EDAF50 – C++ Programming

10. <chrono>. *Concurrency. Integer types.*

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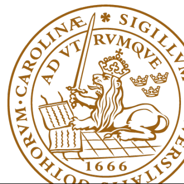


Outline

1. Time representation
2. Concurrency
3. Types
   - Integer types
   - Type casts

What is a value

The semantics of a value often include

- a quantity
- a number
- a unit

E.g `int length = 2;`

- two meters?
- two millimeters?

Including quantity and unit in the ***type*** *helps avoid mistakes.*

Time representation

- A "time value" can be either
  - A duration – a time interval
  - A point in time
    - relative to a particular *clock*
- Different units
  - seconds
  - milliseconds
  - nanoseconds
  - *manual conversion error prone*
- Different semantics
  - `duration + duration = duration`
  - `duration - duration = duration`
  - `time_point + duration = time_point`
  - `time_point - duration = time_point`
  - `time_point - time_point = duration`
  - `time_point + time_point =` *error*

Time representation
<chrono>

- Uses the type system to denote
  - if a value is a duration or a point in time
  - the unit used (seconds, milliseconds, etc.)
  - which clock a point in time is relative to
    - `system_clock` – wall clock time
    - `steady_clock` – stopwatch
- Uses compile-time computations for
  - conversions between units
    - implicit conversions when safe
    - explicit conversions when loosing information
    - E.g. `duration_cast<seconds>(milliseconds)`

Time representation
<chrono>

A duration is

- an *integer value* and
- *a ratio* (the number of seconds between two values).

```
std::chrono::nanoseconds duration<signed integer (>= 64 bits),
                                  std::nano>
std::chrono::microseconds duration<signed integer (>= 55 bits),
                                  std::micro>
std::chrono::milliseconds duration<signed integer (>= 45 bits),
                                  std::milli>

std::chrono::seconds duration<signed integer (>= 35 bits)>

std::chrono::minutes duration<signed integer (>= 29 bits),
                              std::ratio<60>>
std::chrono::hours   duration<signed integer (>= 23 bits),
                              std::ratio<3600>>
```

`std::ratio` provides compile-time rational arithmetic

Concurrency

- Tasks and threads
- Passing arguments
- Returning results
- Sharing data
- Waiting for events
- Communicating tasks

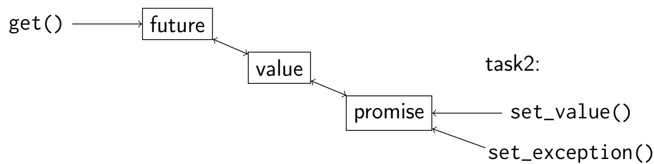
Concurrency

Demo

Concurrency
futures and promises

- Transfer a value between tasks without an explicit lock
- A `future` represents a (possibly not yet existing) result of a computation
- A `promise` is used to deliver a value to a future

task1:



Concurrency
packaged_task

A future is connected to a promise

- create a `promise`
- get a `future` by calling `promise::get_future()`

More conventient to use a `packaged_task`

- a function (object) and the associated future and promise

Concurrency

Demo

Integer types

- Signed integers

Type	Size	Range (at least)
`signed char`	8 bits	$[-127, 127]^*$
`short`	at least 16 bits	$[-2^{15}+1,\ 2^{15}-1]$
`int`	at least 16 bits, usually 32	$[-2^{15}+1,\ 2^{15}-1]$
`long`	at least 32 bits	$[-2^{31}+1,\ 2^{31}-1]$
`long long`	at least 64 bits	$[-2^{63}+1,\ 2^{63}-1]$

*typically $[-128, 127]$, etc.

- Unsigned integers
  - same size as corresponding **`signed`** type
  - **`unsigned char`**: $[0, 255]$, **`unsigned short`**: $[0,\ 2^{16}-1]$. etc.
- special case
  - **`char`** (can be *represented* as **`signed char`** *or* **`unsigned char`**)
  - Use **`char`** only for characters
  - Use **`signed char`** or **`unsigned char`** for integer values
- Sizes according to the standard:
  `char` $\leq$ **`short`** $\leq$ **`int`** $\leq$ **`long`** $\leq$ **`long long`**

Integer types
Overflow

- overflow of an **unsigned** n-bit integer is defined as *the value modulo* 2^n
- overflow of a **signed** integer is *undefined*

Integer types

Example with sizeof

```
#include <iostream>
using namespace std;
int main () {
   cout << "sizeof(char)= \t" << sizeof(char)<<endl;
   cout << "sizeof(short)= \t" << sizeof(short) <<endl;
   cout << "sizeof(int) = \t" << sizeof(int) <<endl;
   cout << "sizeof(long)= \t" << sizeof(long)<<endl;
}
```

```
sizeof(char)=   1
sizeof(short)=  2
sizeof(int) =   4
sizeof(long)=   8
```


Integer types – Example of value range by casting
or: *be careful with casts* from **signed** to **unsigned** types

```
int main () {
 cout << "(signed char) -1 = " << (int)(signed char) -1 << endl;
 cout << "(unsigned char) -1 = " << (int)(unsigned char) -1 << endl;
 cout << "(short int) -1 = " << (short int) -1 << endl;
 cout << "(unsigned short int) -1 = "<<(unsigned short int)-1<<endl;
 cout << "(int) -1 = " << (int) -1 << endl;
 cout << "(unsigned int) -1 = " << (unsigned int) -1 << endl;
 cout << "(long) -1 = " << (long) -1 << endl;
 cout << "(unsigned long) -1 = " << (unsigned long) -1 << endl;

}
```

```
(char) -1 = -1
(unsigned char) -1 = 255
(short int) -1 = -1
(unsigned short int) -1 = 65535
(int) -1 = -1
(unsigned int) -1 = 4294967295
(long) -1 = -1
(unsigned long) -1 = 18446744073709551615
```


Integer types
Sizes are specified in `<climits>`

```
CHAR_BIT    Number of bits in a char object (byte)  (>=8)
SCHAR_MIN   Minimum value for an object of type signed char
SCHAR_MAX   Maximum value for an object of type signed char
UCHAR_MAX   Maximum value for an object of type unsigned char
CHAR_MIN    Minimum value for an object of type char
            (either SCHAR_MIN or 0)
CHAR_MAX    Maximum value for an object of type char
            (either SCHAR_MAX or UCHAR_MAX)
SHRT_MIN    Minimum value for an object of type short int
SHRT_MAX    Maximum value for an object of type short int
USHRT_MAX   Maximum value for an object of type unsigned short int
INT_MIN     Minimum value for an object of type int
INT_MAX     Maximum value for an object of type int
UINT_MAX    Maximum value for an object of type unsigned int
LONG_MIN    Minimum value for an object of type long int
LONG_MAX    Maximum value for an object of type long int
ULONG_MAX   Maximum value for an object of type unsigned long int
LLONG_MIN   Minimum value for an object of type long long int
LLONG_MAX   Maximum value for an object of type long long int
ULLONG_MAX  Maximum value for an object of type unsigned long long
```


Integer types
Sizes are specified in `<climits>`

```
#include <iostream>
#include <climits>
int main()
{
    std::cout << CHAR_MIN << ", " << CHAR_MAX << ", ";
    std::cout << UCHAR_MAX << std::endl;
    std::cout << SHRT_MIN << ", " << SHRT_MAX << ", ";
    std::cout << USHRT_MAX << std::endl;
    std::cout << INT_MIN << ", " << INT_MAX << ", ";
    std::cout << UINT_MAX << std::endl;
    std::cout << LONG_MIN << ", " << LONG_MAX << ", ";
    std::cout << ULONG_MAX << std::endl;
    std::cout << LLONG_MIN << ", " << LLONG_MAX << ", ";
    std::cout << ULLONG_MAX << std::endl;

}
```

```
128, 127, 255
-32768, 32767, 65535
-2147483648, 2147483647, 4294967295
-9223372036854775808, 9223372036854775807, 18446744073709551615
-9223372036854775808, 9223372036854775807, 18446744073709551615
```


Integer types
Sizes are implementation defined

Typedefs for specific sizes are in <cstdint> (`<stdint.h>`)

- integer types with exact with:
  `int8_t int16_t int32_t int64_t`
- fastest signed integer type with at least the width
  `int_fast8_t int_fast16_t int_fast32_t int_fast64_t`
- smallest signed integer type with at least the width
  `int_least8_t int_least16_t int_least32_t int_least64_t`
- signed integer type capable of holding a pointer:
  `intptr_t`
- unsigned integer type capable of holding a pointer:
  `uintptr_t`

The corresponding unsigned typedefs are named `uint_...._t`

Type casts
Implicit conversions

Automatic conversions

- Expressions of the type $x \odot y$, for some binary operator $\odot$
  E.g.: `double + int ==> double`
  `float + long + char ==> float`
- Assignments and initialization: The value of the right-hand-side is converted to the type of the left-hand-side
- Conversion of an argument to the type of the (formal) parameter
- Expresions in `if` statements, etc. ⇒ `bool`
- built-in array ⇒ pointer (*array decay*)
- `0` ⇒ `nullptr` (empty pointer in C++11, previously the constant `NULL` was defined)

type casts
Named casts (C++-11)

Example

```
char c;                 // 1 byte
int *p = (int*) &c;     // pointer to int: 4 bytes

*p = 5; // undefined behaviour, stack corruption

int *q = static_cast<int*> (&c); // compiler error
```

- `static_cast<new_type> (expr)`
  - convert between compatible types (*does not do range check*)
  - "the inverse of a standard implicit conversion sequence"
- `reinterpret_cast<new_type> (expr)`
  - no safety net, same as C-style cast
- `const_cast<new_type> (expr)` - remove `const`
- `dynamic_cast<new_type> (expr)` - use for pointers to objects in class hierarchies. Uses *run-time type info*, like `instanceof` in Java.

Type casting
C style casts

Syntax in C and in C++, like in Java

`(type) expression` , e.g. `(float) 10`

- Greater risk of mistakes - use named casts
  - makes the code clearer, e.g., **const_cast** can only change **const**
  - easy to search for: casts are among the first to look for when debugging
- Warning in GCC: `-Wold-style-casts`
- Common in older code

Alternative syntax in C++

```
type(expression)
```

`type` must be *a single word*,
`int *(...)` eller i.e., `unsigned long(...)` is not OK.

Type casts
Warning example

```
struct Point{
    int x;
    int y;
};

struct Point3d {
    int x;
    int y;
    int z;
};
```

Point: | x: | y: |

Point3d: | x: | y: | z: |

Data types and variables

- some concepts:
  - a *type* defines the set of possible values and operations (for an *object*)
  - an *object* is a place in memory that holds a *value*
  - a *value* is a set of bits interpreted according to a *type*.

*A typecast changes the **value** of a particurlar memory location by changing how **it** should be **interpreted**.*

Type casts
Warning example

```
struct Point{
    int x;
    int y;
};

Point ps[3];

struct Point3d{
    int x;
    int y;
    int z;
};
Point3d* foo = (Point3d*) ps;
```

ps: x: y: ~~x~~ z: ~~y~~ x: ~~x~~ y: ~~y~~ z:

$ps[0]$, $ps[1]$, $ps[2]$; $foo[0]$, $foo[1]$

With *named casts*, this requires a **reinterpret_cast**<Point3d*>

With **static_cast**<Point3d*> the compiler gives the error
`invalid static_cast from type 'Point[3] to type 'Point3d*'`

special case: `void` pointer

A **void*** can point to an object of any type

In C
: a **void*** is implicitly converted to/from any pointer type.

In C++
: a T* is implicitly converted to **void***. The other direction requires an explicit *type cast*.

Next lecture
Low-level details and loose ends

References to sections in Lippman

C-style strings	3.5.4
Multi-dimensional arrays	3.6
Bitwise operations	4.8
The comma operator	4.10
Union	19.6
Bit-fields	19.8.1

Suggested reading

References to sections in Lippman

Built-in types	2.1
Type casts	4.11