Apex.AI®

The vehicle OS company.

Bazel and ROS 2 –
Building Large Scale Safety Applications

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at ROSCon ‘22

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Large scale safety applications. How hard can it be?

Function and Performance in a distributed system

- Efficient communication for large data
- Realtime requirements

Fail-Safe or Fail-Operational Behavior

- Error-detection
- Redundancy
- Special Hardware (e.g. lock step)
- Architectural measures

Well defined Process

- Compliance to State of the Art (e.g. V-Model, ISO 26262)
- Safety Case (HARA, FMEA, FuSaCo, TeSaCo)
- Verification and Validation
- Standardized code creation (four eyes, etc.)
- CI/CD for a large team of developers

- Traceability
- Reproducibility

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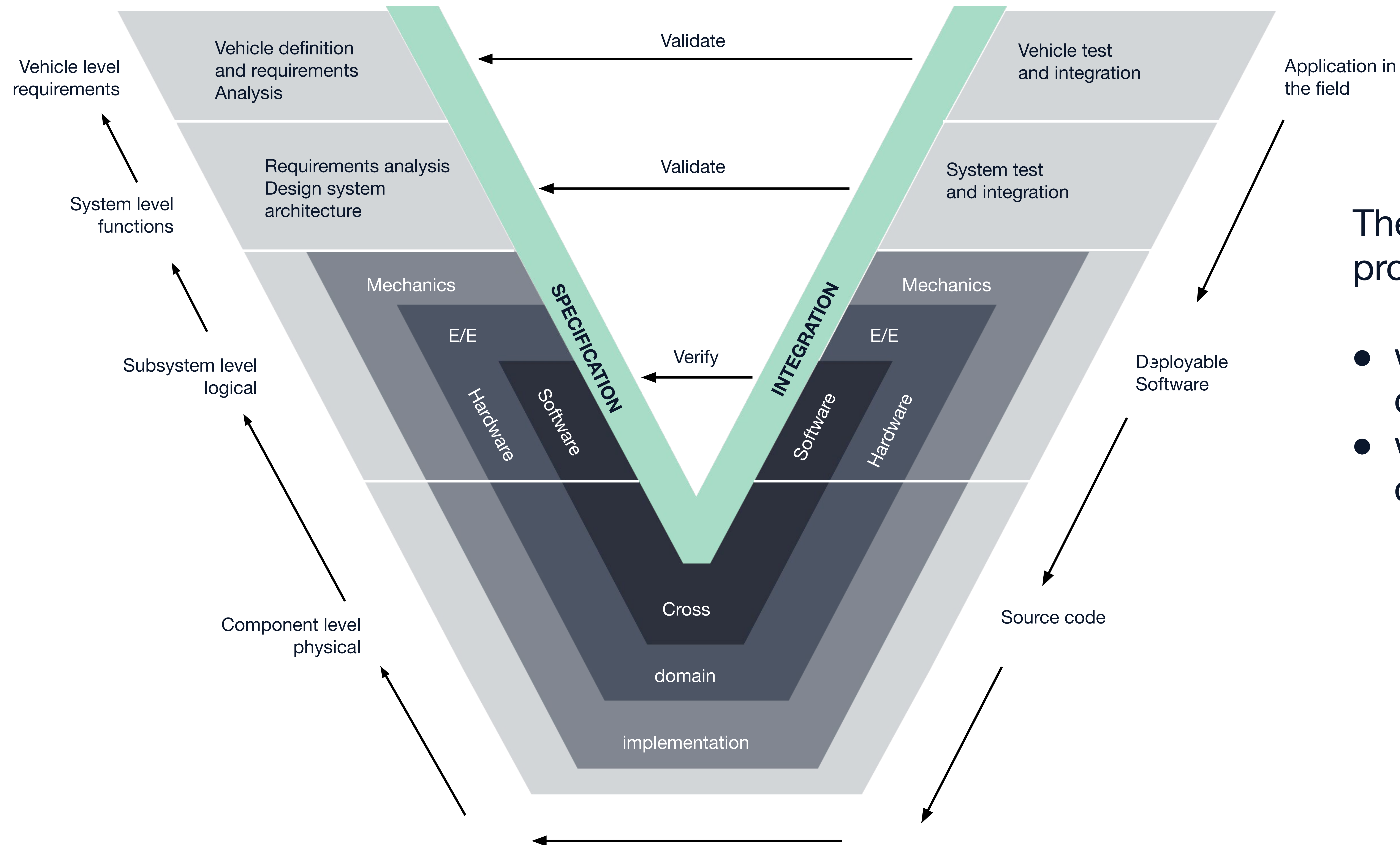
Traceability & reproducibility



The safety case relies on our ability to prove transparently:

- why our application behaves like it does
- what exactly we have developed and deployed into the field

Arrows show dependencies that shall be traceable.

- Along the V for artifact creation
- Right to left for verification and validation

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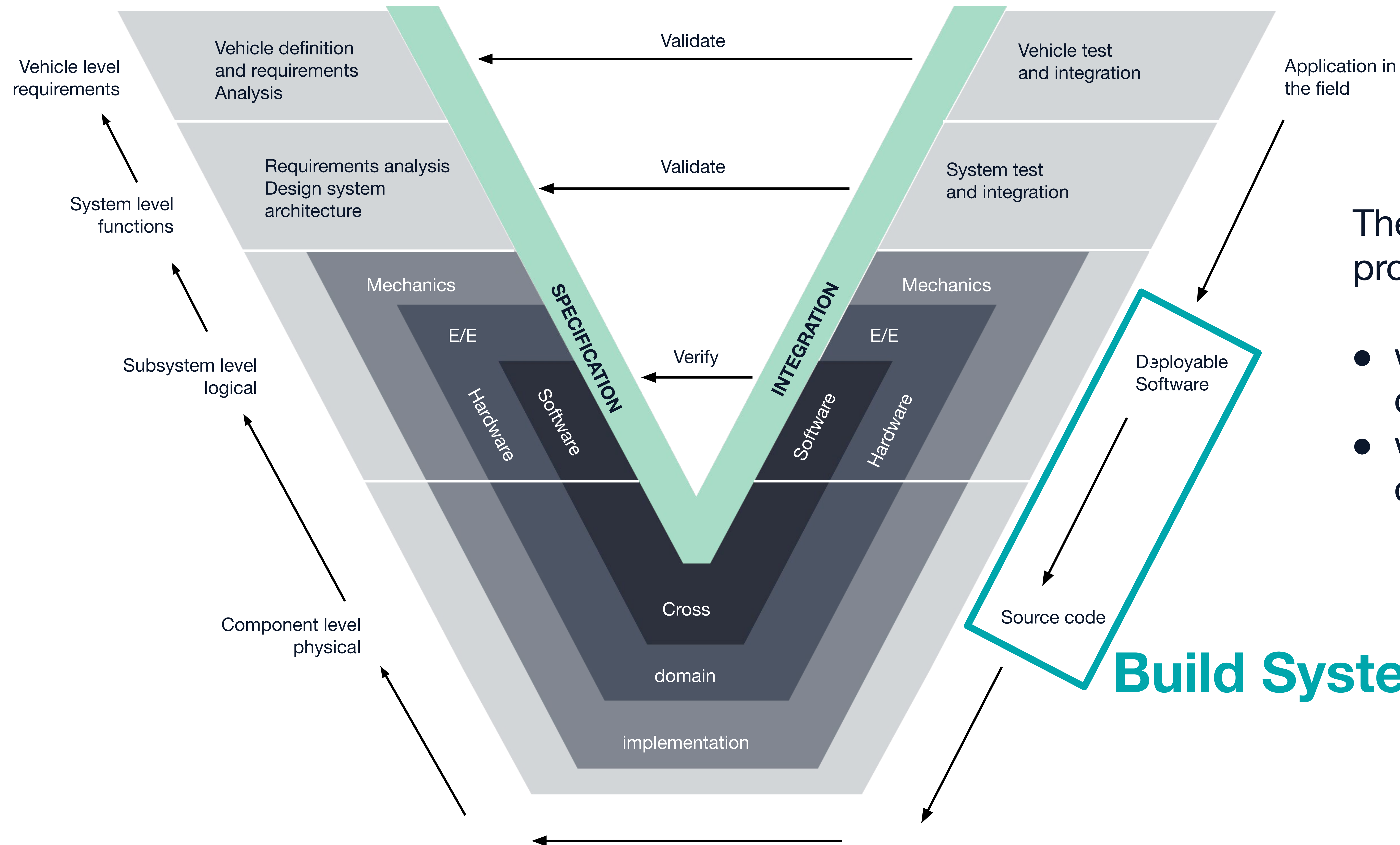
Traceability & reproducibility



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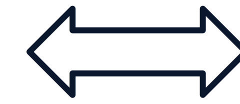
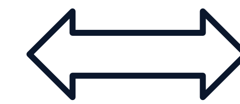
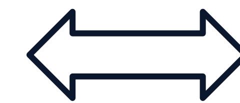
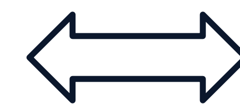
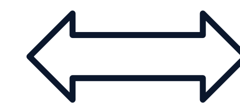
Comparing Colcon/CMake vs. Bazel

Imperative macro language, different (redundant) definitions		Declarative, abstract definition of build
Various different build tools (CMakeLists.txt, setuptools, Make)		Full programming language (starlark) for extension/customization
C/C++ as (main) target language		Multi language support
Caching not safe, due to potentially missing dependencies		Integrated (reliable, artifact based) local and remote caching
Building in host environment		(Almost) Hermetic build in sandboxes
Compile time and runtime dependency discovery		Explicit (full) dependency tree

Disclaimer: Biased towards use case of large scale safety applications!

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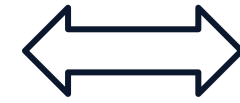
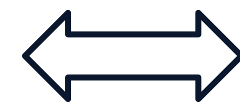
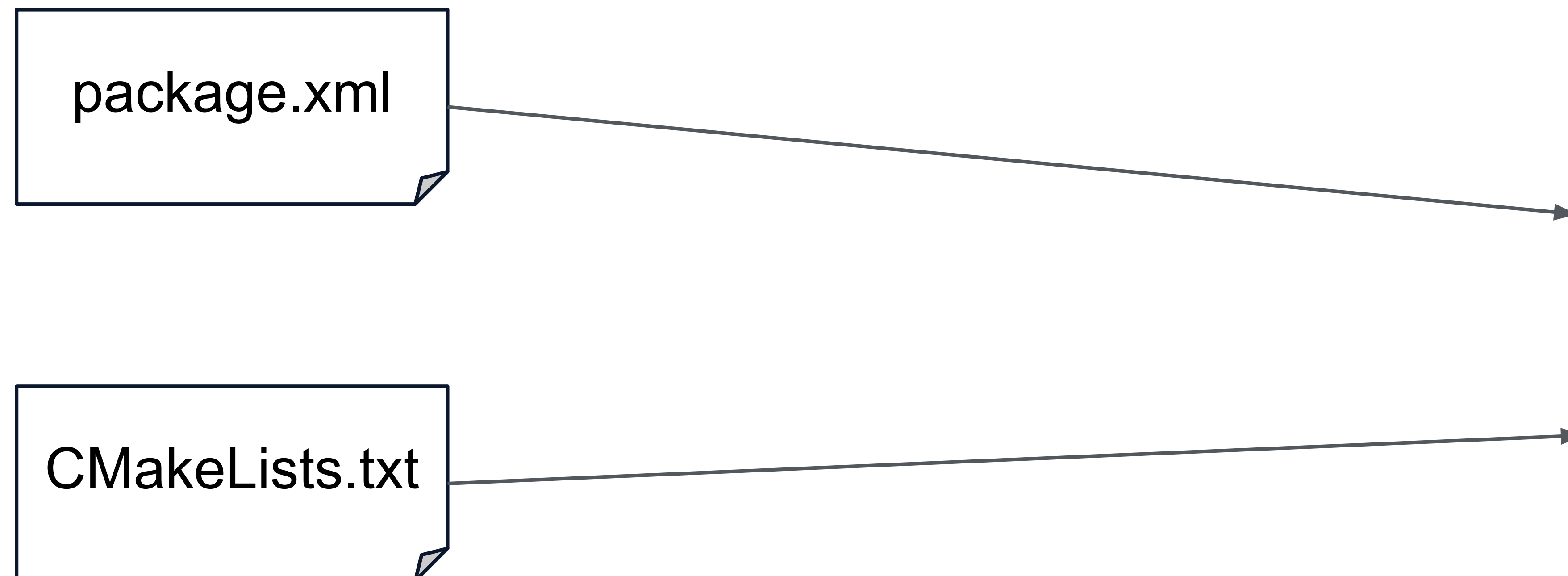
Things to consider when migrating to Bazel

Colcon/CMake		Bazel
Artifacts are tightly organized in **packages**		Strongly **artifacts** oriented; packages are mainly to improve clarity for user
Package names must be unique		Workspace names must be unique. Package and target names are absolute paths within a workspace




```
# BUILD.bazel

cc_binary(
    name = "simple_publisher",
    …
)

msg_library(
    name = "my_msgs",
    …
)

ros_pkg(
    name = "my_cool_pkg",
    executables_lib = ["simple_publisher"],
)
```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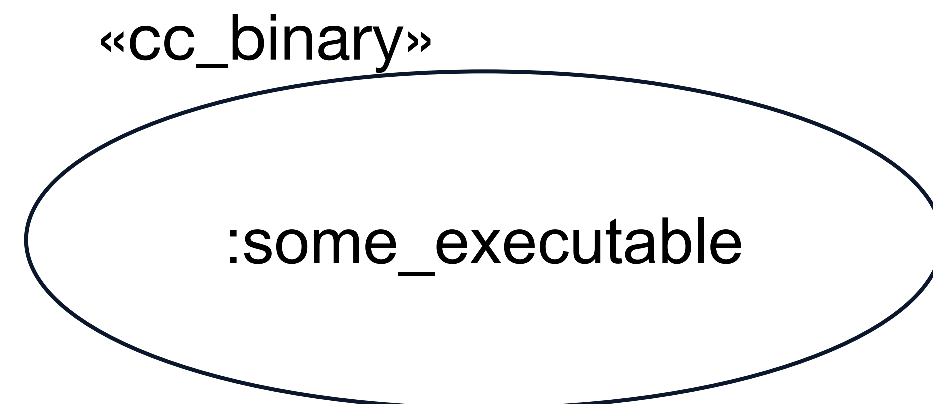
Package deployment

Goal: Provide a means to “install/setup” bazel built ROS 2 packages (C++, Python for now) onto a target for usage with ros2cli

Non-Goal: Provide a pre-built ROS 2 package that can be dependent on for building other ROS 2 packages




```
$ # Execute directly in your bazel workspace:
$ bazel run :some_executable
```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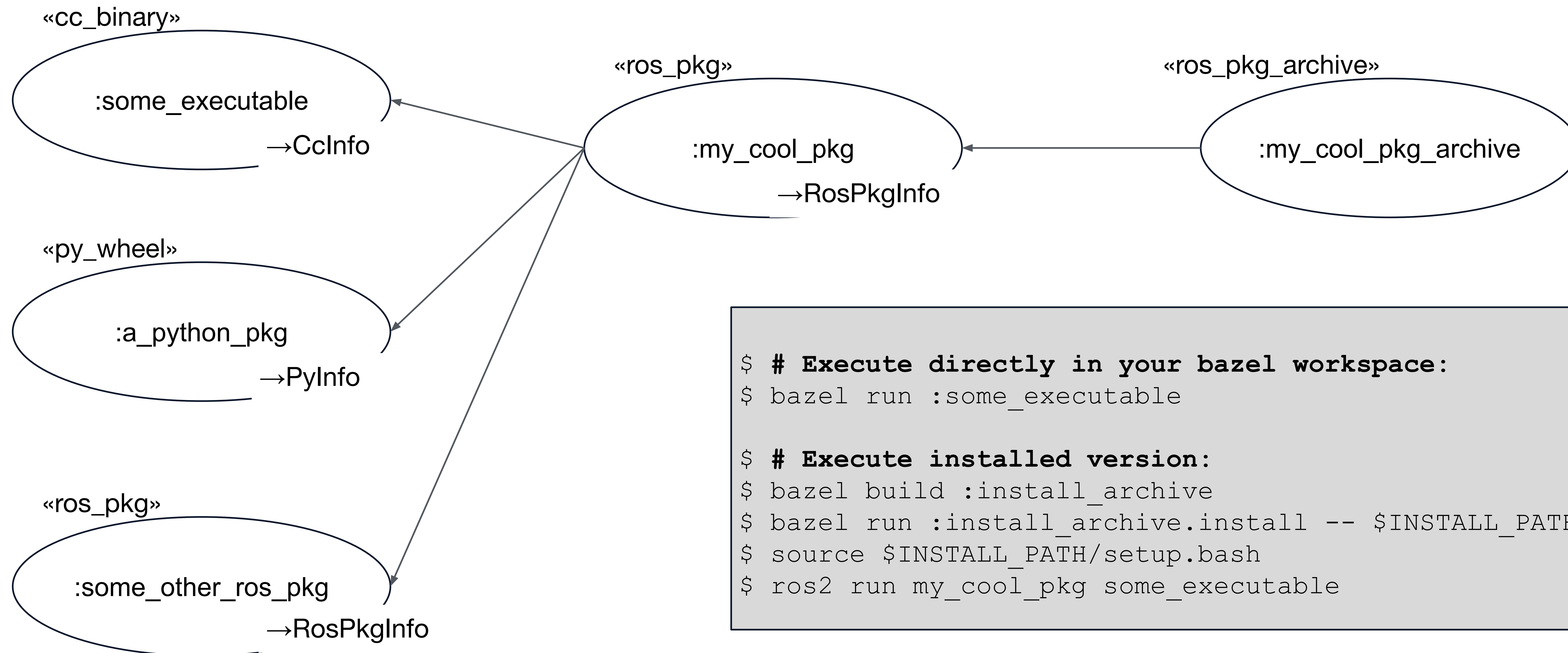


```
$ # Execute directly in your bazel workspace:
$ bazel run :some_executable

$ # Execute installed version:
$ bazel build :install_archive
$ bazel run :install_archive.install -- $INSTALL_PATH
$ source $INSTALL_PATH/setup.bash
$ ros2 run my_cool_pkg some_executable
```


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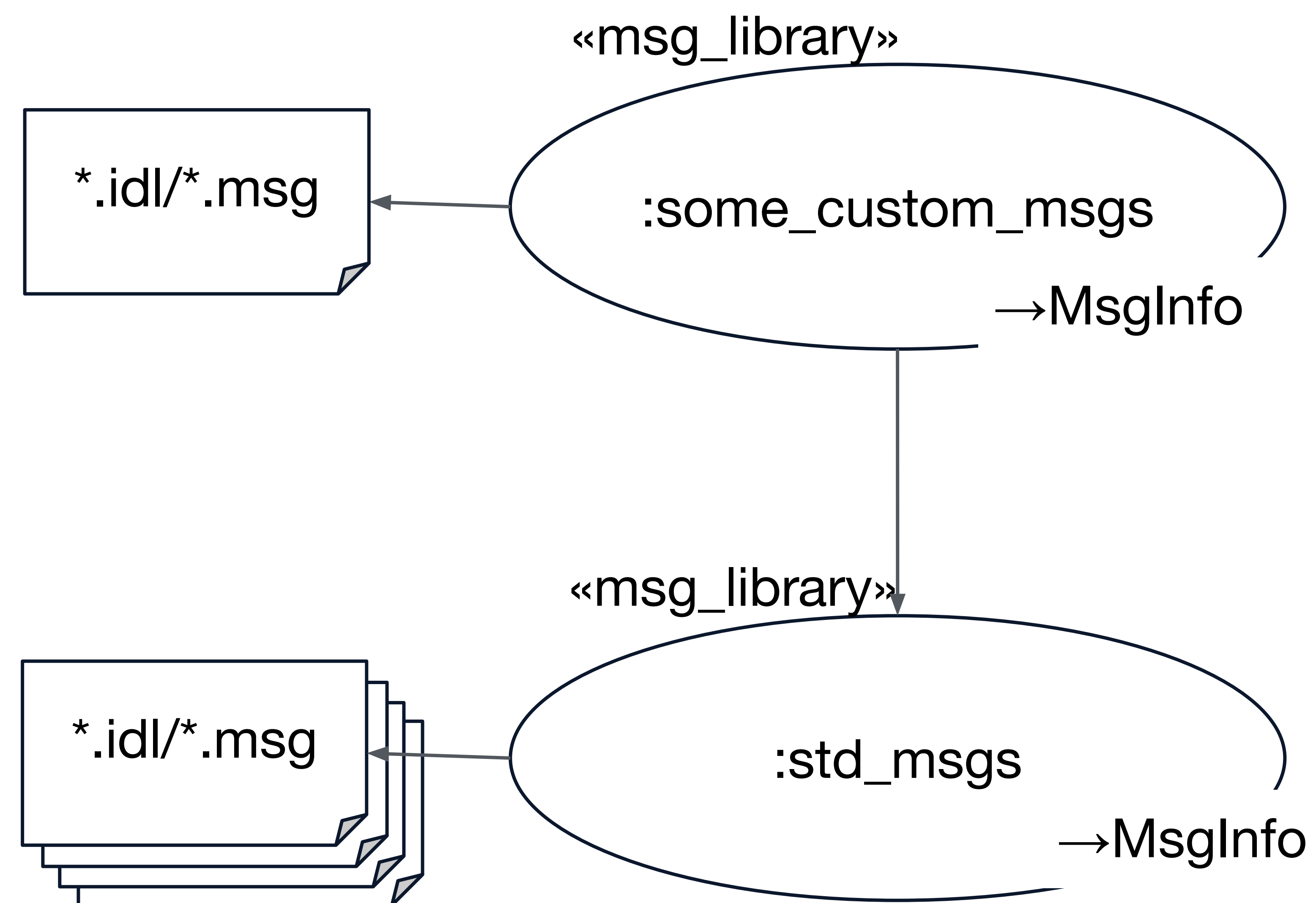
Message generation

Goal: Provide an extensible multi-language concept for message code generation

- `msg_library` rule only provides information about the input
- no output artifact is generated



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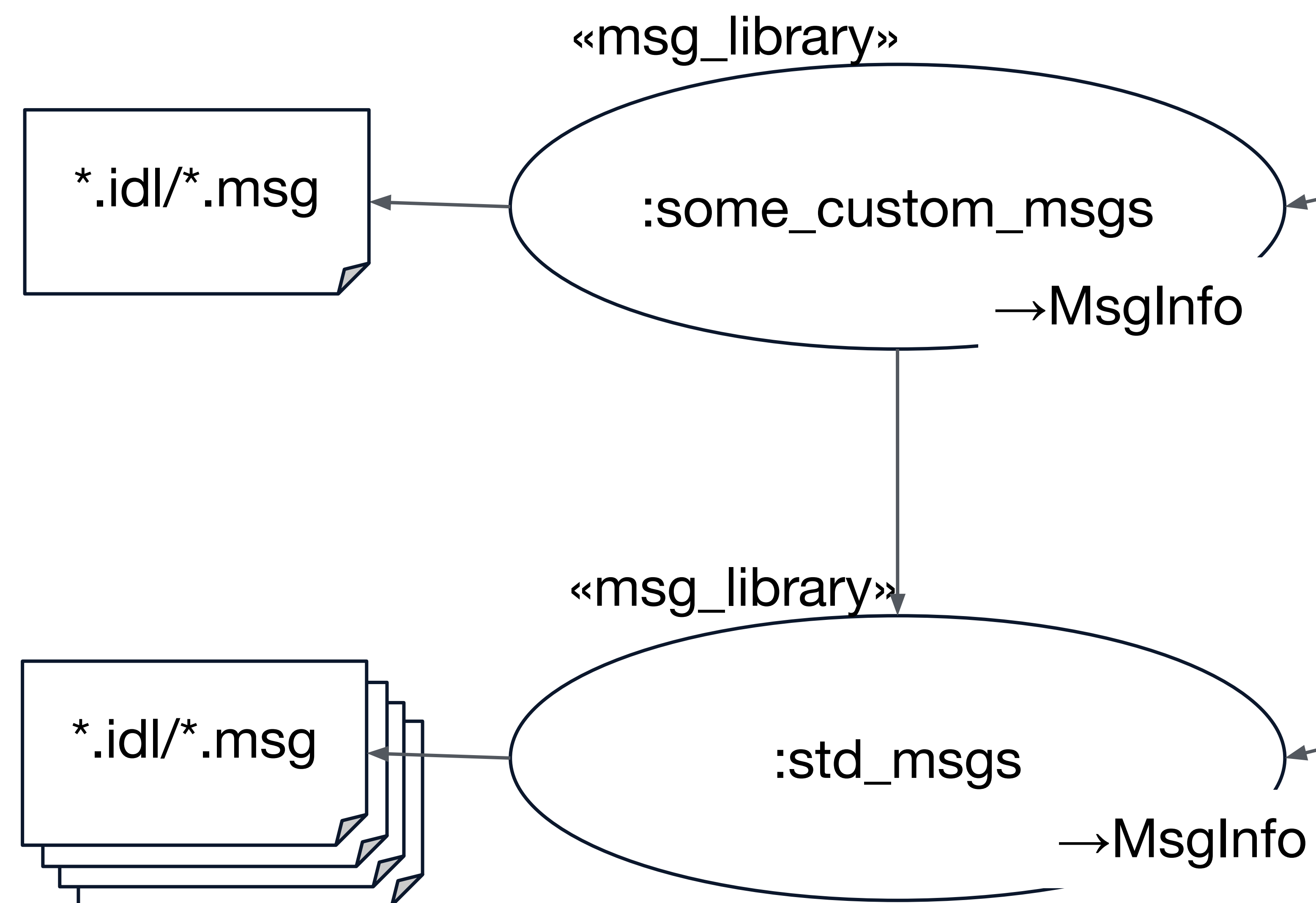
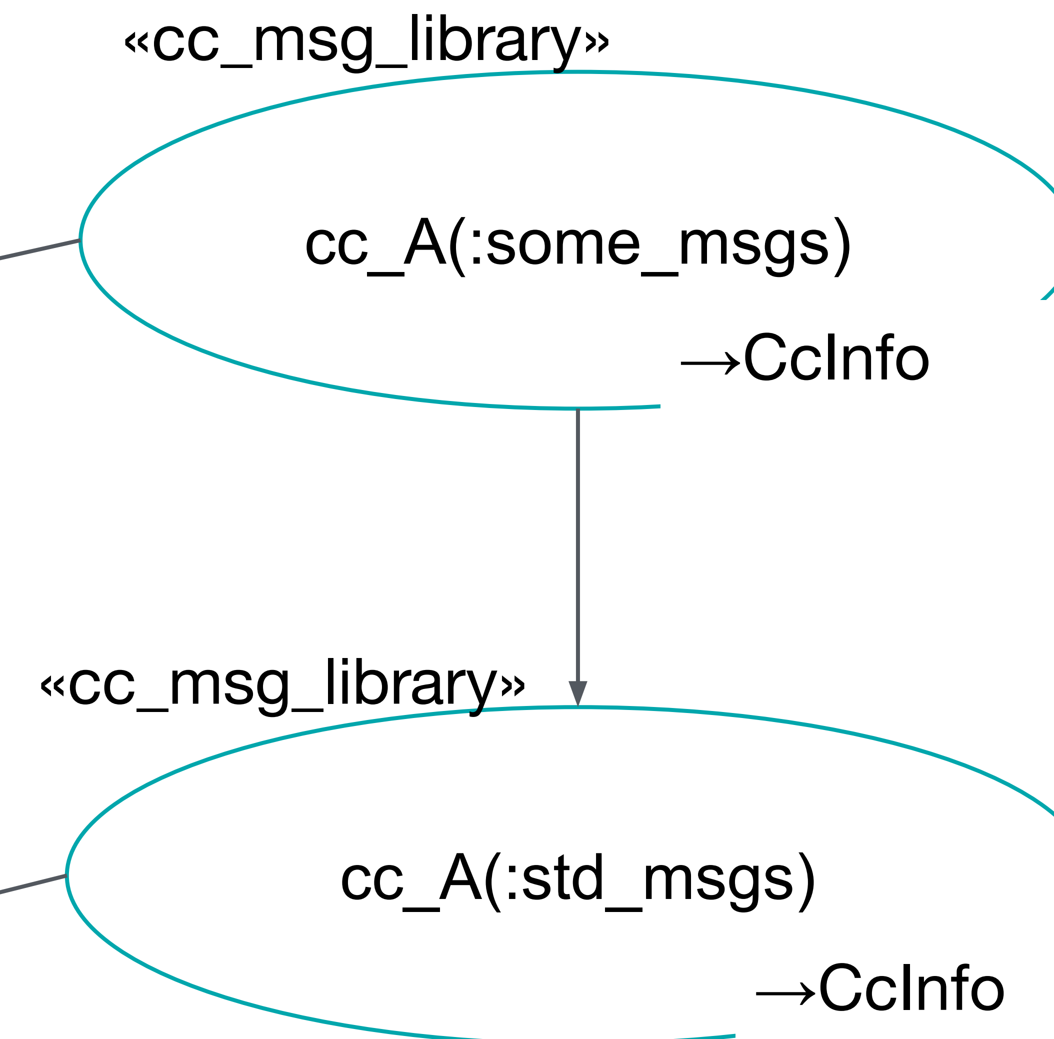


- `cc_msg_library` aspects are instantiated by the user of a message on demand
- they generate the “linkable” library for the required language



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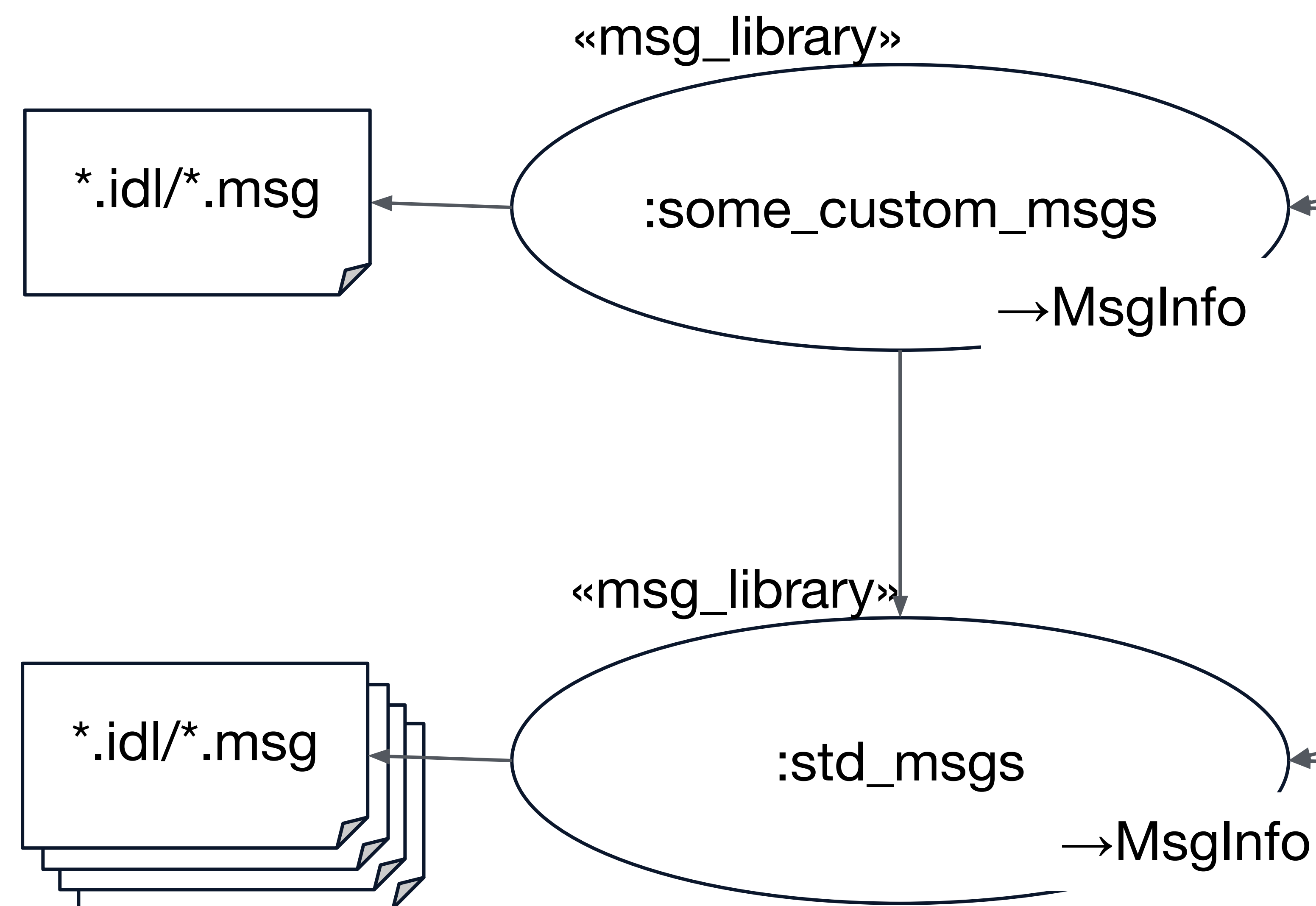
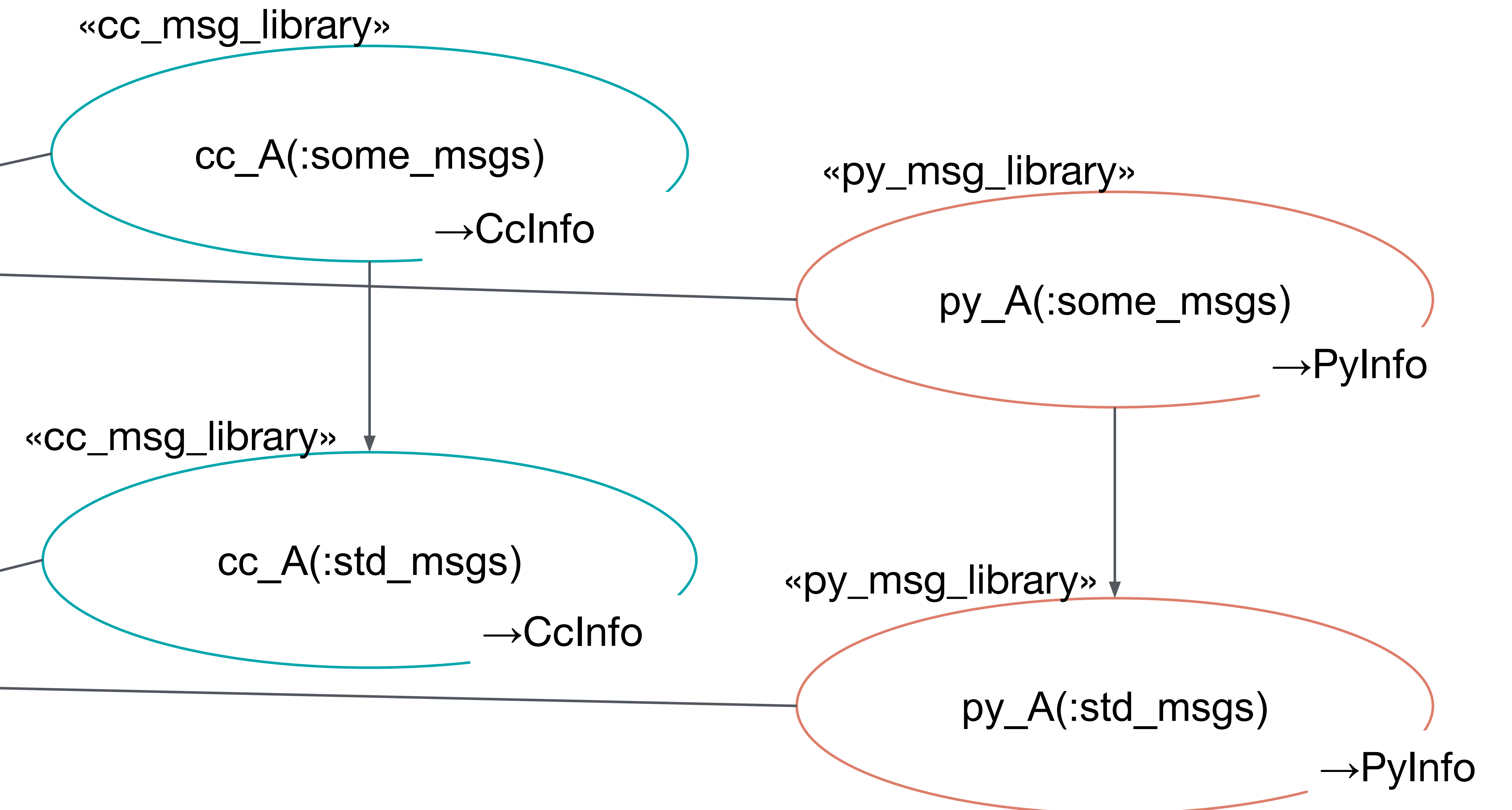


- `cc_msg_library` and `py_msg_library` aspects are instantiated by the user of a message on demand
- they generate the “linkable” library for the required language



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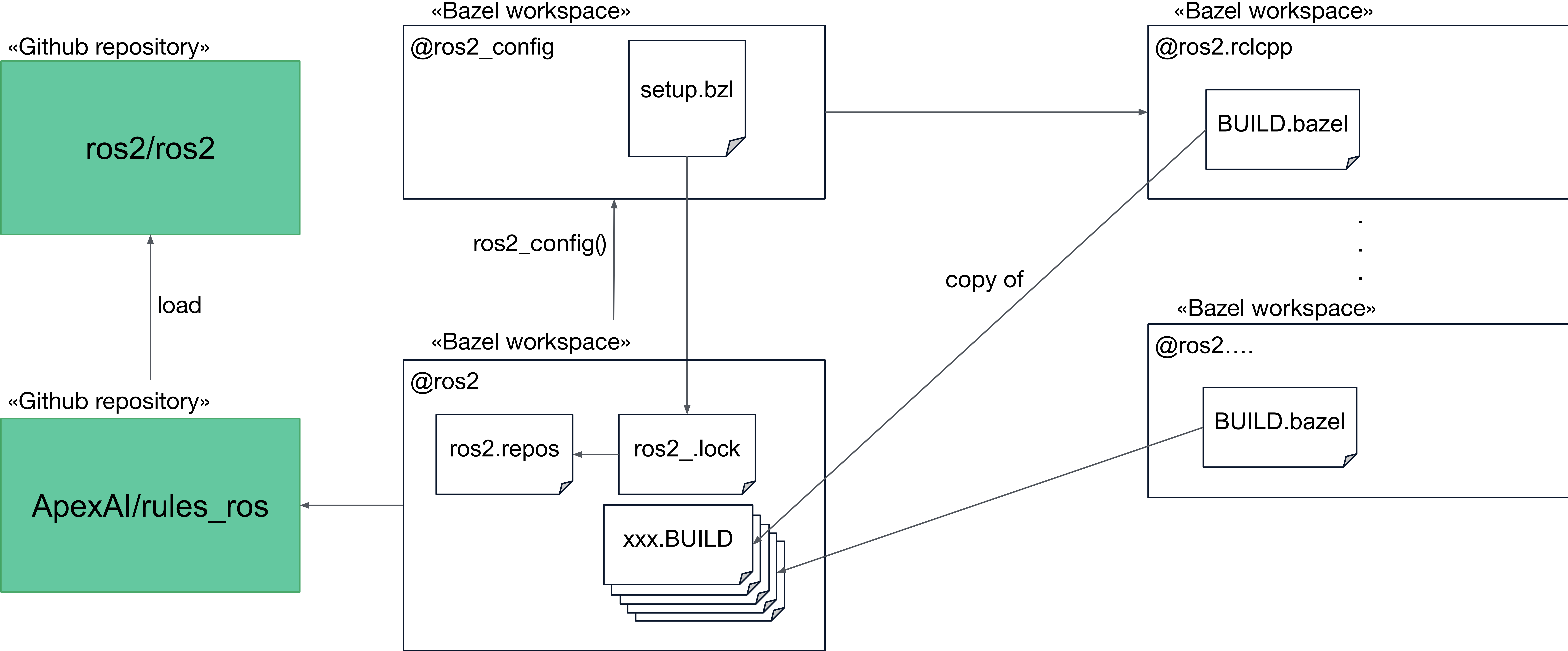
Repository setup

Goal: Keep as much of the federated repo concept as possible

- Bazel build configuration can be added on top of existing ROS 2
- A pinning mechanism is introduced to ensure reproducibility



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Setup a workspace to use the ROS2-Bazel fork

- Install bazel/bazelisk on your host system
- Add the WORKSPACE file to an empty folder
- Add (.bazelrc, .bazelingore, .bazelversion) as needed
- Create your own package within your workspace

```
# WORKSPACE
workspace(name = "my_cool_workspace)

http_archive(
   name = "ros2",
   url =
"https://github.com/ApexAI/rules_ros/…/rules_ros-x.x.tgz"
   sha = "xxxxxx",
)

load("@ros2//bazel/rules_repo:defs.bzl", "configure_ros2")
configure_ros2(distro = "humble")

load("@ros2_config//:setup1.bzl", "setup1")
setup1()

[...]

load("@ros2_config//:setup4.bzl", "setup4")
setup4()
```


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Summary

- Bazel is an alternative to the native ROS 2 build system Colcon/CMake
- Traceability from deployed software back to source code is achieved by a complete dependency tree
- Reproducibility can be achieved through a hermetic build
- We have shown how ROS 2 can be set up with bazel including core concepts like message generation and package deployment

We are in the process of open sourcing the contents of this talk:

http://github.com/ApexAI/rules_ros

We are looking forward to your feedback on github.

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