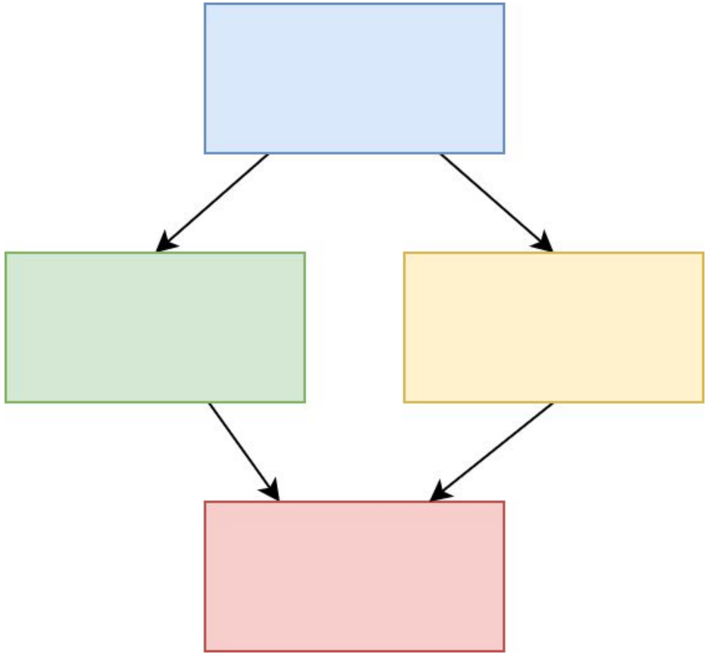
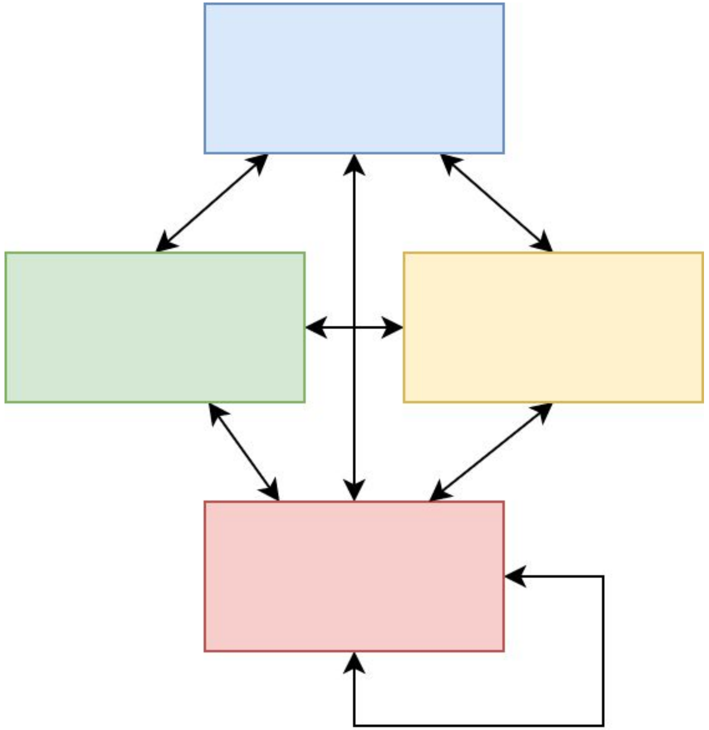
Modern CMake for modular design





Did you ever...

About this talk

- Modular design
- Build systems (CMake in particular)
- … and how to combine that to improve your codeline

Hello!

I am Mathieu Ropert

I'm a senior developer at Murex, a contributor to Conan, and I love portable C++.

You can reach me at:

- ✉ mro@puchiko.net
- @MatRopert
- @mropert

Let’s talk about CMake

- Not a build system!
- “Cross-platform C++ build generator”
- First released in 2000
- Used by many projects

Let’s talk about CMake

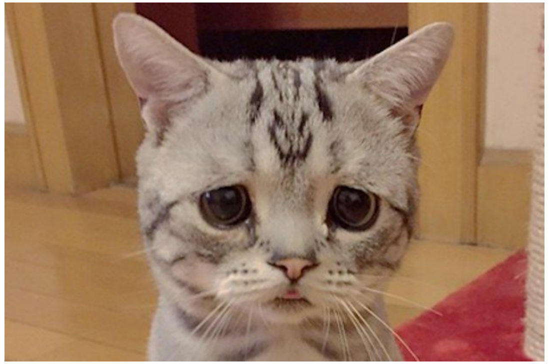
```
> cmake -G “Visual Studio 15 2017 Win64” .
```

```
$ cmake -DCMAKE_CXX_COMPILER=”clang++”
      -DCMAKE_CXX_FLAGS=”-stdlib=libc++ -m64” .
```

Modern CMake?

- Available since version 2.8.12 (Oct 2013)
- In practice, version 3.0.0 (June 2014)

```
cmake_minimum_required(VERSION 2.8)
```



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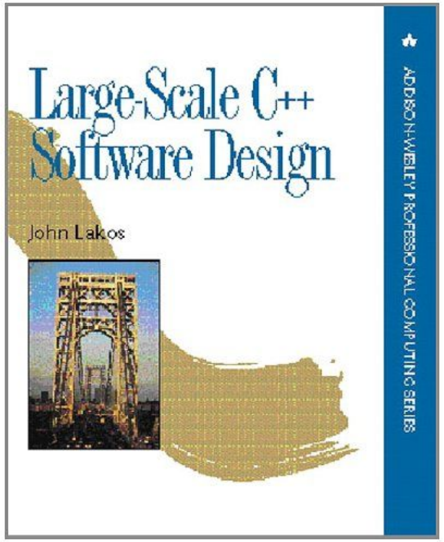
Modular Design

A brief recap of the philosophy

Modular Design at scale

- *Large-Scale C++ Software Design (1996)*
- *Advanced Levelization techniques* talk series *(CppCon 2016)*


Large-Scale C++ Software Design
John Lakos
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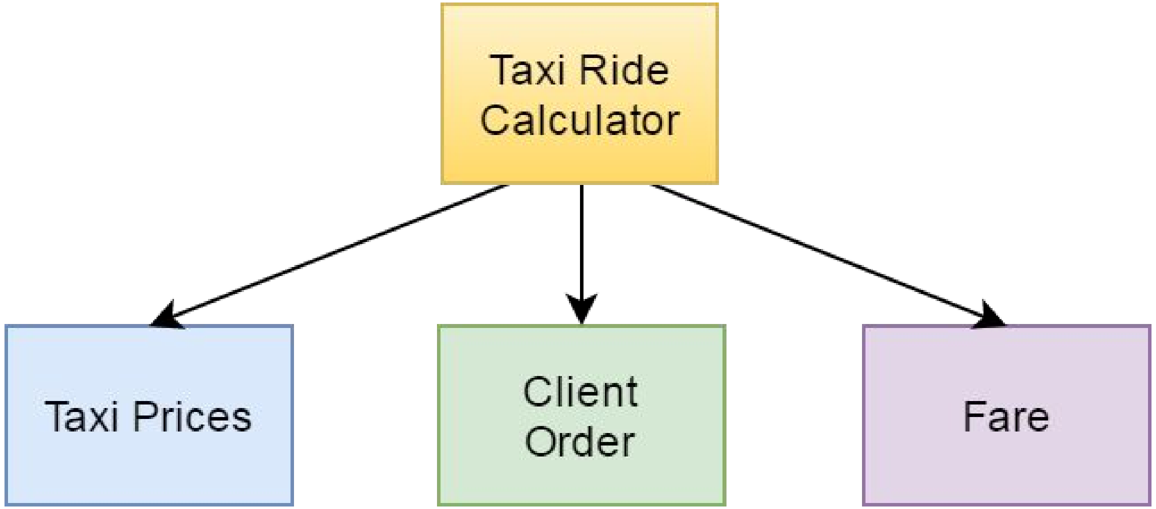
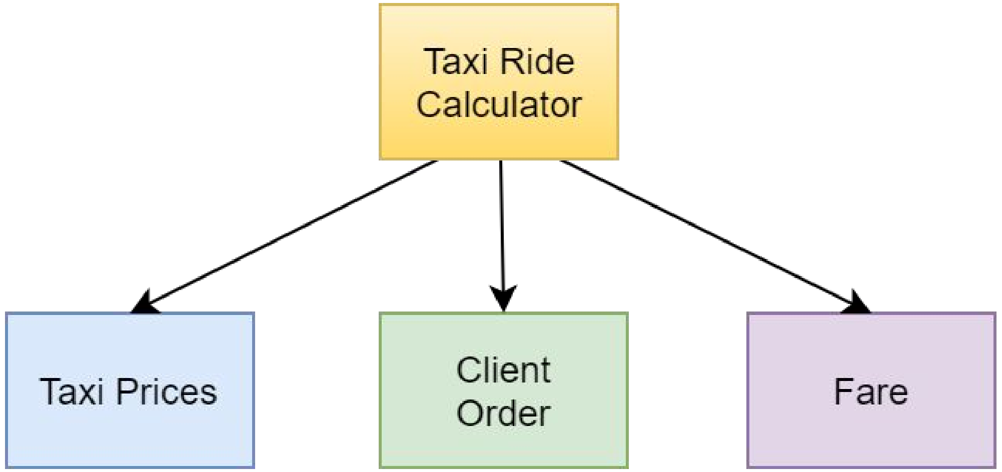

Taxi Ride Calculator
Taxi Prices
Client Order
Fare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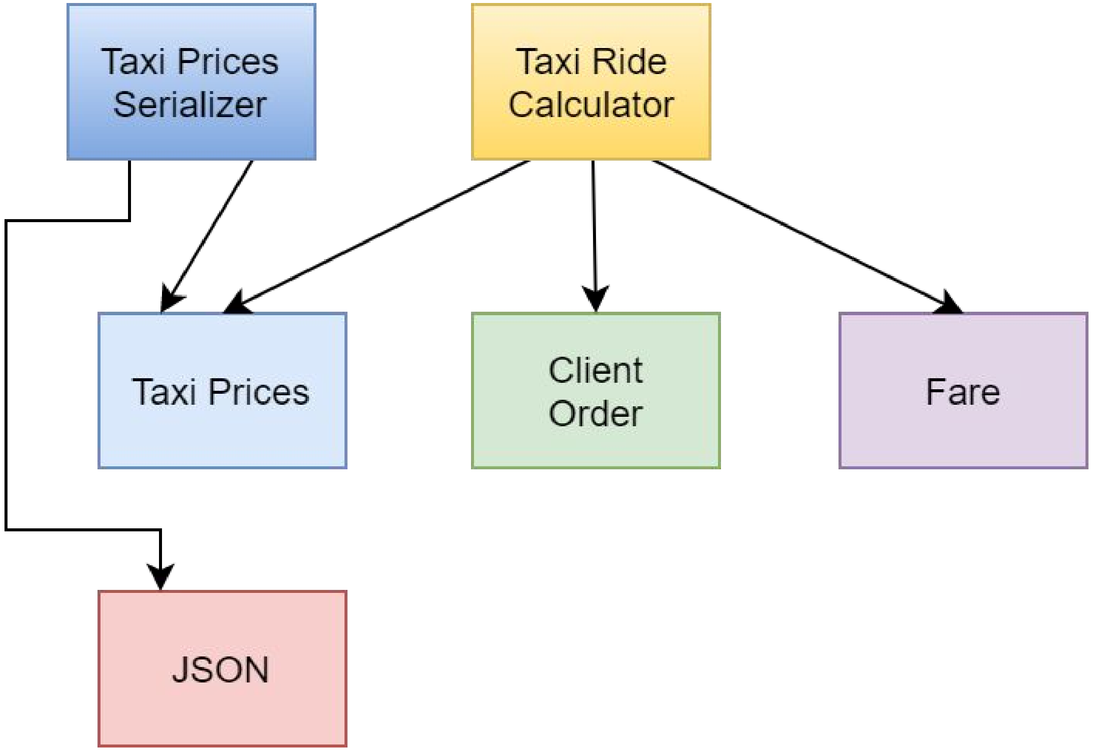
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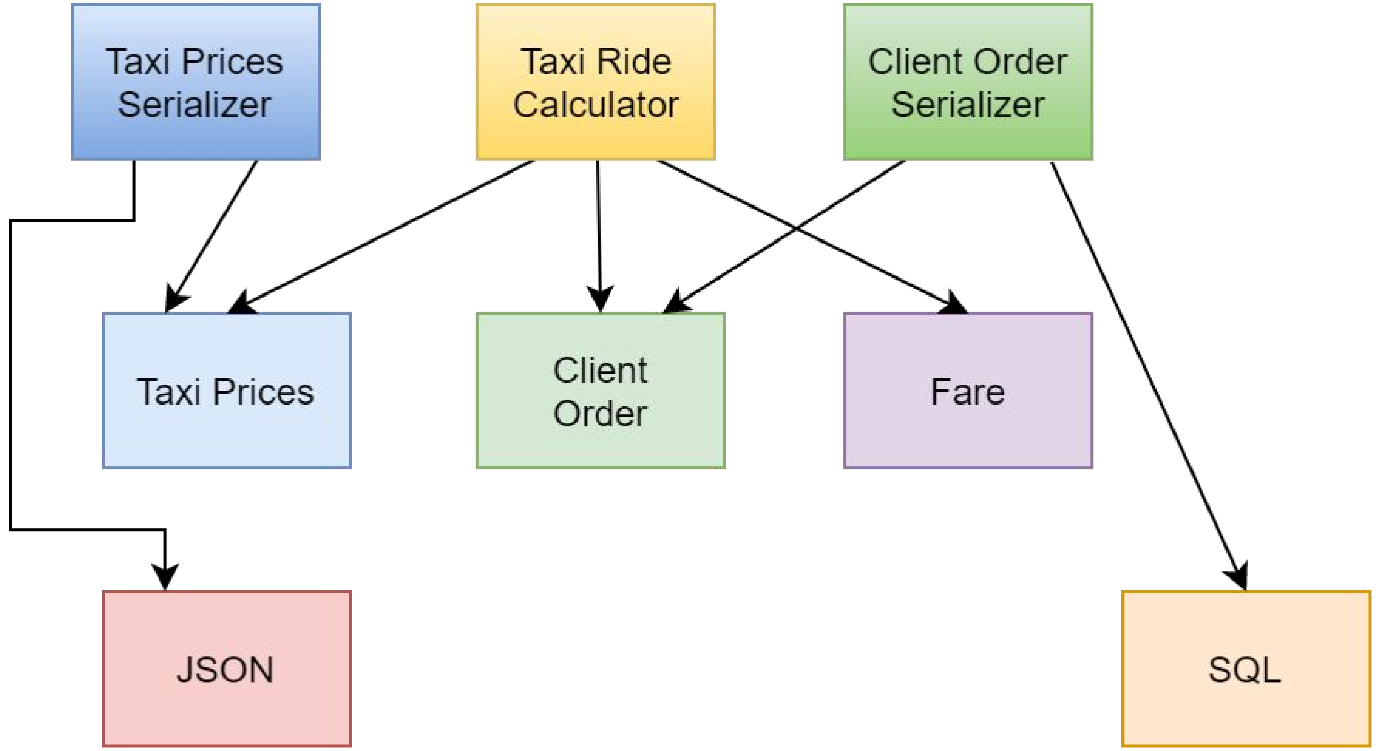
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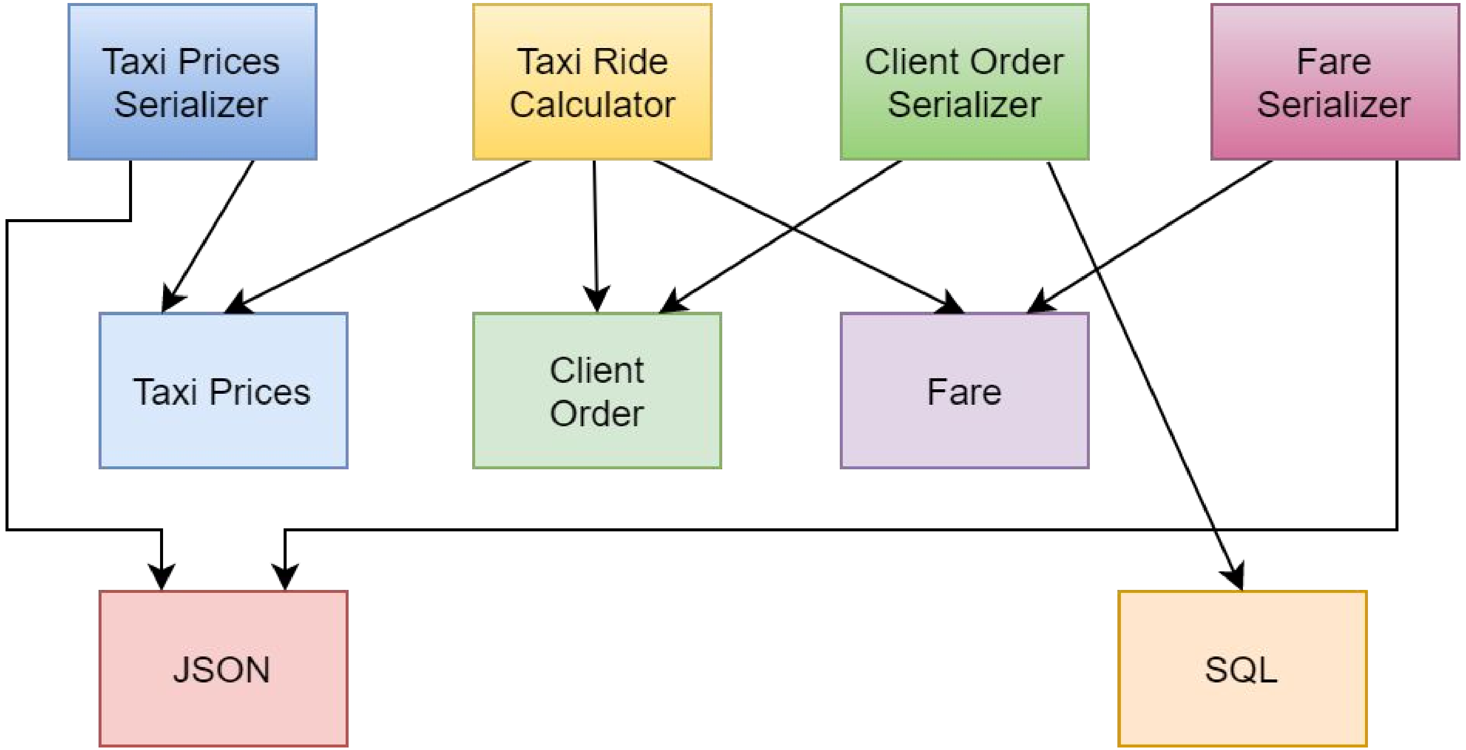
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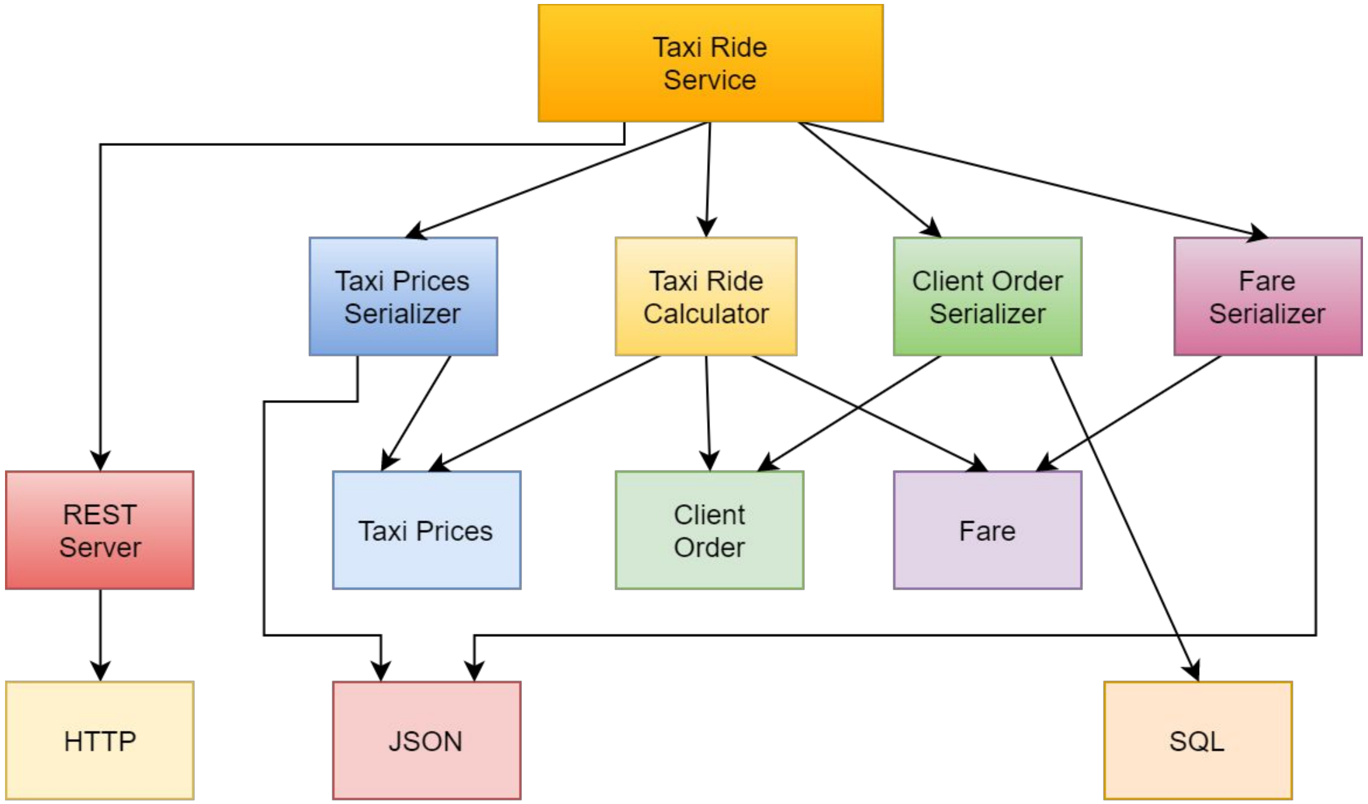
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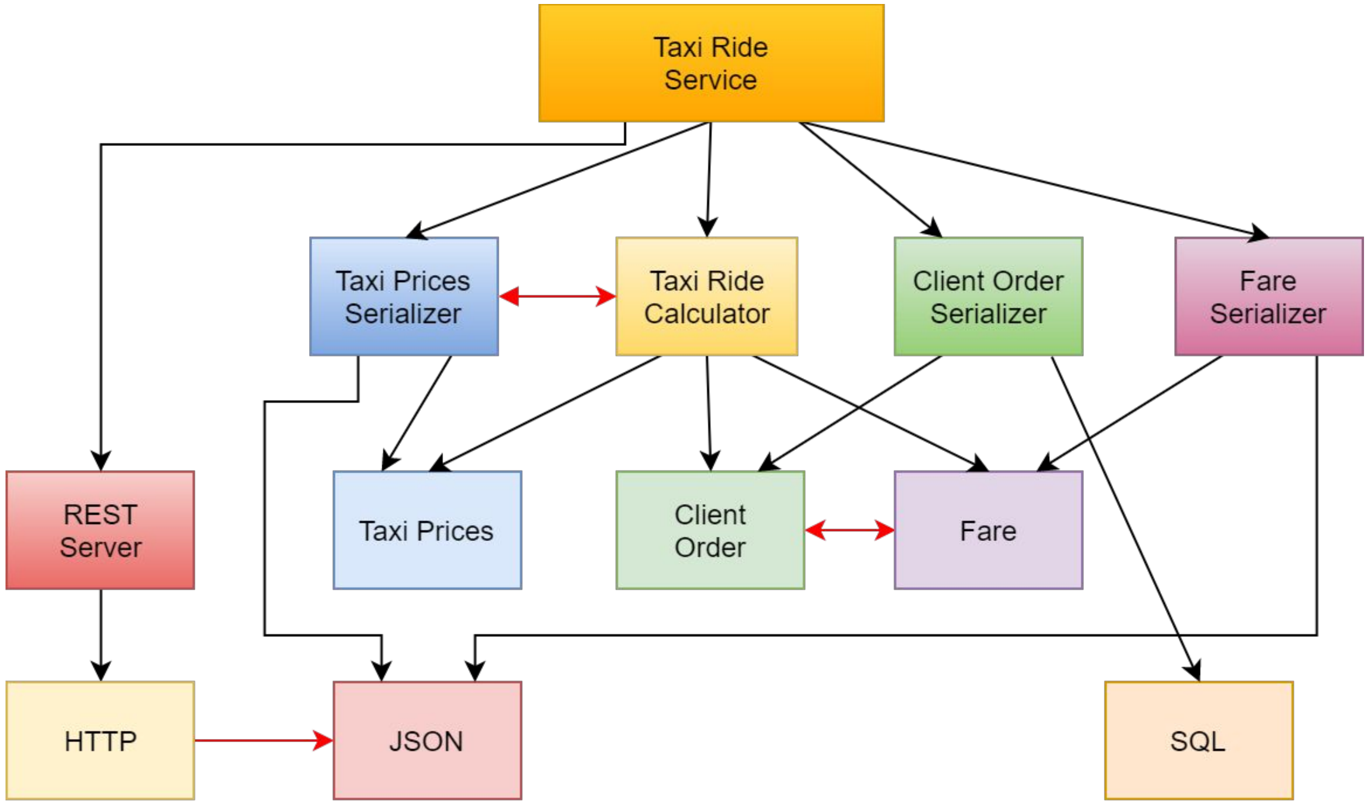
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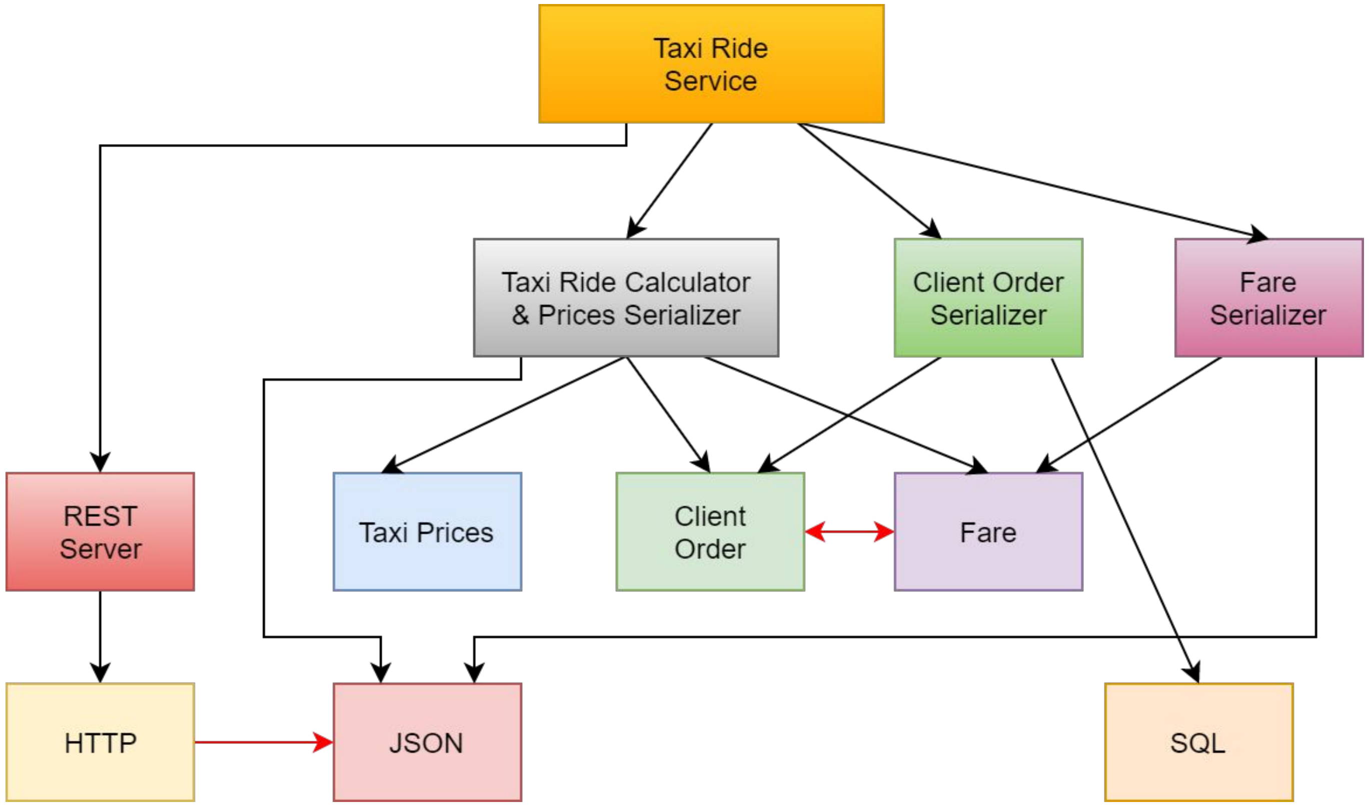
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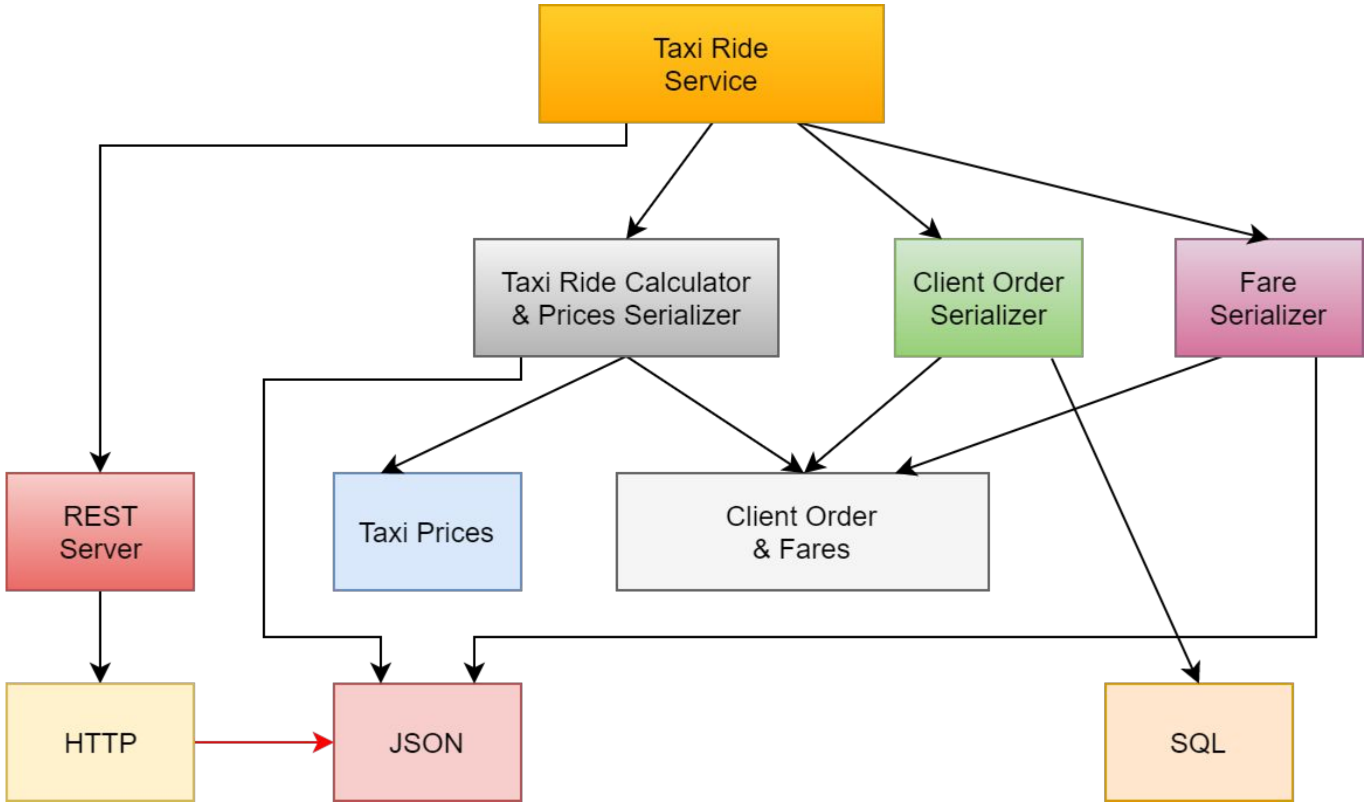

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REST Server
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Client Order & Fares
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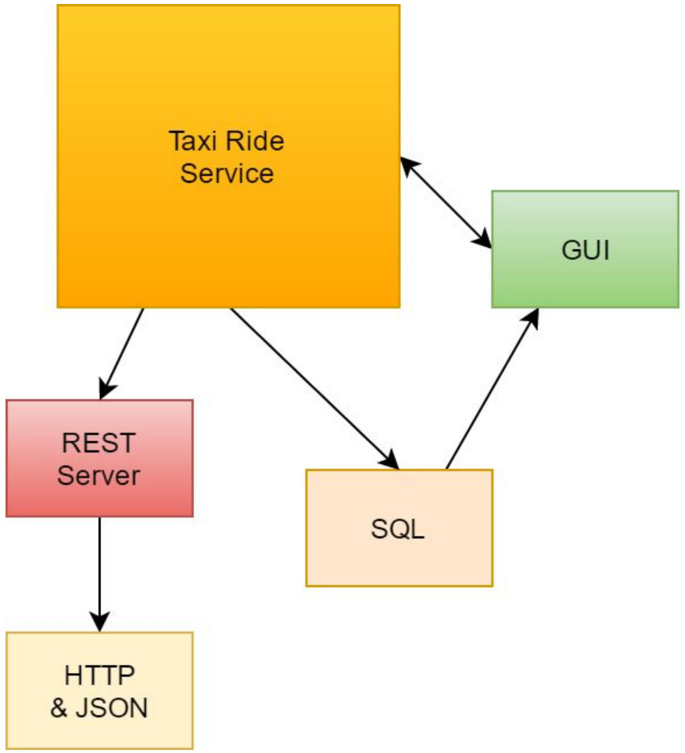
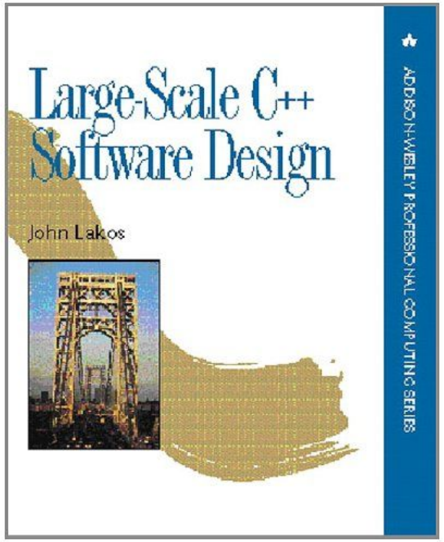

Taxi Ride Service
GUI
REST Server
SQL
HTTP & JSON

Modular Design at scale

- Retain control of your dependency graph
- Keep concerns separated
- Make modules reusable in other contexts at minimal cost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Modern build systems

Theory & practice

Modern build system

Facilitate large scale modular design
& protect against antipatterns

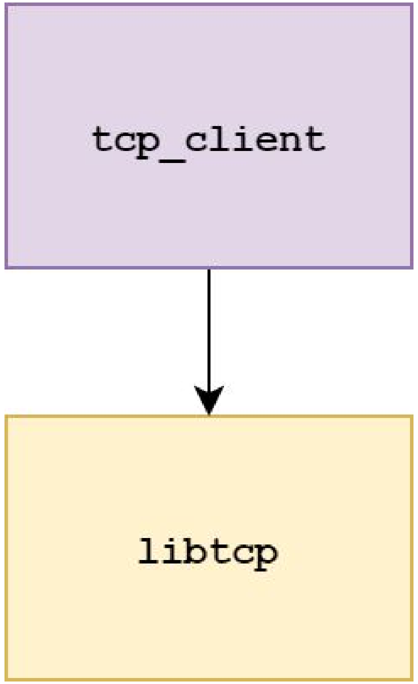
Build before

```
ADD_SUBDIRECTORY(libtcp)

ADD_EXECUTABLE(tcp_client
     tcp_client.cpp)

INCLUDE_DIRECTORIES(tcp/include)
ADD_DEFINITIONS(IPV6)

TARGET_LINK_LIBRARIES(tcp_client
                      libtcp)
```



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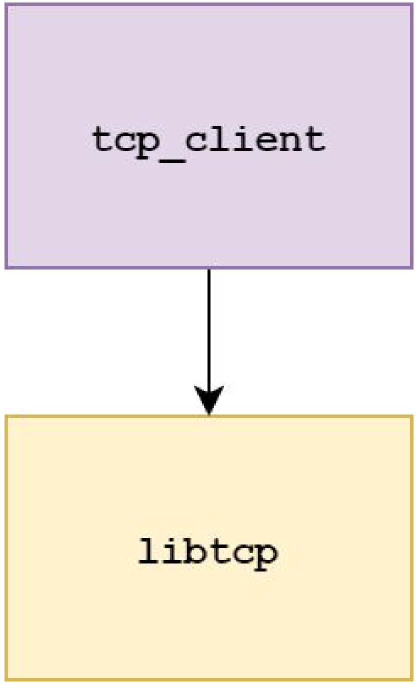

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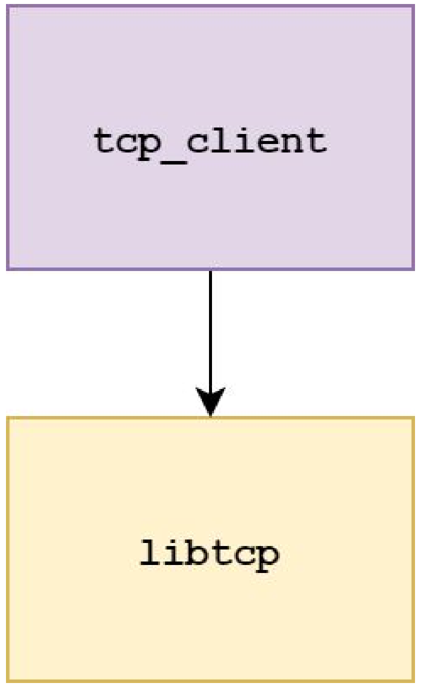

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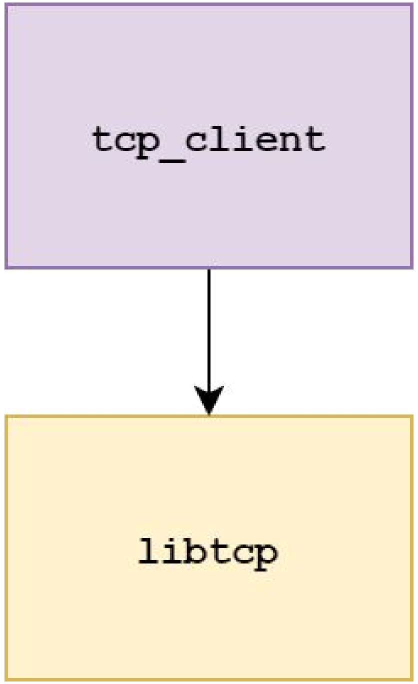

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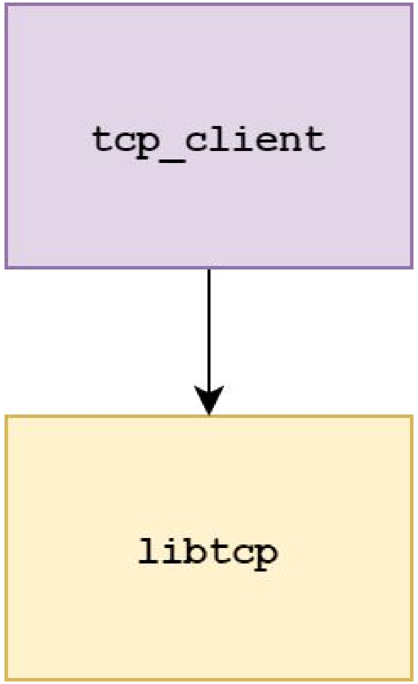

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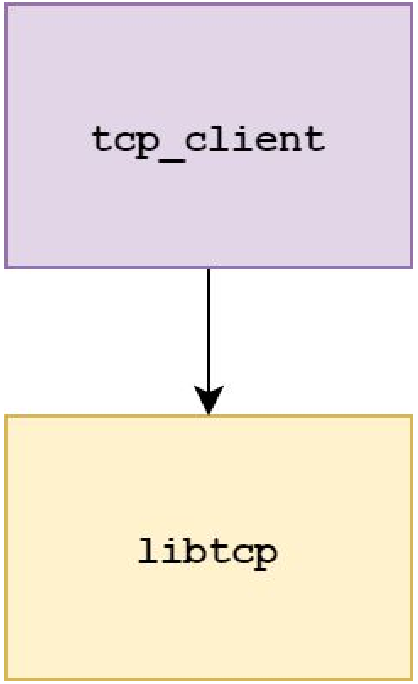
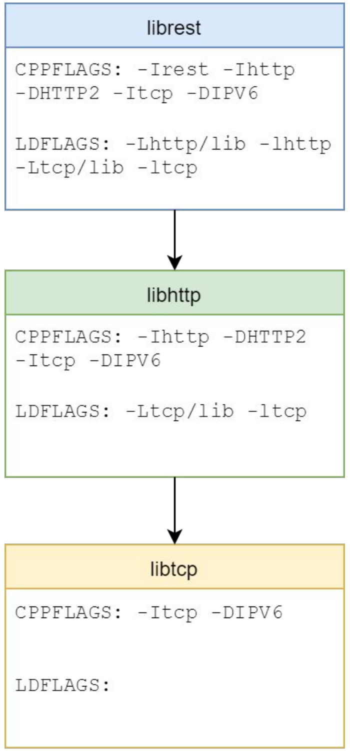


Build flags don't scale

- Every change in public flags has to be propagated upwards

- Most people usually give up and put every include directory in a common/root build file



```
librest
CPPFLAGS: -Irest -Ihttp
-DHTTP2 -Itcp -DIPV6

LDFLAGS: -Lhttp/lib -lhttp
-Ltcp/lib -ltcp
```

```
libhttp
CPPFLAGS: -Ihttp -DHTTP2
-Itcp -DIPV6

LDFLAGS: -Ltcp/lib -ltcp
```

```
libtcp
CPPFLAGS: -Itcp -DIPV6

LDFLAGS:
```

Help the build system help you

- It's not easy to detect bad code architecture patterns when looking at build flags
- In contrast, defining build in term of modules depending on other modules makes the problem trivial

Modern build systems

- Forbid/report circular and hidden dependencies
- Help developer reason at module level
- Do more than build as you are told!

Modern build, in practice

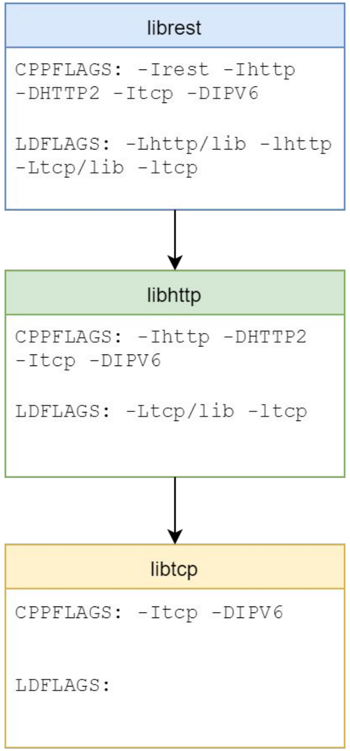
- Define your module build flags
- Define your module dependencies
- Keep out of other modules internals

Modern build, in practice

- Each module has a set of private flags (required to build its implementation)
- Each module has a set of public flags (required to build against its interface)
- Build interfaces are transitive

Public/private dependencies

- Dependencies are either public or private
- Public dependencies are transitive and will be passed down to clients



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libhttp
CPPFLAGS: -Ihttp -DHTTP2
-Itcp -DIPV6

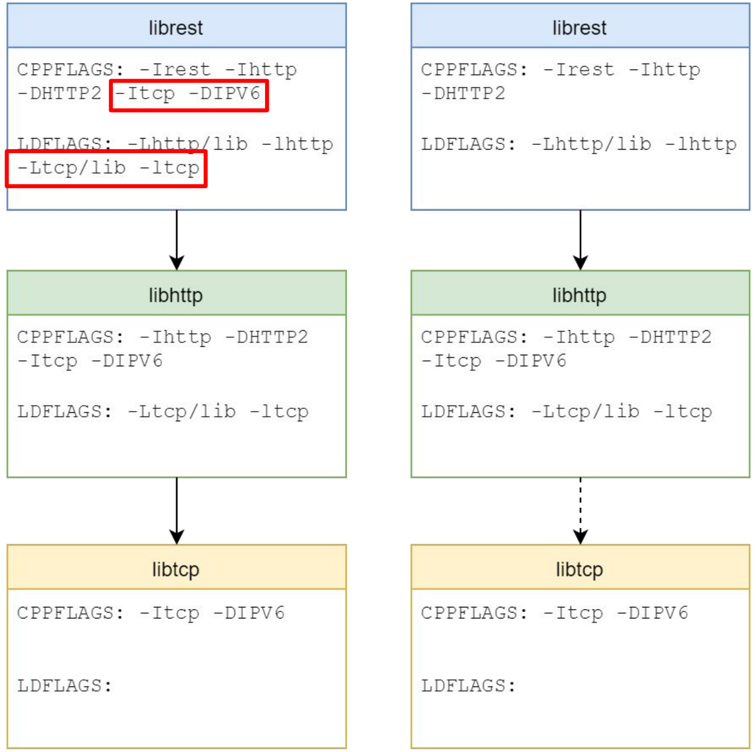
LDFLAGS: -Ltcp/lib -ltcp
```

```
libtcp
CPPFLAGS: -Itcp -DIPV6

LDFLAGS:
```

Public/private dependencies

- Dependencies are either public or private
- Public dependencies are transitive and will be passed down to clients
- Private dependencies are not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LDFLAGS: -Ltcp/lib -ltcp
libtcp
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librest
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LDFLAGS: -Lhttp/lib -lhttp
libhttp
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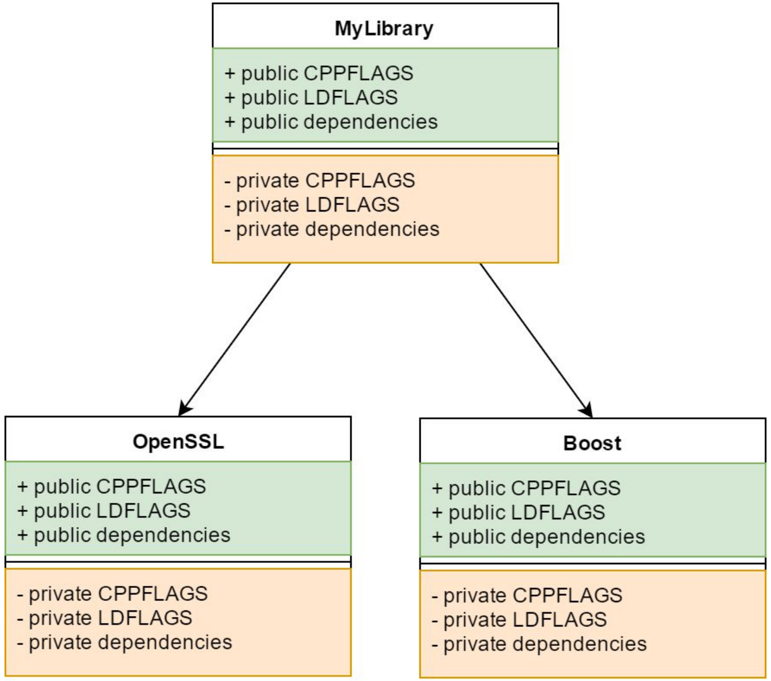
LDFLAGS: -Ltcp/lib -ltcp
libtcp
CPPFLAGS: -Itcp -DIPV6
LDFLAGS:

Keep calm and focus



- Build flags aren't gone, only encapsulated
- You can still go crazy with CPPFLAGS, CXXFLAGS and LDFLAGS in your module
- But external flags aren't your concern anymore

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Modern CMake

Let’s see some code!

Modern CMake in a nutshell

- Declare your module with ADD_LIBRARY or ADD_EXECUTABLE
- Declare your build flags with TARGET_xxx()
- Declare your dependencies with TARGET_LINK_LIBRARIES
- Specify what is PUBLIC and what is PRIVATE

Global setup

```
cmake_minimum_required(VERSION 3.0)

if(MSVC)
    add_compile_options(/W3 /WX)
else()
    add_compile_options(-W -Wall -Werror)
endif()
```

Declare your module

```
add_library(mylib
    src/file1.cpp
    src/file2.cpp
    ...)
```

Declare your flags

```
target_include_directories(mylib PUBLIC include)
target_include_directories(mylib PRIVATE src)

if (SOME_SETTING)
    target_compile_definitions(mylib
                    PUBLIC WITH_SOME_SETTING)
endif()
```

If the setting only affects implementation, use `PRIVATE` instead

Declare your dependencies

```cmake
# Public (interface) dependencies
target_link_libraries(mylib PUBLIC abc)

# Private (implementation) dependencies
target_link_libraries(mylib PRIVATE xyz)
```

Header-only libraries

```
add_library(mylib INTERFACE)
```

Nothing to build so it must be INTERFACE

```
target_include_directories(mylib INTERFACE include)

target_link_libraries(mylib INTERFACE Boost::Boost)
```

Recognize antipatterns

- Don’t use macros that affect all targets
  - INCLUDE_DIRECTORIES()
  - ADD_DEFINITIONS()
  - LINK_LIBRARIES
- Don’t use TARGET_INCLUDE_DIRECTORIES() with a path outside your module

Recognize antipatterns

- Don’t use TARGET_LINK_LIBRARIES() without specifying PUBLIC, PRIVATE or INTERFACE
- Don’t use TARGET_COMPILE_OPTIONS() to set flags that affect the ABI

That’s it!

Remember this
and you know 90% of Modern CMake

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Beyond CMake

How to interact with the rest of the world

External projects

- Require external packages

```
find_package(GTest)
find_package(Threads)

add_executable(foo ...)

target_include_directories(foo
      PRIVATE ${GTEST_INCLUDE_DIRS})

target_link_libraries(foo
      PRIVATE ${GTEST_BOTH_LIBRARIES}
              Threads::Threads)
```

External projects

- Require external packages
- Don’t fall back to the old “flags” approach!

```
find_package(GTest)
find_package(Threads)

add_executable(foo ...)

target_include_directories(foo
    PRIVATE ${GTEST_INCLUDE_DIRS})

target_link_libraries(foo
    PRIVATE ${GTEST_BOTH_LIBRARIES}
            Threads::Threads)
```

External projects

- External packages should be targets too
- CMake built-in finders have undergone an effort in that sense

```
cmake_minimum_required(VERSION 3.5)

find_package(GTest)

add_executable(foo ...)

target_link_libraries(foo
                   GTest::GTest GTest::Main)
```

External projects

- Modern finders provide targets instead of flags
  - 3.4: OpenSSL
  - 3.5: Boost, GTest, GTK, PNG, TIFF
  - 3.6: PkgConfig
  - 3.7: Bzip2, OpenCL
  - 3.8: OpenGL

- Another reason to upgrade your CMake version!

Hand-made finder

- Creating your own target finder isn’t hard
- You should provide one with your public libraries
- CMake can even generate it for you!

Finder expectations

```
find_library(BAR_LIB bar HINTS ${BAR_DIR}/lib)
add_library(bar SHARED IMPORTED
            LOCATION ${BAR_LIB})


target_include_directories (bar INTERFACE ${BAR_DIR}/include)


target_link_libraries (bar INTERFACE Boost::boost)
```

Finder reality

Finder reality

```
find_library(BAR_LIB bar HINTS ${BAR_DIR}/lib)
add_library(bar SHARED IMPORTED)
set_target_properties(bar PROPERTIES
                      LOCATION ${BAR_LIB})
```

```
set_target_properties (bar PROPERTIES
                 INTERFACE_INCLUDE_DIRECTORIES  ${BAR_DIR}/include)
                 INTERFACE_LINK_LIBRARIES  Boost::boost)
```

Easier alternative(s)?

- There are a few but…
- As Fermat famously said: “it wouldn’t fit in the margin of this talk”
- Check-out Daniel Pfeifer’s talk *Effective CMake*

5 Wrapping up

Modern CMake in three slides

Modern build

- Keep your flags to yourself
- Think in terms of modules
- Let the build system handle transitivity

Modern CMake

- Switch to CMake 3.X
- Use the TARGET_xxx version of macros
- Specify if a property is PUBLIC, PRIVATE or INTERFACE
- Link against targets to get their build flags

External Packages

- Use modern finders that declare targets
- Generate them with CMake, from your actual project definition
- Use a package manager

Thanks!

Any questions ?

You can find me at

- mro@puchiko.net
- @MatRopert
- @mropert