xeus-cling

Johan Mabille, Loic Gouarin and Sylvain Corlay

Jul 18, 2019

INSTALLATION

xeus-cling is a Jupyter kernel for C++ based on the C++ interpreter cling and the native implementation of the Jupyter protocol xeus.

CHAPTER

ONE

LICENSING

We use a shared copyright model that enables all contributors to maintain the copyright on their contributions.

This software is licensed under the BSD-3-Clause license. See the LICENSE file for details.

1.1 Installation

1.1.1 Using the conda package

A package for xeus-cling is available on the conda package manager.

```
conda install -c conda-forge xeus-cling
```

1.1.2 From source with cmake

You can also install `xeus-cling` from source with cmake. This requires that you have all the dependencies installed in the same prefix.

```
mkdir build
cd build
cmake -DCMAKE_INSTALL_PREFIX=/path/to/prefix ..
make install
```

On Windows platforms, from the source directory:

```
mkdir build
cd build
cmake -G "NMake Makefiles" -DCMAKE_INSTALL_PREFIX=/path/to/prefix ..
nmake
nmake install
```

1.2 Magic commands

Magics are special commands for the kernel that are not part of the C++ programming language.

There are defined with the symbol `%` for a line magic and `%%` for a cell magic.

A few magics are available in xeus-cling. In the future, user-defined magics will also be enabled.

1.2.1 %%file

This magic command copies the content of the cell in a file named *filename*.

```
%%file [-a] filename
```

- Example

```
In [1]: %%file tmp.txt
        Demo of magic command

        Writing tmp.txt

In [2]: %%file -a tmp.txt
        append at the end

        Appending to tmp.txt

In [3]: !cat tmp.txt

        Demo of magic command
        append at the end

In [ ]:
```

- Optional argument:

-a	append the content to the file.

1.2.2 %timeit

Measure the execution time execution for a line statement (*%timeit*) or for a block of statements (*%%timeit*)

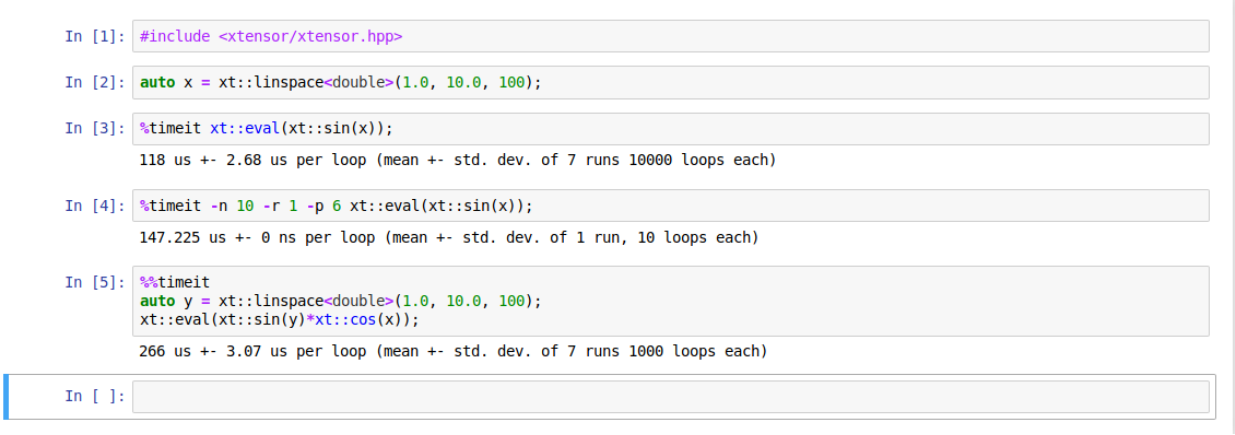
- Usage in line mode

```
%timeit [-n<N> -r<R> -p<P>] statement
```

- Usage in cell mode

```
%%timeit [-n<N> -r<R> -p<P>]
statements
```

- Example



- Optional arguments:

-n	execute the given statement <N> times in a loop. If this value is not given, a fitting value is chosen.
-r	repeat the loop iteration <R> times and take the best result. Default: 7
-p	use a precision of <P> digits to display the timing result. Default: 3

1.3 Displaying rich content

The Jupyter rich display system allows displaying rich content in the Jupyter notebook and other frontend.

This is achieved by sending mime bundles to the front-end containing various representations of the data that the frontend may use.

A mime bundle may contain multiple alternative representations of the same object for example

- a `text/html` representation for the notebook and other web frontends.
- a `text/plain` representation for the console.

Besides plain text and html, other mime type can be used such as `image/png` or even custom mime type for which a renderer is available in the front-end.

1.3.1 Default plain text representation

By default, xeus-cling provides a plain text representation for any object.

In the case of a basic type such as `double` or `int`, the value will be displayed.

For sequences (exposing an iterator pair `begin` / `end`), the content of the sequence is also displayed.

Finally, for more conplex types, the address of the object is displayed.

1.3.2 Providing custom mime representations for user-defined types

For a user-defined class `myns::foo`, you can easily provide a mime representation taylored to your needs such as a styled `html` table including the values of various attributes.

This can be achieved by simply overloading the function

```
nlohmann_json mime_bundle_repr(const foo&);
```

in the same namespace `myns` as `foo`.

The rich display mechanism of `xeus-cling` will pick up this function through argument-dependent-lookup (ADL) and make use of it upon display.

Example: `image/png` representation of an image class

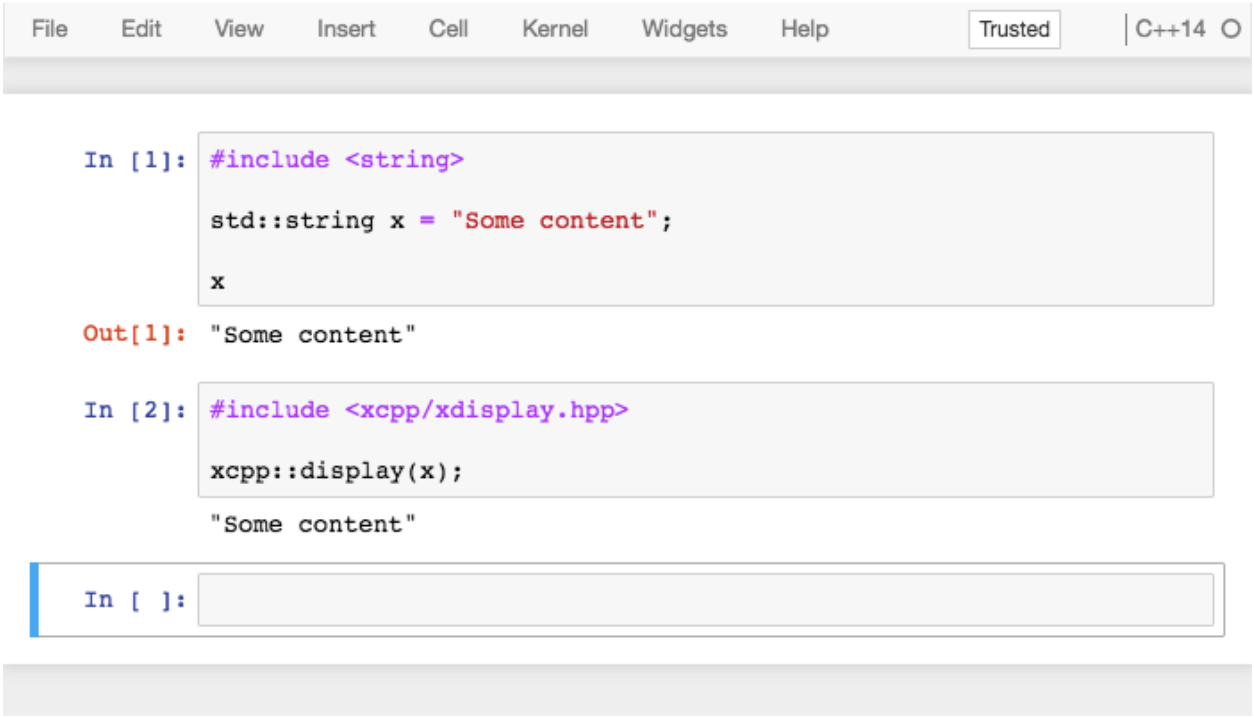
In this example, the `im::image` class holds a buffer read from a file. The `mime_bundle_repr` overload defined in the same namespace simply forwards the buffer to the frontend.

```
#include <string>
#include <fstream>

#include "xtl/xbase64.hpp"
#include "nlohmann/json.hpp"

namespace im
{
    struct image
    {
        inline image(const std::string& filename)
        {
            std::ifstream fin(filename, std::ios::binary);
            m_buffer << fin.rdbuf();
        }

        std::stringstream m_buffer;
    };

    nlohmann::json mime_bundle_repr(const image& i)
    {
        auto bundle = nlohmann::json::object();
        bundle["image/png"] = xtl::base64encode(i.m_buffer.str());
        return bundle;
    }
}
```

1.3.3 Displaying content in the frontend

The first way to display an object in the front-end is to omit the last semicolon of a code cell. When doing so, the last expression will be displayed.

Another way of achieving this, is to include the `xcpp::display` function and passing the object to display. `xcpp::display` is defined in the `<xcpp/xdisplay.hpp>` header.



Note: A subtle distinction between using `xcpp::display` and omitting the last semicolon is that the latter results in a cell *output* including a prompt number, while the former will only show the rich front-end representation.

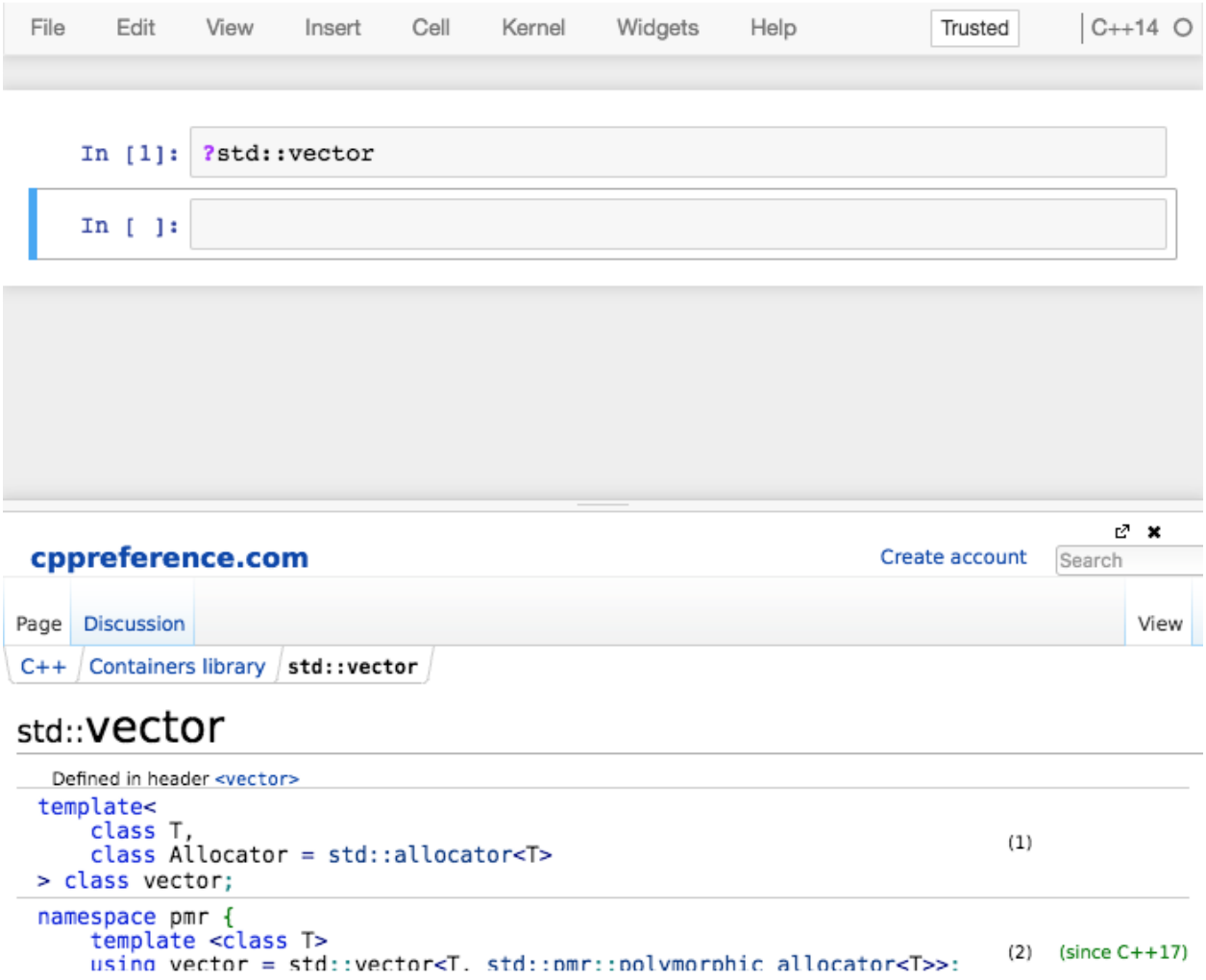
This behavior is consistent to the Python kernel implementation where `1` results in an output while `print(1)` result in a display message.

1.4 Inline documentation

1.4.1 The standard library

The `xeus-cling` kernel allows users to access help on functions and classes of the standard library.

In a code cell, typing `?std::vector` will simply display the help page on vector from the cppreference website.



1.4.2 Enabling the quick-help feature for third-party libraries

The quick help feature can be enabled for other libraries. To do so, a doxygen tag file for your library must be placed under the `xcpp` *data* directory of the installation prefix, namely

```
PREFIX/share/xcpp/tagfiles
```

For `xeus-cling` to be able to make use of that information, a JSON configuration file must be placed under the `xcpp` *configuration* directory of the installation prefix, namely

```
PREFIX/etc/xcpp/tags.d
```

Note: For more information on how to generate tag files for a doxygen documentation, check the relevant section of the doxygen documentation.

The format for the JSON configuration file is the following

```
{
    "url": "Base URL for the documentation",
    "tagfile": "Name of the doxygen tagfile"
}
```

For example the JSON configuration file for the documentation of the standard library is

```
{
    "url": "https://en.cppreference.com/w/",
    "tagfile": "cppreference-doxygen-web.tag.xml"
}
```

Note: We recommend that you only use the `https` protocol for the URL. Indeed, when the notebook is served over `https`, content from unsecure sources will not be rendered.

1.4.3 The case of breathe and sphinx documentation

Another popular documentation system is the combination of doxygen and sphinx, thanks for the breathe package, which generates sphinx documentation using the XML output of doxygen.

The xhale Python package can be used to convert the sphinx inventory files produced breathe into doxygen tag files.