgabe: 42
```

Referenzen als Funktionsparameter

Konstante Referenzparameter

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

Nicht-konstante Referenzparameter

```
void inc(int& i) { i++; }

int foo = 23;
inc(foo);

std::cout << foo << std::endl; // Ausgabe: 24
```

Überladen von Funktionen

```
bool isZero(int i){
    return i == 0;
}

bool isZero(double i){
    const double eps = 0.00001;
    return i < eps && i > -eps;
}
```

Überladen von Funktionen

```
bool isZero(int i){
    return i == 0;
}

bool isZero(double i){
    const double eps = 0.00001;
    return i < eps && i > -eps;
}
```

Overload resolution ist nicht trivial!

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    struct Disp p;
    p.val = 'X';
    p.x = 2;
    p.y = 0;
    cout << p.val << endl;
}

// Geht in C++ nicht:
// struct Disp p = {
//     .val = 'X',
//     .x = 2,
//     .y = 0
// }
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp() {
       val = 'X';
       this->x = 2;
       this->y = 0;
    }
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p;
    cout << p.val << endl;
}
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0) {
       val = c;
       this->x = x;
       this->y = y;
    }
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p('X', 2);
    cout << p.val << endl;
}
```

```
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
```

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

→ Häufiger, „most vexing parse“ genannter Fehler!

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0) {
       val = c;
       this->x = x;
       this->y = y;
    }
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{'X', 2};
    cout << p.val << endl;
}
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0)
      : val(c), x(x), y(y) {}
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{'X', 2};
    cout << p.val << endl;
}
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0)
      : val(c), x(x), y(y) {}

    Disp(int p) : val('X'),
        x(p % 80), y(p / 80) {}
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    cout << p.val << endl;
}
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0)
      : val(c), x(x), y(y) {}

    Disp(int p)
      : Disp('X', p % 80, p / 80) {}
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    cout << p.val << endl;
}
```

Strukturen & Klassen

disp.h:

```
int count = 0;
struct Disp {
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0)
      : val(c), x(x), y(y) {
        count++;
    }

    Disp(int p)
      : Disp('X', p % 80, p / 80) {}

    ~Disp() { count--; }
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    cout << p.val << "-"
         << count << endl;
}
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    static int count;
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0)
      : val(c), x(x), y(y) {
        count++;
    }

    Disp(int p)
      : Disp('X', p % 80, p / 80) {}

    ~Disp() { count--; }
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    cout << p.val << "-"
         << Disp::count << endl;
}

int Disp::count = 0;
```

Strukturen & Klassen

disp.h:

```
struct Disp {
    static int count;
    char val;
    int x, y;

    Disp(char c, int x=0, int y=0);

    Disp(int p)
      : Disp('X', p % 80, p / 80) {}

    ~Disp();
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    cout << p.val << "-"
         << Disp::count << endl;
}

int Disp::count = 0;

Disp::Disp(char c, int x, int y)
  : val(c), x(x), y(y) {
    count++;
}

Disp::~Disp() { count--; }
```

Strukturen & Klassen

disp.h:

```
struct Disp {
  private:
    static int count;
    char val;
    int x, y;

  public:
    Disp(char c, int x=0, int y=0);
    Disp(int p);
    ~Disp();
};
```

disp.cc:

```
#include "disp.h"
using namespace std;

void func() {
    Disp p{2};
    // Übersetzerfehler bei:
    cout << p.val << endl;
}

int Disp::count = 0;

Disp::Disp(char c, int x, int y)
  : val(c), x(x), y(y) {
    count++;
}

Disp::~Disp() { count--; }
```

Strukturen & Klassen

```
class Disp {
    static int count;
    char val;
    int x, y;

  public:
    Disp(char c, int x=0, int y=0);
    Disp(int p);
    ~Disp();
};
```

Unterschied Standardsichtbarkeit

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

Vererbung

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

```
class Foo {
    int n;
  protected:
    int f1(int i){
        return i * n;
    }
};
```

```
class Bar : Foo {
  public:
    int n;  // eigene Var
    int f2(int i){
        return f1(i) * n;
    }
};
```

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

```
class FooBaz: public Foo, protected Baz
{
    // ...
}
```

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

```
class Foo {
  public:
    void f1() { cout << "Foo::f1" << endl; };
    virtual void f2() { cout << "Foo::f2" << endl; };
    virtual void f3() = 0;
};
class Bar : public Foo {
  public:
    void f2() override { cout << "Bar::f2" << endl; }
    void f3() override { cout << "Bar::f3" << endl; }
};
class Baz : public Foo {
  public:
    void f1() { cout << "Baz::f1" << endl; }
    void f3() override { cout << "Baz::f3" << endl; }
};
```

Virtuelle Methoden

```
class Foo {
  public:
    void f1() {...};
    virtual void f2() {...};
    virtual void f3() = 0;
};
class Bar : public Foo {
  public:
    void f2() override {...}
    void f3() override {...}
};
class Baz : public Foo {
  public:
    void f1() {...}
    void f3() override {...}
};
```

```
Foo foo;
// Nicht erlaubt
// Übersetzerfehler
```

Virtuelle Methoden

```
class Foo {
  public:
    void f1() {...};
    virtual void f2() {...};
    virtual void f3() = 0;
};
class Bar : public Foo {
  public:
    void f2() override {...}
    void f3() override {...}
};
class Baz : public Foo {
  public:
    void f1() {...}
    void f3() override {...}
};
```

```
Bar bar;
bar.f1();
// "Foo::f1"
bar.f2();
// "Bar::f2"
bar.f3();
// "Bar::f3"

Baz baz;
baz.f1();
// "Baz::f1"
baz.f2();
// "Foo::f2"
baz.f3();
// "Baz::f3"
```

Virtuelle Methoden

```
class Foo {
  public:
    void f1() {...};
    virtual void f2() {...};
    virtual void f3() = 0;
};
class Bar : public Foo {
  public:
    void f2() override {...}
    void f3() override {...}
};
class Baz : public Foo {
  public:
    void f1() {...}
    void f3() override {...}
};
```

```
Foo * foo = &bar;
foo->f1();
// "Foo::f1"
foo->f2();
// "Bar::f2"
foo->f3();
// "Bar::f3"

foo = &baz;
foo->f1();
// "Foo::f1"
foo->f2();
// "Foo::f2"
foo->f3();
// "Baz::f3"
```

Operatorüberladung & Freundschaft

```
class Complex {
  int real, img;
 public:
  Complex(int real, int img) : real(real), img(img) { }

  Complex operator+(const Complex &o) {
    return Complex{real + o.real, img + o.img};
  }

  friend Complex operator-(Complex l, Complex r);
};

Complex operator-(Complex l, Complex r) {
  return Complex{l.real - r.real, l.img - r.img};
}

std::cout << Complex{4,2} - Complex{2,1} << std::endl;
```

Operatorüberladung – wofür in StuBS?

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

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

Äquivalent in StuBS: `OutputStream`

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

Manipulatoren:

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

Casting & Typkonvertierungen

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

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

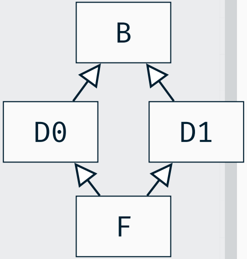
```
const int *x = get();
int* y = const_cast<int*>(x);
```

Casting & Typkonvertierungen

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

```
D0 d{};
B *x = &d;
D0 *a = static_cast<D0*>(x); ✓
D1 *b = static_cast<D1*>(x); ↯
// Laufzeit: Undef. Verhalten

D1 *c = static_cast<D1*>(a); ↯
// Compiler: invalid static_cast from
// type 'D1*' to type 'D0*'
```

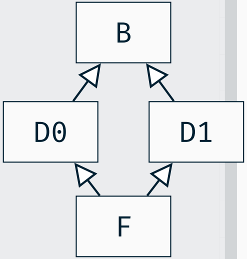


Casting & Typkonvertierungen

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

```
F f{};
B *x = &f;
D0 *a = static_cast<D0*>(x); ✓
D1 *b = static_cast<D1*>(x); ✓
// Okay: F erbt von D0 und D1

D1 *c = static_cast<D1*>(a); ↯
// Compiler: invalid static_cast from
// type 'D1*' to type 'D0*'
```

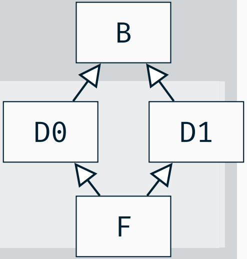


Casting & Typkonvertierungen

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

Typprüfung zur Laufzeit (nur polymorphe Klassen):

```
D0 d{};
B *x = &d;
D0 *a = dynamic_cast<D0*>(x); ✓
D1 *b = dynamic_cast<D1*>(x); ↯ nullptr
```



Casting & Typkonvertierungen

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

„Reinterpretieren“ der Bitwerte

```
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)