Lifetime of the C++ object?

Dawid Pilarski

dawid.pilarski@tomtom.com
dawid.pilarski@panicsoftware.com
blog.panicsoftware.com

Introduction

Agenda

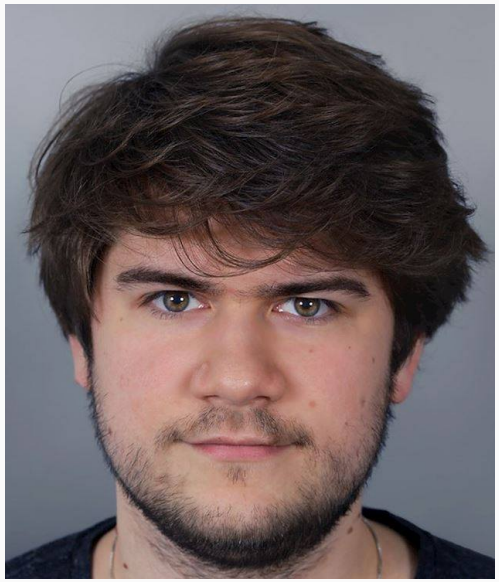
Theory

Object model intuition

Beyond the object lifetime.

Who am I?

Dawid Pilarski



- Senior Software Developer in TomTom
- Member of the ISO/JTC1/SC22/WG21
- Member of the PKN KT **(programming languages)**
- C++ blog writer

Questions.

Questions...

What we talk about are basics.

6 Basics [basic]

6.7 Memory and objects [basic.memobj]

6.7.2 Object model [intro.object]

1 The constructs in a C++ program create, destroy, refer to, access, and manipulate objects. An *object* is created by a definition, by a *new-expression*, when implicitly changing the active member of a union, or when a temporary object is created ([conv.rval], [class.temporary]). An object occupies a region of storage in its period of construction ([class.cdtor]), throughout its lifetime, and in its period of destruction ([class.cdtor]). [*Note:* A function is not an object, regardless of whether or not it occupies storage in the way that objects do. — *end note*] The properties of an object are determined when the object is created. An object can have a name ([basic.pre]). An object has a storage duration ([basic.stc]) which influences its lifetime ([basic.life]). An object has a type ([basic.types]). Some objects are polymorphic ([class.virtual]); the implementation generates information associated with each such object that makes it possible to determine that object's type during program execution. For other objects, the interpretation of the values found therein is determined by the type of the *expressions* ([expr.compound]) used to access them.

2 Objects can contain other objects, called *subobjects*. A subobject can be a *member subobject* ([class.mem]), a *base class subobject* ([class.derived]), or an array element. An object that is not a subobject of any other object is called a *complete object*. If an object is created in storage associated with a member subobject or array element *e* (which may or may not be within its lifetime), the created object is a subobject of *e*'s containing object if:

(2.1) — the lifetime of *e*'s containing object has begun and not ended, and

(2.2) — the storage for the new object exactly overlays the storage location associated with *e*, and

(2.3) — the new object is of the same type as *e* (ignoring cv-qualification).

3 If a complete object is created ([expr.new]) in storage associated with another object *e* of type "array of *N* `unsigned char`" or of type "array of *N* `std::byte`" ([cstddef.syn]), that array *provides storage* for the created object if:

(3.1) — the lifetime of *e* has begun and not ended, and

(3.2) — the storage for the new object fits entirely within *e*, and

Theory

Title decomposition

What's the lifetime of your object?

Title decomposition

What's the lifetime of your object?

- What is a lifetime?

Title decomposition

What's the lifetime of your object?

- What is a lifetime?
- What is an object?

Objects

The object

Objects are:

- created
- destroyed
- refered to
- accessed
- manipulated

The Object

Is created:

- by the definition

```
int a;
```

The Object

Is created:

- by the definition
- by the new expression

```
new int(5);
```

The Object

Is created:

- by the definition
- by the new expression
- when changing active member of a union

```
union U{int x; int y;};

U u;
u.y = 2; // active member y;
```

The Object

Is created:

- by the definition
- by the new expression
- when changing active member of a union
- by creation of the temporary

```
int{};
```

The object

Has:

- optional name

The object

Has:

- optional name
- storage and it's duration

The object

Has:

- optional name
- storage and it's duration
  - static

program duration

The object

Has:

- optional name
- storage and it's duration
  - static
  - thread

thread duration

The object

Has:

- optional name
- storage and it's duration
  - static
  - thread
  - automatic

enclosing scope duration

The object

Has:

- optional name
- storage and it's duration
  - static
  - thread
  - automatic
  - dynamic

controlled by user

The object

Has:

- optional name
- storage and it's duration
  - static
  - thread
  - automatic
  - dynamic
- lifetime

The object

Has:

- optional name
- storage and it's duration
  - static
  - thread
  - automatic
  - dynamic
- lifetime
- type

The object

Is not a reference (although reference has lifetime)

The variable

Is created by a declaration of an object or the reference.

The variable

Is created by a declaration of an object or the reference.

```
int x;
```

Is a variable.

The variable

Is created by a declaration of an object or the reference.

```
int x;
```

Is a variable.

```
int& x = ...
```

Is variable.

The variable

Is created by a declaration of an object or the reference.

```
int x;
```

Is a variable.

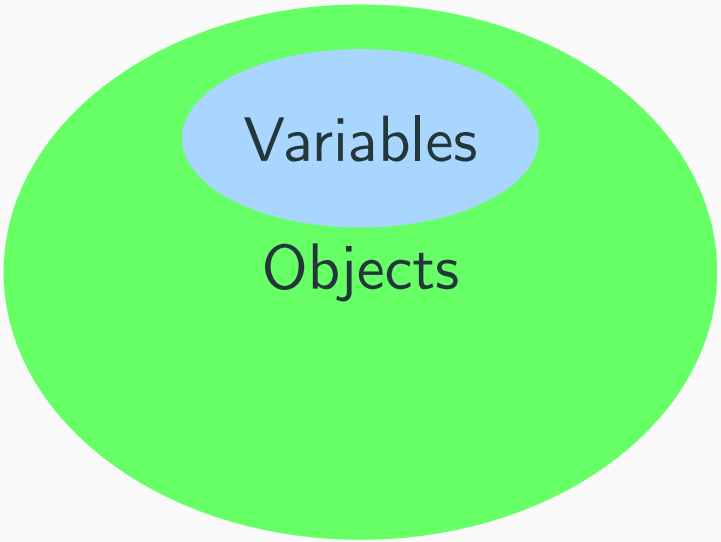
```
int& x = ...
```

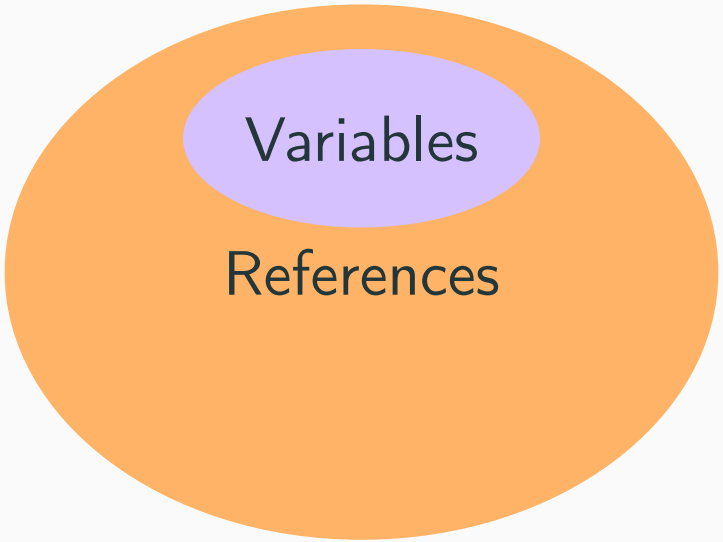
Is variable.

```
struct X{int z;}x;
```

Neither `X` nor `z` are variables.
`x` is a variable.

Summary: variable, reference, object





Summary: variable, reference, object

Just in case you want to check validity with the cppreference:

- The object has been recently updated.

Summary: variable, reference, object

Just in case you want to check validity with the cppreference:

- The object has been recently updated.
- The variable definition is unmaintained and unsupported.

Summary: variable, reference, object

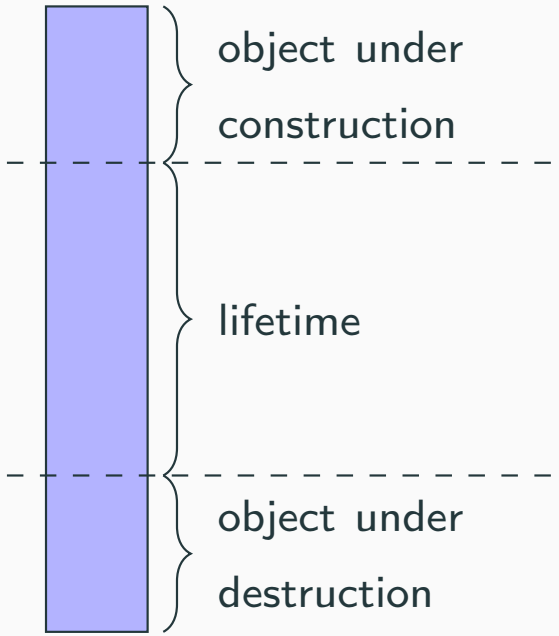
Just in case you want to check validity with the cppreference:

- The object has been recently updated.
- The variable definition is unmaintained and unsupported.
- Same about references...

Lifetime

What is a lifetime?

Lifetime is a runtime property of an object.



During the lifetime of an object you can use it without additional restrictions.

When does the lifetime start?

The lifetime of an object starts, when:

- storage with the proper alignment and size for type T is obtained

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The lifetime of an object starts, when:

- storage with the proper alignment and size for type T is obtained
- its initialization (if any) is complete
- if the object is a union member or subobject thereof, its lifetime only begins if that union member is the initialized member

When does the lifetime end?

The lifetime of an object ends, when:

- object is destroyed (for non class types),

When does the lifetime end?

The lifetime of an object ends, when:

- object is destroyed (for non class types),
- destructor is called (for the class types), or

When does the lifetime end?

The lifetime of an object ends, when:

- object is destroyed (for non class types),
- destructor is called (for the class types), or
- storage occupied by an object is reused or released.

Object model intuition

Vacuous initialization and trivial types

You need to create a variable, even if you do not think so (additional copy)

TBAA

How to fix above

Richard's changes to the implicit object creation.

Beyond the object lifetime.

Before birth

Delayed members initialization

Concurrent access and vptr

dynamic_cast and type_id

Afterlife

vptr and synchronization in the destructor

Immortality