Software Build Systems and Dependencies

Cooperating and Competing with Distributions

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HUAWEI

Background: `just`

- generic build system
  - high-level build description, provided by rules
  - remote execution
  - separation of physical and logical paths (“staging”)
  - multi-repository builds based on local names; target-level caching

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- generic build system
  - high-level build description, provided by rules
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  - separation of physical and logical paths (“staging”)
  - multi-repository builds based on local names; target-level caching
- open source
  - open since Nov 2022; Relase 1.0.0 Dec 12, 2022; active development *(1.1.0 May 19, 2023, 1.2.0 Aug 25, 2023, …)*
  - Apache 2.0 license
  - `https://github.com/just-buildsystem/justbuild`
  - Packed in AUR, Nixpkgs, Spack, Void Linux
    pending: Debian

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  - get early access to vulnerability reports ⇝ need to establish trust
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- Each upstream archive/tree packaged only at a single place—no embedded copies!
- Build offline! No fetches of dependencies during the build.
  (Also for complience reasons!)

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- In package build, dependencies passed as inputs
  …possibly explicit, but often in form of the “ambient environment”
  (which might well be a controlled `chroot` *in which the build happens!)*

TLM and Software Development in Industry

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- It should just work, also for cooperation partners.
  (and they should get the same binary out)
- Ex-post proof that a binary was built from certain sources. (specific use case)
- “So, why doesn’t the build tool just download the dependencies?”
  (We have known-good hashes to verify the downloads, so all is fine.)

Existing Approaches

- “I’m just a build system”
  - Just traverses a graph in topological order
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- “Let me inspect the environment for you”
  - search the environment for the required dependencies
    (trying all “standard paths”, “standard names”, heuristics . . .)
  - interpolate the found locations into the build description
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  - example: `autotools`

That's basically the world of traditional Linux distributions.

Existing Approaches (cont'd)

- "Trust us, we're the experts"
  - Host pre-built JDKs for all OS/architectures
  - embedd URLs and hashes into the build tool
    (You're updating your build tool regularly, aren't you?)
  - download as needed
  - example: `bazel`

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  - download as needed
  - example: `bazel`
- "Let me download the right `bazel` version for you"
  - With frequent incompatible changes, the buildtool becomes itself a dependency
  - Have a wrapper, that inspects `.bazelversion`, downloads the needed version of `bazel` if not present, and run it
  - example: `bazelisk`

Existing Approaches (cont'd again)

- "You'll only need this programming language anyway"
  - tailor towards one language
  - keep exhaustive collection of packages for that language *(and handle dependency resolution, etc)*
  - encourage every one to download from there, ignoring the distribution
  - examples: `pip`, `cargo`

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  - tailor towards one language
  - keep exhaustive collection of packages for that language *(and handle dependency resolution, etc)*
  - encourage every one to download from there, ignoring the distribution
  - examples: `pip`, `cargo`
- "Let me manage everything for you"
  - attempt a collection for everything you might possibly need
  - encourge users of your build system to take everything from there
  - example: `Bazel Central Registry`

Flexible Repository Configuration

- Already have abstract repository configuration
  - Build descriptions only use local names for other repositories
    (association to global names in the `"bindings"` *of the repository configuration)*
  - names of target files configurable
  - roots can be taken from various places

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⇝ Easy to rebind a dependency, switch between alternative definitions, etc

- Also easy to do programatically, as it is simply a JSON file

Support pkg-config for Dependencies and Dependents

```
$ cat TARGETS
{ "fmt": {"type": ["@", "rules", "CC/pkgconfig", "system_library"], "name": ["fmt"]}
, "hello":
  { "type": ["@", "rules", "CC", "library"]
  , "name": ["hello"]
  , "hdrs": ["hello.hpp"]
  , "srcs": ["hello.cpp"]
  , "deps": ["fmt"]
  }
, "": {"type": ["@", "rules", "CC", "install-with-deps"], "targets": ["hello"]}
}
$
```

Support pkg-config for Dependencies and Dependents

```
$ just-mr analyse fmt --dump-actions actions-fmt.json
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","analyse","-C","/worker/build/62d9cc5ae42928f8/...
INFO: Requested target is [["@","","","fmt"],{}]
INFO: Result of target [["@","","","fmt"],{}]: {
        "artifacts": {
        },
        "provides": {
          "compile-args": [
            "@fmt.cflags"
          ],
          "compile-deps": {
          },
          "link-args": [
            "@fmt.ldflags"
          ],
          "link-deps": {
          },
          "package": {
            "cflags-files": {"fmt.cflags":{"data":{"id":"c3291488ce224adfd7363c5a0...
            "ldflags-files": {"fmt.ldflags":{"data":{"id":"d49ced3c1f6735822eb14bb...
          }
        },
        "runfiles": {
          }
        }
INFO: Dumping actions for target [["@","","","fmt"],{}]
$
```

Support pkg-config for Dependencies and Dependents

```
$ cat actions-fmt.json
[
  {
    "command": ["/bin/sh","-c","pkg-config '--cflags' 'fmt' > 'fmt.cflags'"],
    "env": {
      "PATH": "/bin:/usr/bin"
    },
    "output": ["fmt.cflags"]
  },
  {
    "command": ["/bin/sh","-c","pkg-config '--libs' 'fmt' > ldflags.raw"],
    "env": {
      "PATH": "/bin:/usr/bin"
    },
    "output": ["ldflags.raw"]
  },
  {
    "command": ["/bin/sh","-c","./add_rpath $(cat ldflags.raw) > 'fmt.ldflags'"],
    "input": {
      "add_rpath": {
        "data": {
          "path": "CC/pkgconfig/add_rpath",
          "repository": "rules"
        },
        "type": "LOCAL"
      },
      "ldflags.raw": {
        "data": {
          "id": "68c1d7dafa4e91467154ac91ed5252943af483
          "path": "ldflags.raw"
        },
        "type": "ACTION"
      }
    },
    "output": ["fmt.ldflags"]
  }
]
$
```

Support pkg-config for Dependencies and Dependents

```
$ just-mr analyse hello
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","analyse","-C","/worker/build/62d9cc5ae42928f8/...
INFO: Requested target is [["@","","","hello"],{}]
INFO: Result of target [["@","","","hello"],{}]: {
        "artifacts": {
          "libhello.a": {"data":{"id":"8d5b08509547e6eae6c21cfa46cf4ec2da045321","...
        },
        "provides": {
          "compile-args": [
            "@fmt.cflags"
          ],
          "compile-deps": {
          },
          "link-args": [
            "libhello.a",
            "@fmt.ldflags"
          ],
          "link-deps": {
          },
          "package": {
            "cflags-files": {"fmt.cflags":{"data":{"id":"c3291488ce224adfd7363c5a0...
            "ldflags-files": {"fmt.ldflags":{"data":{"id":"d49ced3c1f6735822eb14bb...
            "name": "hello"
          },
          "run-libs": {
          },
          "run-libs-args": [
          ]
        },
        "runfiles": {
          "hello.hpp": {"data":{"path":"hello.hpp","rep
        }
      }
$
```

Support pkg-config for Dependencies and Dependents

```
$ just-mr build -P lib/pkgconfig/hello.pc
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","build","-C","/worker/build/62d9cc5ae42928f8/root/home/.cache/just/protocol-dependent/generation-0/git-sha1
INFO: Requested target is [["@","","",""],{}]
INFO: Analysed target [["@","","",""],{}]
INFO: Discovered 5 actions, 1 trees, 1 blobs
INFO: Building [["@","","",""],{}].
INFO: Processed 5 actions, 0 cache hits.
INFO: Artifacts built, logical paths are:
        include/hello.hpp [358d39118af999403eb19bc97647340e08c64725:119:f]
        lib/libhello.a [39be270eeff3c3a52871a120bc4318c100802a4a:5982:f]
        lib/pkgconfig/fmt.cflags [8b137891791fe96927ad78e64b0aad7bded08bdc:1:f]
        lib/pkgconfig/fmt.ldflags [734287fcf96cc358652d4c91c277824a311de558:7:f]
        lib/pkgconfig/hello.pc [fb57462962400668bd67ba9bbaf36a3b81d5df2b:283:f]
prefix=/
libdir=${prefix}/lib
includedir=${prefix}/include
Name: hello
Version: unknown
Description: Pkg-config for hello, generated by JustBuild
URL: unknown
Cflags: -I${includedir} @${prefix}/lib/pkgconfig/fmt.cflags
Libs: ${libdir}/libhello.a @${prefix}/lib/pkgconfig/fmt.ldflags
$
```

Tool Defaults

- Targets implicitly depend on the toolchain
  … provided by the respective "`defaults`" target of the rules

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```
$ just-mr describe --main rules CC defaults
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/628797c6a...
[["@","rules","CC","defaults"],{}] is defined by user-defined rule ["@","ru...

 | A rule to provide defaults.
 | All CC targets take their defaults for CC, CXX, flags, etc from
 | the target ["CC", "defaults"]. This is probably the only sensible
 | use of this rule. As targets form a different root, the defaults
 | can be provided without changing this directory.
String fields
- "CC"
   | The C compiler to use
- "CXX"
   | The C++ compiler to use
- "CFLAGS"
   | Flags for C compilation. Specifying this field overwrites
   | values from "base".
- "CXXFLAGS"
   | Flags for C++ compilation. Specifying this field overwrites
   | values from "base".
- "LDFLAGS"
   | Linker flags for linking the final CC library. Specifying this field
   | overwrites values from "base".
- "ADD_CFLAGS"
   | Additional compilation flags for C. Specifying this field
   | extends values from "base".
- "ADD_CXXFLAGS"
   | Additional compilation flags for C++. Specifying this field
   | extends values from "base".
- "ADD_LDFLAGS"
   | Additional linker flags for linking the final CC library. Specifying
   | this field extends values from "base".
- "AR"
   | The archiver tool to use
- "PATH"
   | Path for looking up the compilers. Individual paths are joined
   | with ":". Specifying this field extends values from "base".
- "SYSTEM_TOOLS"
   | List of tools ("CC", "CXX", or "AR") that should be taken from
   | the system instead of from "toolchain" (if specified).
Target fields
- "base"
   | Other targets (using the same rule) to inherit values from.
- "toolchain"
   | Optional toolchain directory. A collection of artifacts that provide
   | the tools CC, CXX, and AR (if needed). Note that only artifacts of
   | the specified targets are considered (no runfiles etc.). Specifying
   | this field extends artifacts from "base". If the toolchain
   | supports cross-compilation, it should perform a dispatch on the
   | configuration variable "BUILD_ARCH" to determine for which
   | architecture to generate code for.
- "deps"
   | Optional CC libraries any CC library and CC binary implicitly depend
   | on. Those are typically "libstdc++" or "libc++" for C++ targets.
   | Specifying this field
Variables taken from the
- "ARCH"
- "HOST_ARCH"
- "TARGET_ARCH"
Result
- Artifacts
- Runfiles

$
```

Tool Defaults

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  … provided by the respective "`defaults`" target of the rules

```
$ just-mr describe --main rules CC/proto defaults
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/628797c6a...
[["@","rules","CC/proto","defaults"],{}] is defined by user-defined rule ["...

 | A rule to provide protoc/GRPC defaults.
 | Used to implement ["CC/proto", "defaults"] for CC proto libraries
 | and ["CC/proto", "service defaults"] for CC proto service libraries
 | (GRPC).
String fields
- "PROTOC"
   | The proto compiler. If "toolchain" is empty, this field's value is
   | considered the proto compiler name that is looked up in "PATH". If
   | "toolchain" is non-empty, this field's value is assumed to be the
   | relative path to the proto compiler in "toolchain". Specifying this
   | field overwrites values from "base".
- "LDFLAGS"
   | Linker flags for linking the final CC library. Specifying this field
   | overwrites values from "base".
- "ADD_LDFLAGS"
   | Additional linker flags for linking the final CC library. Specifying
   | this field extends values from "base".
- "GRPC_PLUGIN"
   | The GRPC plugin for the proto compiler. If "toolchain" is empty,
   | this field's value is considered to be the absolute system path to the
   | plugin. If "toolchain" is non-empty, this field's value is assumed
   | to be the relative path to the plugin in "toolchain". Specifying
   | this field overwrites values from "base".
- "PATH"
   | Path for looking up the proto compiler. Individual paths are joined
   | with ":". Specifying this field extends values from "base".
Target fields
- "base"
   | Other targets (using the same rule) to inherit values from. If
   | multiple targets are specified, for values that are overwritten (see
   | documentation of other fields) the last specified value wins.
- "toolchain"
   | Optional toolchain directory. A collection of artifacts that provide
   | the protobuf compiler and the GRPC plugin (if needed). Note that only
   | artifacts of the specified targets are considered (no runfiles etc.).
   | Specifying this field extends artifacts from "base".
- "deps"
   | Optional CC libraries the resulting CC proto libraries implicitly
   | depend on. Those are typically "libprotobuf" for CC proto libraries
   | and "libgrpc++" for CC proto service libraries. Specifying this
   | field extends dependencies from "base".
Variables taken from the configuration
- "ARCH"
- "HOST_ARCH"
Result
- Artifacts
- Runfiles

$
```

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```
$ just-mr describe --main rules patch defaults
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/628797c6a...
[["@","rules","patch","defaults"],{}] is defined by user-defined rule ["@",...

 | A rule to provide defaults.
 | All targets take their defaults for PATCH from the target
 | ["patch", "defaults"]. This is probably the only sensible
 | use of this rule. As targets form a different root, the defaults
 | can be provided without changing this directory.
 String fields
 - "PATCH"
   | The patch binary to use
 - "PATH"
   | Path for looking up the compilers. Individual paths are joined
   | with ":". Specifying this field extends values from "base".
 - "SYSTEM_TOOLS"
   | List of tools ("PATCH") that should be taken from
   | the system instead of from "toolchain" (if specified).
 Target fields
 - "base"
   | Other targets (using the same rule) to inherit values from.
 - "toolchain"
   | Optional toolchain directory. A collection of artifacts that provide
   | the tool PATCH. Note that only artifacts of
   | the specified targets are considered (no runfiles etc.). Specifying
   | this field extends artifacts from "base".

Variables taken from the configuration
- "ARCH"
- "HOST_ARCH"
Result
- Artifacts
- Runfiles

$
```

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  … provided by the respective "`defaults`" target of the rules
- Those defaults …
  - support inheriting from other defaults
  - specify names of the tools
  - specify path where to find them (if taken from host)
  - set flags, as well as flags to add on top of what is inherited
  - allow tools to be built by other targets

Interact with Foreign Build Tools

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- want to bundle—but writing `just` target files is effort!

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- want to bundle—but writing `just` target files is effort!

⇝ call the foreign tool
(one huge action, but updates kind-of rare, so shared caching saves)

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```
$ just-mr describe --main rules --rule CC/foreign/make data
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/62c162591...
 | Data produced by Configure and Make build and install.
 |
 | All variables accessible to commands and options are: "TMPDIR",
 | "LOCALBASE", "CC", "CXX", "CFLAGS", "CXXFLAGS", "LDFLAGS",
 | "AR", and "PREFIX". "LOCALBASE" contains the path to the
 | installed artifacts from "deps".
String fields
- "subdir"
  | The subdirectory that contains the configure and Makefile. Individual
  | directory components are joined with "/".
- "configure"
  | Run ./configure if non-empty.
- "configure_options"
  | The configure options (the "--prefix" option is automatically set.
  | Variables can be accessed via "${<varname>}", e.g., "${TMPDIR}"
  | for variable "$TMPDIR".
- "targets"
  | The Make targets to build in the specified order
  | (default: ["install"]).
- "prefix"
  | The prefix used for the Make target. The path will be made absolute
  | and individual directory components are joined with "/". If no
  | prefix is specified, the value from the config variable "PREFIX" is
  | taken, with the default value being "/".
- "options"
  | Make options for the configuration phase
  | (e.g., ["-f", "Makefile", "ARCH=x86", "LD=${CC}"]). Variables
  | can be accessed via "${<varname>}", e.g., "${TMPDIR}" for
  | variable "$TMPDIR".
- "jobs"
  | Number of jobs to run simultaneously. If omitted, Make's default
  | number is used.
- "pre_cmds"
  | List of commands executed in the project directory before calling
  | Configure or Make. Useful for renaming files or directories. Note
  | that data between "pre_cmds" and "post_cmds" can be exchanged via
  | "$TMPDIR", which is uniquely reserved for this action.
- "post_cmds"
  | List of commands executed in the install directory after successful
  | installation but before the output files are collected. Useful for
  | renaming files or directories. Note that data between "pre_cmds" and
  | "post_cmds" can be exchanged via "$TMPDIR", which is uniquely
  | reserved for this action.
- "out_files"
  | Paths to the produced output files. The paths are considered relative
  | to the install directory.
  | Note that "out_files" and "out_dirs" may not overlap.
- "out_dirs"
  | Paths to the produced output directories. The paths are considered
  | relative to the install directory.
  | Note that "out_files" and "out_dirs" may not overlap.
Target fields
- "project"
  | The Make project directory. It should contain a single tree artifact
- implict dependency
  - ["@","rules","CC","defaults"]
- implict dependency
  - ["@","rules","CC/foreign","expand_exec"]
- implict dependency
  - ["@","rules","CC/foreign","defaults"]
Variables taken from the configuration
- "ARCH"
- "HOST_ARCH"
- "CC"
  | The name of the C compiler to be used.
  | If null, the respective value from ["CC", "defa
- "CXX"
  | The name of the C++ compiler to be used.
  | If null, the respective value from ["CC", "defa
- "CFLAGS"
  | The flags for CC to be used instead of the defa
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice
- "CXXFLAGS"
  | The flags for CXX to be used instead of the def
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "LDFLAGS"
  | The linker flags to be used instead of the defa
  | For libraries that should be linked in a non-st
  | adapting the default target ["CC", "defaults"]
  | choice
- "ADD_CFLAGS"
  | The flags to add to the default ones for CC.
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ADD_CXXFLAGS"
  | The flags to add to the default ones for CXX.
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ADD_LDFLAGS"
```

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- many interesting libraries are built using other build tools

```
$ just-mr describe --main rules --rule CC/foreign/make library
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/62c162591...
 | Library produced by Configure and Make build and install.
 |
 | All variables accessible to commands and options are: "TMPDIR",
 | "LOCALBASE", "CC", "CXX", "CFLAGS", "CXXFLAGS", "LDFLAGS",
 | "AR", and "PREFIX". "LOCALBASE" contains the path to the
 | installed artifacts from "deps".
String fields
- "subdir"
  | The subdirectory that contains the configure and Makefile. Individual
  | directory components are joined with "/".
- "name"
  | The name of the library (without leading "lib" or trailing file name
  | extension), also used as name for pkg-config files.
- "version"
  | The library version, used for pkg-config files. Individual version
  | components are joined with ".".
- "stage"
  | The logical location of the public headers and library files.
  | Individual directory components are joined with "/".
- "configure"
  | Run ./configure if non-empty.
- "configure_options"
  | The configure options (the "--prefix" option is automatically set.
- "targets"
  | The Make targets to build in the specified order
  | (default: ["install"]).
- "prefix"
  | The prefix used for the Make target. The path will be made absolute
  | and individual directory components are joined with "/". If no
  | prefix is specified, the value from the config variable "PREFIX" is
  | taken, with the default value being "/".
- "options"
  | Make options for the build phase.
  | (e.g., ["-f", "Makefile", "ARCH=x86"])
- "jobs"
  | Number of jobs to run simultaneously. If omitted, Make's default
  | number is used.
- "pre_cmds"
  | List of commands executed in the project directory before calling
  | Configure or Make. Useful for renaming files or directories. Note
  | that data between "pre_cmds" and "post_cmds" can be exchanged via
  | "$TMPDIR", which is uniquely reserved for this action.
- "post_cmds"
  | List of commands executed in the install directory after successful
  | installation but before the output files are collected. Useful for
  | renaming files or directories (e.g., in case of SONAME mismatch). Note
  | that data between "pre_cmds" and "post_cmds" can be exchanged via
  | "$TMPDIR", which is uniquely reserved for this action.
- "out_hdrs"
  | Paths to produced public header files. The path is considered
  | relative to the include directory, which be set via "hdr_prefix".
  | Note that "out_hdrs" and "out_hdr_dirs" may not overlap.
- "out_hdr_dirs"
  | Paths to produced public header directories. The path is considered
  | relative to the include directory, which be set via "hdr_prefix".
  | Note that "out_hdrs" and "out_hdr_dirs" may not overlap.
- "out_libs"
  | Paths to produced library files. The path is considered relative
  | to the library directory, which be set via "lib_prefix".
  | Order matters in the case of one library depending on another.
- "cflags"
  | List of compile flags set for this target and its consumers.
- "ldflags"
  | Additional linker flags that are required for t
  | produced libraries.
- "pkg-config"
  | Pkg-config file for optional infer of public cf
  | multiple files are specified (e.g., one depends
  | first one is used as entry. Note that if this f
  | tool "pkg-config" must be available in "PATH",
  | from ["CC", "defaults"] or the "ENV" variable.
- "hdr_prefix"
  | Prefix where headers will be installed by Make.
  | components are joined with "/". Defaults to "in
- "lib_prefix"
  | Prefix where libraries will be installed by Mak
  | directory components are joined with "/". Defau
  | not set.
- "pc_prefix"
  | Prefix where pkg-config files will be installed
  | directory components are joined with "/". Defau
  | "lib/pkgconfig" if not set.
Target fields
- "project"
  | The Make project directory. It should contain a
- "deps"
  | Public dependency on other CC libraries.
- implict dependency
  - ["@","rules","CC","prebuilt/read_pkgconfig.py"]
- implict dependency
  - ["@","rules","CC","defaults"]
- implict dependency
  - ["@","rules","CC/foreign","expand_exec"]
- implict dependency
  - ["@","rules","CC/foreign","defaults"]
```

Interact with Foreign Build Tools

- many interesting libraries are built using other build tools

```
$ just-mr describe --main rules CC/foreign defaults
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/62c162591...
[["@","rules","CC/foreign","defaults"],{}] is defined by user-defined rule ...

 | A rule to provide defaults for foreign rules.
 | All foreign rules take their defaults for MAKE, CMAKE, etc from
 | the target ["CC/foreign", "defaults"].
String fields
- "MAKE"
  | The make binary to use
- "CMAKE"
  | The cmake binary to use
- "PATH"
  | Path for looking up the tools. Individual paths are joined with
  | with ":". Specifying this field extends values from "base".
- "SYSTEM_TOOLS"
  | List of tools ("MAKE", "CMAKE") that should be taken from
  | the system instead of from "toolchain" (if specified).
Target fields
- "base"
  | Other targets (using the same rule) to inherit values from.
- "toolchain"
  | Optional toolchain directory. A collection of artifacts that provide
  | the tools MAKE, CMAKE. Note that only artifacts of
  | the specified targets are considered (no runfiles etc.). Specifying
  | this field extends artifacts from "base".
Variables taken from the configuration
- "ARCH"
- "HOST_ARCH"
Result
- Artifacts
- Runfiles
$
```

Interact with Foreign Build Tools

- many interesting libraries are built using other build tools

```
$ just-mr describe --main rules --rule CC/foreign/cmake data
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/62c162591...
 | Data produced by CMake configure, build, and install.
 |
 | All variables accessible to commands and options are: "TMPDIR",
 | "LOCALBASE", "CC", "CXX", "CFLAGS", "CXXFLAGS", "LDFLAGS",
 | and "AR". "LOCALBASE" contains the path to the installed artifacts
 | from "deps".
String fields
- "subdir"
  | The subdirectory that contains the entry CMakeLists.txt. Individual
  | directory components are joined with "/".
- "options"
  | CMake options for the configuration phase.
  | (e.g., ["-GNinja", "-Ax64"])
- "defines"
  | CMake defines for the configuration phase.
  | (e.g., ["CMAKE_BUILD_TYPE=Release"])
- "targets"
  | The CMake targets to build in the specified order
  | (default: ["install"]).
- "jobs"
  | Number of jobs to run simultaneously. If omitted, CMake's default
  | number is used.
- "pre_cmds"
  | List of commands executed in the project directory before calling
  | CMake. Useful for renaming files or directories. Note that data
  | between "pre_cmds" and "post_cmds" can be exchanged via
  | "$TMPDIR" which is uniquely reserved for this action.
- "post_cmds"
  | List of commands executed in the install directory after successful
  | installation but before the output files are collected. Useful for
  | renaming files or directories. Note that data between "pre_cmds" and
  | "post_cmds" can be exchanged via "$TMPDIR", which is uniquely
  | reserved for this action. The CMake source and build directory can be
  | accessed via "$CMAKE_SOURCE_DIR" and "$CMAKE_BINARY_DIR",
  | respectively.
- "out_files"
  | Paths to the produced output files. The paths are considered relative
  | to the install directory.
  | Note that "out_files" and "out_dirs" may not overlap.
- "out_dirs"
  | Paths to the produced output directories. The paths are considered
  | relative to the install directory.
  | Note that "out_files" and "out_dirs" may not overlap.
Target fields
- "project"
  | The CMake project directory. It should contain a single tree artifact
- implict dependency
  - ["@","rules","CC","defaults"]
- implict dependency
  - ["@","rules","CC/foreign","expand_exec"]
- implict dependency
  - ["@","rules","CC/foreign","defaults"]
Variables taken from the configuration
- "ARCH"
- "HOST_ARCH"
- "CC"
  | The name of the C compiler to be used.
  | If null, the respective value from ["CC", "defaults"] will be taken.
- "CXX"
  | The name of the C++ compiler to be used.
  | If null, the respective value from ["CC", "defaults"] will be taken.
- "CFLAGS"
  | The flags for CC to be used instead of the defa
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice
- "CXXFLAGS"
  | The flags for CXX to be used instead of the def
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "LDFLAGS"
  | The linker flags to be used instead of the defa
  | For libraries that should be linked in a non-st
  | adapting the default target ["CC", "defaults"]
  | choice
- "ADD_CFLAGS"
  | The flags to add to the default ones for CC.
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ADD_CXXFLAGS"
  | The flags to add to the default ones for CXX.
  | For libraries that should be built in a non-sta
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ADD_LDFLAGS"
  | The linker flags to add to the default ones.
  | For libraries that should be linked in a non-st
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ENV"
  | The environment for any action generated.
  | If null, the respective value from ["CC", "defa
- "AR"
```

Interact with Foreign Build Tools

- many interesting libraries are built using other build tools

```
$ just-mr describe --main rules --rule CC/foreign/shell data
INFO: Performing repositories setup
INFO: Found 2 repositories to set up
INFO: Setup finished, exec ["just","describe","-C","/worker/build/62c162591...
 | Data produced by generic shell commands with toolchain support.
 |
 | All variables accessible to commands and options are: "TMPDIR",
 | "LOCALBASE", "WORKDIR", "DESTDIR", "CC", "CXX", "CFLAGS",
 | "CXXFLAGS", "LDFLAGS", and "AR". "LOCALBASE" contains the path
 | to the staged artifacts from "localbase" and the installed artifacts
 | from "deps". Furthermore, the variable "ACTION_DIR" points to the
 | current action directory, if needed for achieving reproducibility.
String fields
- "cmds"
  | List of commands to execute by "sh". Multiple commands will be
  | joined with the newline character.
- "outs"
  | Paths to the produced output files in "DESTDIR".
- "out_dirs"
  | Paths to the produced output directories in "DESTDIR".
Target fields
- "project"
  | The project directory. It should contain a single tree artifact.
  | It's path can be accessed via the "WORKDIR" variable.
- "localbase"
  | Artifacts to stage to "LOCALBASE".
- "deps"
  | CC targets to install to "LOCALBASE".
- implict dependency
  - ["@","rules","CC","defaults"]
- implict dependency
  - ["@","rules","CC/foreign","expand_exec"]
- implict dependency
  - ["@","rules","CC/foreign","defaults"]
Variables taken from the configuration
- "CC"
  | The name of the C compiler to be used.
  | If null, the respective value from ["CC", "defaults"] will be taken.
- "CXX"
  | The name of the C++ compiler to be used.
  | If null, the respective value from ["CC", "defaults"] will be taken.
- "CFLAGS"
  | The flags for CC to be used instead of the default ones.
  | For libraries that should be built in a non-standard way; usually
  | adapting the default target ["CC", "defaults"] is the better
  | choice
- "CXXFLAGS"
  | The flags for CXX to be used instead of the default ones.
  | For libraries that should be built in a non-standard way; usually
  | adapting the default target ["CC", "defaults"] is the better
  | choice.
- "LDFLAGS"
  | The linker flags to be used instead of the default ones.
  | For libraries that should be linked in a non-standard way; usually
  | adapting the default target ["CC", "defaults"] is the better
  | choice
- "ADD_CFLAGS"
  | The flags to add to the default ones for CC.
  | For libraries that should be built in a non-standard way; usually
  | adapting the default target ["CC", "defaults"] is the better
  | choice.
- "ADD_CXXFLAGS"
  | The flags to add to the default ones for CXX.
  | For libraries that should be built in a non-standard way; usually
  | adapting the default target ["CC", "defaults"] is the better
  | choice.
- "ADD_LDFLAGS"
  | The linker flags to add to the default ones.
  | For libraries that should be linked in a non-st
  | adapting the default target ["CC", "defaults"]
  | choice.
- "ENV"
  | The environment for any action generated.
  | If null, the respective value from ["CC", "defa
- "AR"
  | The archive tool to used for creating the libra
  | If null, the respective value from ["CC", "defa
- "PREFIX"
  | The absolute path that is used as prefix inside
  | files. The default value for this variable is "
  | is ignored if the field "prefix" is set.
- "BUILD_POSITION_INDEPENDENT"
  | Build position independent code.
- "TIMEOUT_SCALE"
  | The scaling of the timeout for the invocation o
  | Defaults to 10.
Result
- Artifacts
- Runfiles

$
```

Interact with Foreign Build Tools

- many interesting libraries are built using other build tools
- want to bundle—but writing `just` target files is effort!

⇝ call the foreign tool
(one huge action, but updates kind-of rare, so shared caching saves)

Toolchain

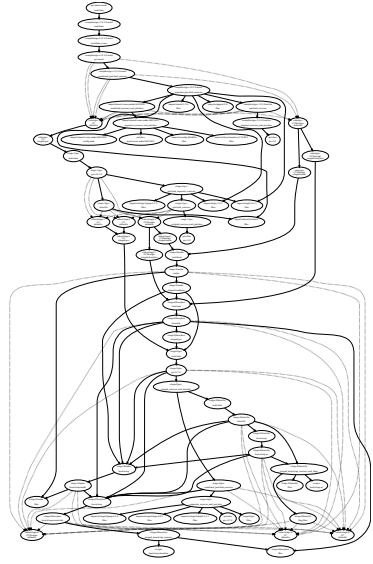
- Cooperation partners want to get the same binaries
  … but work in different environments

Toolchain

- Cooperation partners want to get the same binaries
  … but work in different environments
- ⇝ Bootstrap all tools
  … by first building the production compiler
  using the host `C` compiler

Toolchain

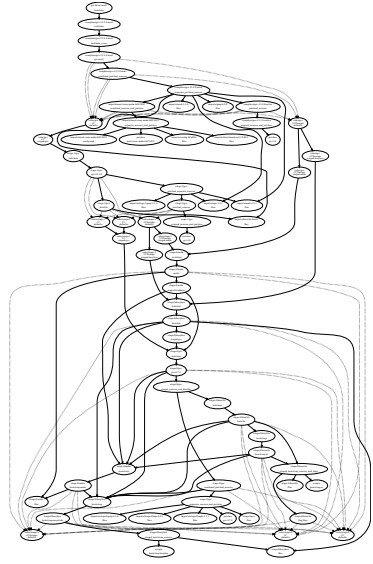
- Cooperation partners want to get the same binaries
  … but work in different environments
- ⇝ Bootstrap all tools
  … by first building the production compiler
  using the host C compiler
- Details are a bit more complicated
  e.g., modern C compilers are written in C++



HUAWEI

Toolchain

- Cooperation partners want to get the same binaries
  … but work in different environments
- ⇝ Bootstrap all tools
  … by first building the production compiler
  using the host `C` compiler
- Details are a bit more complicated
  e.g., modern `C` compilers are written in `C++`
- Now we have
  - rules for foreign build systems
  - bootstrapped modern `gcc`, `clang`, `make`, `cmake`, `busybox`, `python3`
  - an easy way to transitively import dependencies: `just-import-git`, `just-deduplicate-repositories`



Toolchain

- Cooperation partners want to get the same binaries
  … but work in different environments
- ⇝ Bootstrap all tools
  … by first building the production compiler
  using the host `C` compiler
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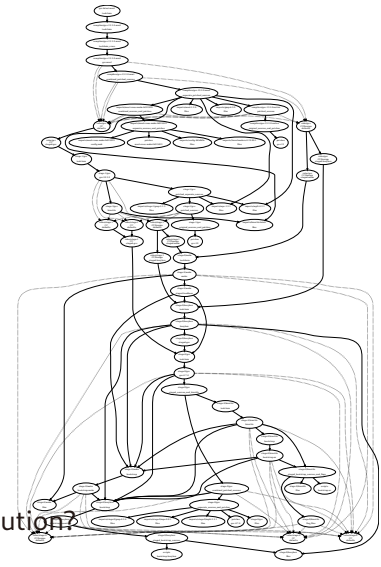
- Now we have
  - rules for foreign build systems
  - bootstrapped modern `gcc`, `clang`, `make`, `cmake`, `busybox`, `python3`
  - an easy way to transitively import dependencies: `just-import-git`, `just-deduplicate-repositories`

Is that the beginning of a new (“the distributed”) distribution?
And if so, is that good, bad, or `xkcd/927`?



Thank You!

- Sources
  - https://github.com/just-buildsystem/justbuild
  - https://github.com/just-buildsystem/rules-cc
  - https://github.com/just-buildsystem/bootstrappable-toolchain
- Background
  - https://bootstrappable.org/
  - https://reproducible-builds.org/