Bazel

{fast, correct} – choose two

Klaus Aehlig

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Bazel

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  I.e., organizes compiling/creating artifacts (libraries, executables, . . .) from sources.
- open-source since 2015
- . . . but a longer (a decade) history as a Google-internal tool

Bazel

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- declarative style of `BUILD` files
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  - central maintenance point for build rules
- generic tool *Can bring your own declarative rules for* `BUILD` *files*

An Example

Let's look at a `helloworld` example.

An Example

- main program `helloworld.c`

helloworld.c

An Example

helloworld.c

- main program `helloworld.c`

```
#include "lib/hello.h"

int main(int argc, char **argv) {
  greet("world");
  return 0;
}
```

An Example

- main program `helloworld.c`, depending on a library

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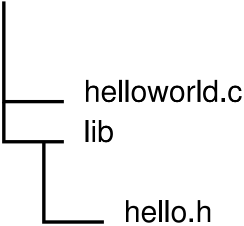
- main program `helloworld.c`, depending on a library
- a library with headers (`lib/hello.h`)



helloworld.c

lib

hello.h

```
#ifndef HELLO_H
#define HELLO_H

void greet(char *);

#endif
```

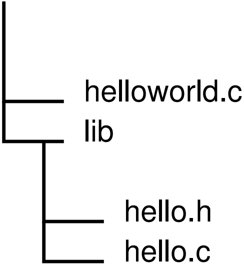
An Example

- main program `helloworld.c`, depending on a library
- a library with headers (`lib/hello.h`)

  . . . and implementation (`lib/hello.c`)

```
#include "hello.h"
#include <stdio.h>

void greet(char *it) {
  printf("Hello %s!", it);
}
```



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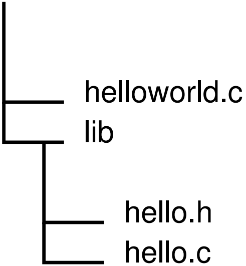

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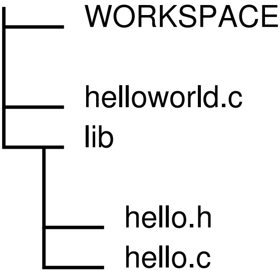

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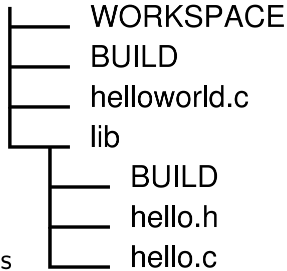

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```

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cc_library(
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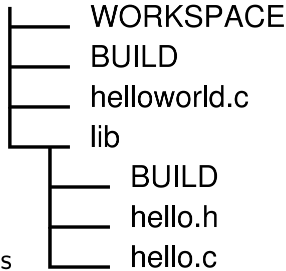

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Note: `CC`, link options, host/target architecture, etc, taken care of elsewhere.

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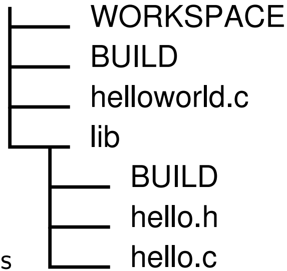

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Have declarative descriptions. What happens at `bazel build`?

- load the `BUILD` files *(all that are needed)*
- analyze dependencies between targets
- from rules generate action graph
- execute actions *(unless already cached)*

on subsequent builds, update the graphs
(client-server architecture to keep graph in memory)

Example cont'd: Dependencies

build //:helloworld

Now let's see what happens if we want to build `:helloworld`. . .

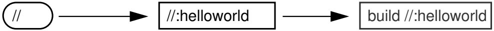
command

Example cont'd: Dependencies

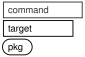
//:helloworld
build //:helloworld
command
target

We look at the target `:helloworld`

Example cont'd: Dependencies



We look at the target `:helloworld`, in package //



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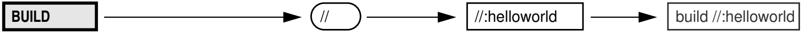
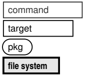


We look at the target `:helloworld`, in package `//`, in file `BUILD`



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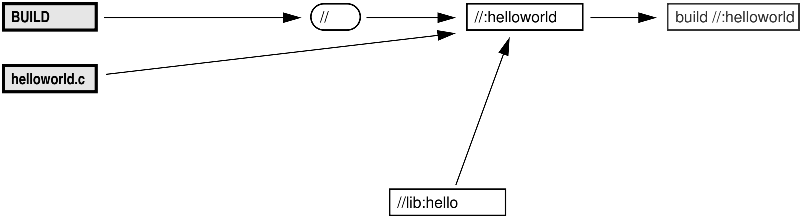
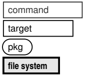


Two declared dependencies



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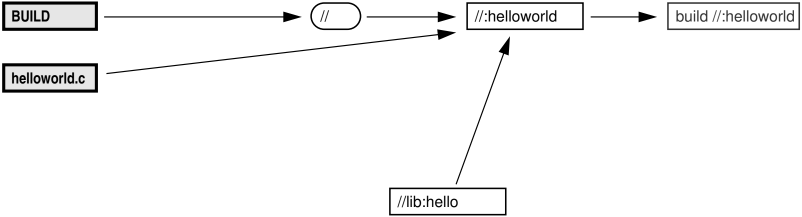
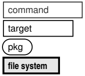


Two declared dependencies

. . . and implicit dependency on the `C` *tool chain (not drawn in this diagram)*



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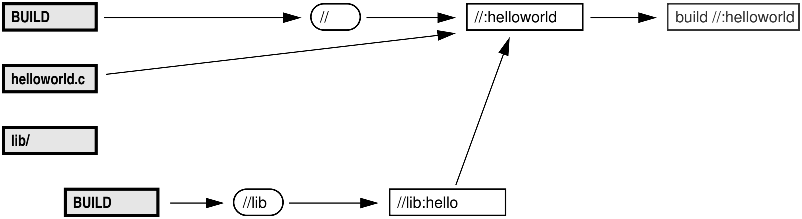
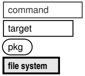


Two declared dependencies, one in a different package

Note: We construct dependency graph over package boundaries!

(no recursive calling)



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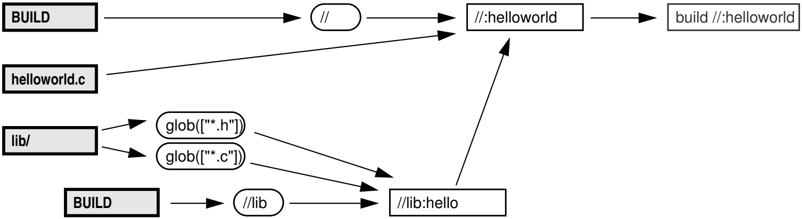
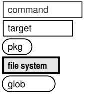


We discover `glob` expressions



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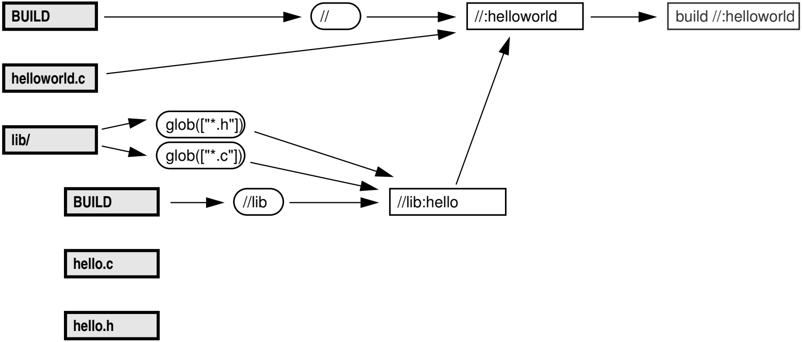
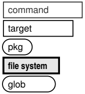


We discover `glob` expressions, and read the directory.



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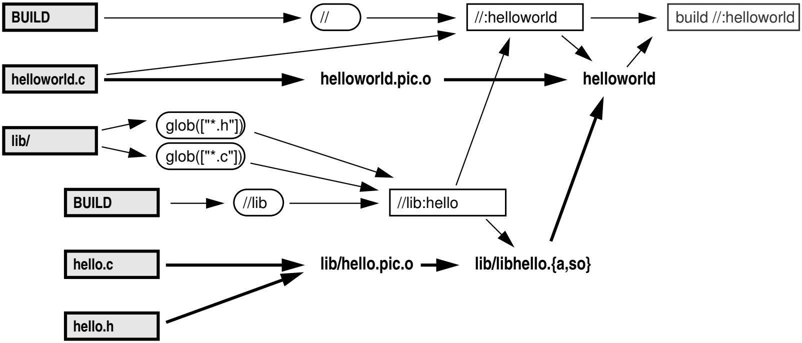
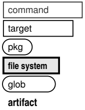


The rules tell us, which artifacts to build.



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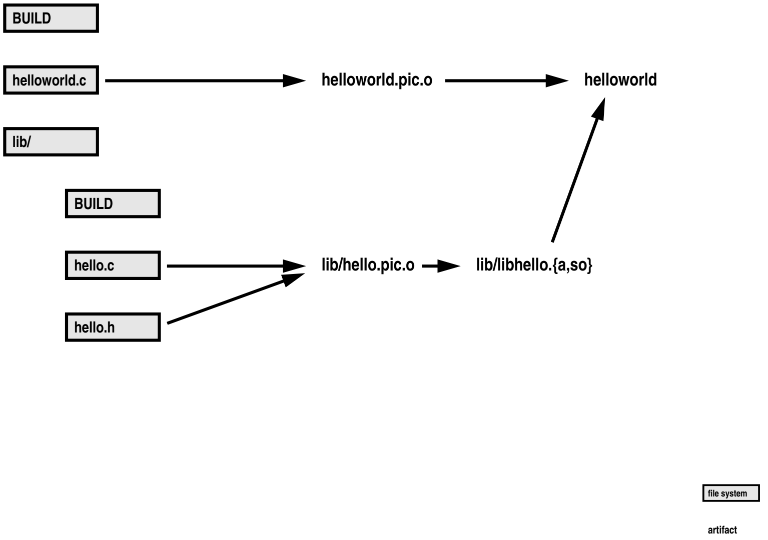

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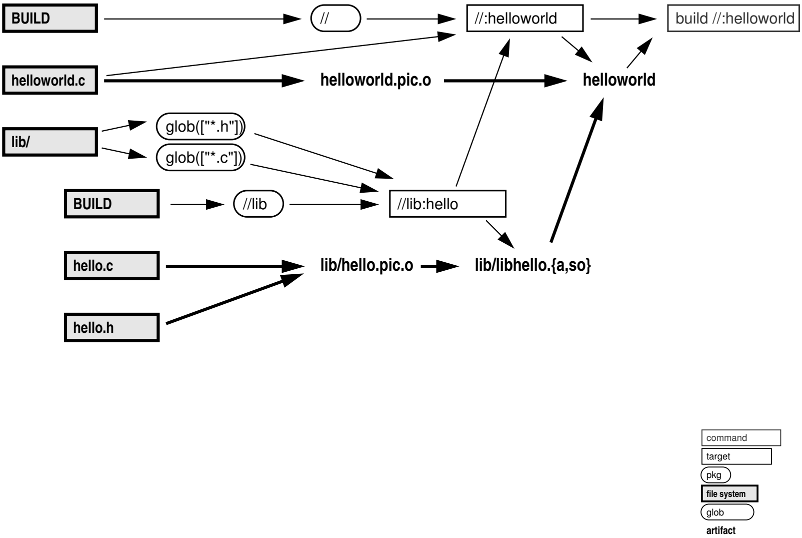

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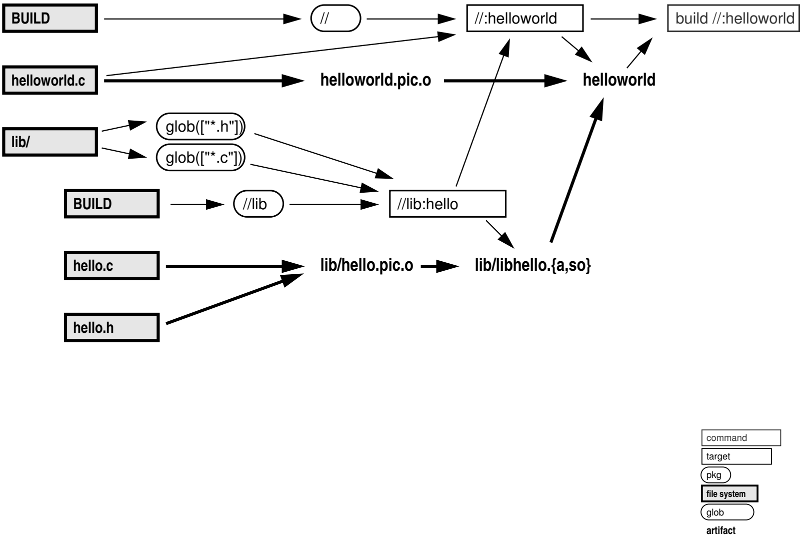

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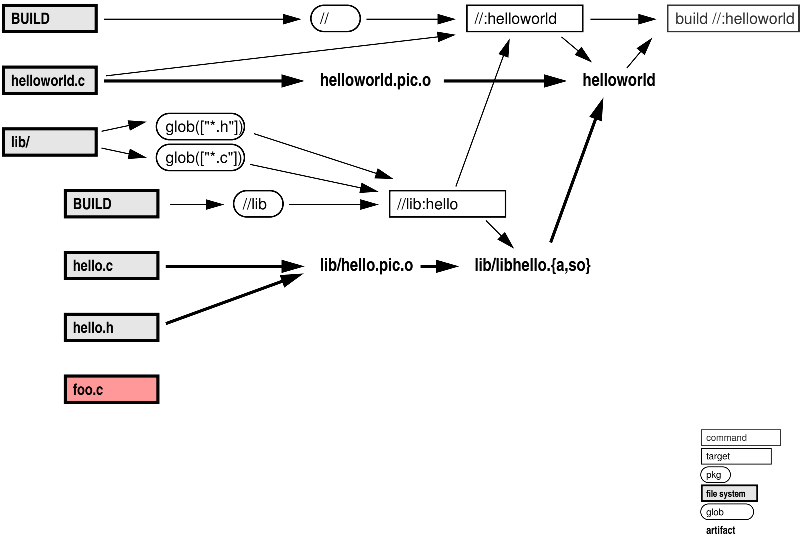

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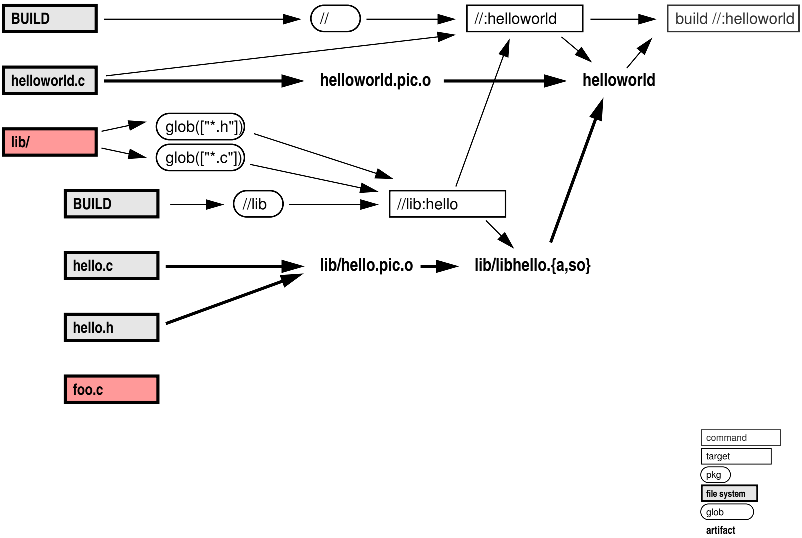

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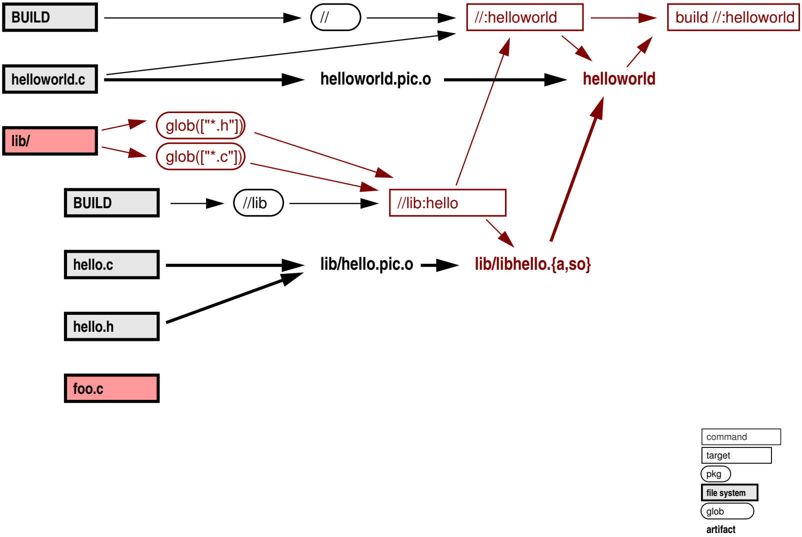

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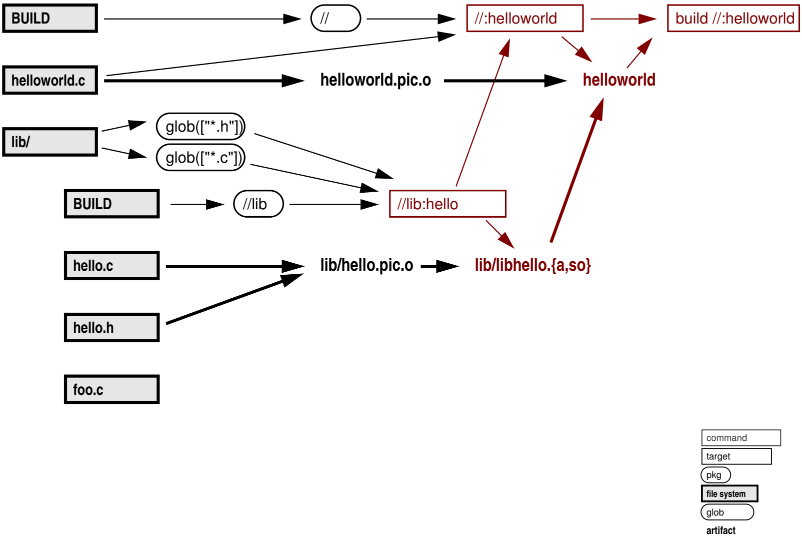

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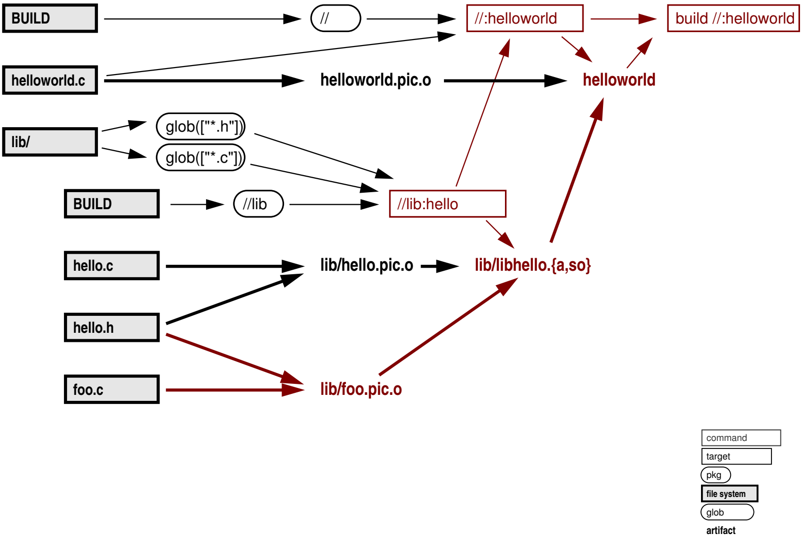

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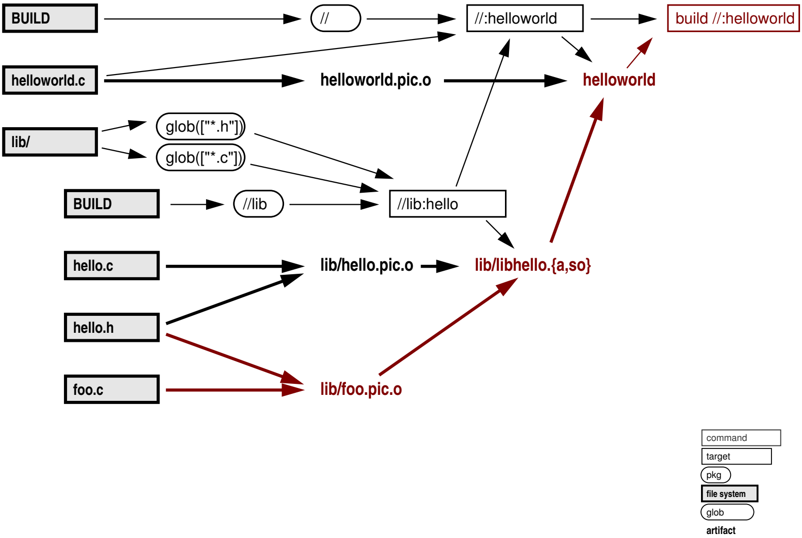

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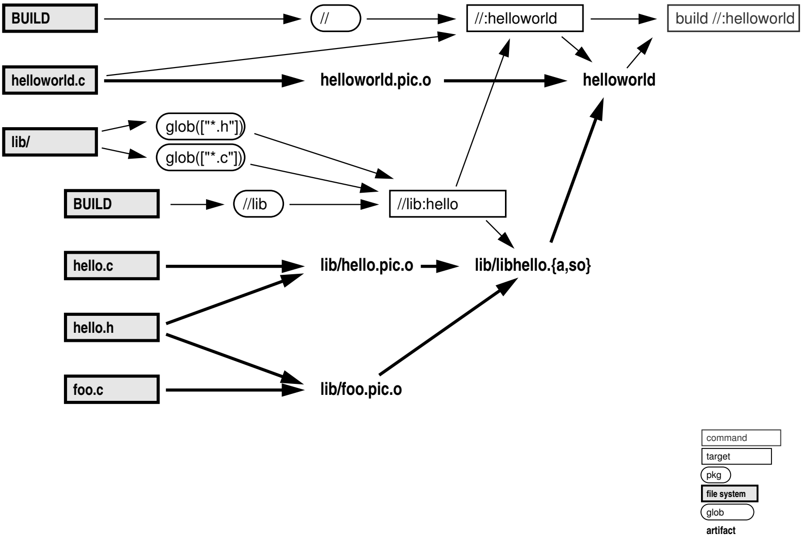

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  - so, no `.done_foo` targets,
  - and only reading *declared inputs*

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  - isolated environment
    - only declared inputs/tools present
    - only declared outputs copied out
  - depending on OS, different approaches (none, temp dir, `chroot`, . . .)

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⇝ facilitate correct I/O by running actions in "sandboxes"

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  ⇒ enables shared caches.

  (Several close-by engineers working on the same code base!)

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    - specialized rules with knowledge about certain languages
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- Bazel has built-in rules
  - specialized rules with knowledge about certain languages
    `cc_library`, `cc_binary`, `java_library`, `java_binary`, ...
  - generic ones, in particular `genrule`
    → just specify a shell command (with `$@`, `$<`, ...)
    (basically the only rule available in a `Makefile`*)*

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⇝ need ways to expend `BUILD` language: Skylark

  - Python-like language *(familiar syntax)*
  - but restricted to a simple core
    without global state, complicated feature, . . .

  ⇝ deterministic, hermetic evaluation

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  - typeset pdf files from textual description (*.tex files)

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- To get a feeling for the language, let's do an example

  . . . and step by step develop rules for LaTeX

  - typeset `pdf` files from textual description (`*.tex` files)
  - the `*.tex` files can pull in other files (`.sty`, images, diagrams, `\input` other `.tex`-files)

Skylark

- Bazel has built-in rules
- but adding specialized rule for every language doesn't scale

⇝ need ways to expend `BUILD` language: Skylark

- To get a feeling for the language, let's do an example

  ... and step by step develop rules for LaTeX
  - typeset `pdf` files from textual description (`*.tex` files)
  - the `*.tex` files can pull in other files (`.sty`, images, diagrams, `\input` other `.tex`-files)
  - `pdflatex main.tex && ...`

Skylark

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- but adding specialized rule for every language doesn't scale

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- To get a feeling for the language, let's do an example

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Macros

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  - `latex`-rule is given by an entry point and a list of source files
  - have a script to typeset this
    (tmpdir, correct number of `pdflatex` *runs, …)*

Macros

- First approach (entry + files; script)

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⇝ write a macro in `rules/latex/latex.bzl`

```
def latex(name="", main="", srcs=[]):
  run = str(Label("//rules/latex:runlatex.sh"))
  native.genrule(
    name = name + "_pdf",
    srcs = srcs,
    cmd = ("sh $(location " + run +") $@"
           + " $(location " + main + ") $(SRCS)",
    outs = [name + ".pdf"],
    tools = [run],
  )
```

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```

- can be loaded in `BUILD` files

```
load("//rules/latex/latex.bzl", "latex")
```

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  ...
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```

- can be loaded in `BUILD` files

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load("//rules/latex/latex.bzl", "latex")
latex(
  name = "slides",
  main = "main.tex",
  srcs = ["diagram.ps"],
)
```

Macros

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$\leadsto$ write a macro in `rules/latex/latex.bzl`

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load("//rules/latex/latex.bzl", "latex")
latex(
  name = "slides",
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)
```

$\leadsto$ central maintenance; convenience-targets (`xpdf`, `pdfnup`, ...)

File Groups

File Groups

- Start thinking in groups of files

File Groups

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  "That slide with all the diagrams belonging to it"

File Groups

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File Groups

- Start thinking in groups of files
- Built-in rule: `filegroup`

```
filegroup(name = "foosection",
          srcs = ["foosection.tex", ":diagram"])
...
filegroup(
  name = "barchapter",
  srcs = ["barchapter.tex", ":foosection", ...])
```

File Groups

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          srcs = ["foosection.tex", ":diagram"])
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  name = "barchapter",
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- Gives a label to a set of files (with traversal order)
  ⇝ single maintenance point

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filegroup(name = "foosection",
          srcs = ["foosection.tex", ":diagram"])
...
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  name = "barchapter",
  srcs = ["barchapter.tex", ":foosection", ...])
```

- Gives a label to a set of files (with traversal order) ⇝ single maintenance point
- Can be nested, inserting the entries *(but implemented in a memory-efficient way!)*

Rules

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  (also changing the script, now expecting an arguments file)

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```
latex = rule(
  attrs = {
    "main" : attr.label(allow_files=True),
    "srcs" : attr.label_list(allow_files=True),
    "_runlatex":  attr.label(
      cfg="host", allow_files=True,
      default = Label("//rules/latex:runlatex.sh")),
  },
  outputs = {"pdf" : "%{name}.pdf"},
  implementation = _latex_impl,
  )
```

Rules

- Next: missing argument checking, argv limits ⇝ Rules *(also changing the script, now expecting an arguments file)*

```
def _latex_impl(ctx):
    inputs = depset(ctx.files.srcs) \
             | depset(ctx.files.main)
    inputs_file = ctx.new_file(
        ctx.label.name + ".allinputs")
    ctx.file_action(
        inputs_file,
        "\n".join([f.path for f in inputs])
    )
    ...
```

Rules

- Next: missing argument checking, `argv` limits ⇝ Rules *(also changing the script, now expecting an arguments file)*

```
def _latex_impl(ctx):
    ...
    ctx.file_action(...)
    ...
```

Rules

- Next: missing argument checking, argv limits ⇝ Rules
  (also changing the script, now expecting an arguments file)

```
def _latex_impl(ctx):
    ...
    ctx.file_action(...)
    output = ctx.new_file(ctx.label.name + ".pdf")
    args = [f.path for f in ctx.files._runlatex] \
           + [output.path] \
           + [f.path for f in ctx.files.main[:1]] \
           + [inputs_file.path]
    ...
```

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def _latex_impl(ctx):
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    args = ...
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def _latex_impl(ctx):
    ...
    args = ...
    ...
```

Rules

- Next: missing argument checking, argv limits ⇝ Rules *(also changing the script, now expecting an arguments file)*

```
def _latex_impl(ctx):
    ...
    args = ...
    ctx.action(
        inputs = list(inputs | depset([inputs_file])
                      | depset(ctx.files._runpdflatex))
        outputs = [output],
        command = ["/bin/sh"] + args,
        mnemonic = "PdfLatex",
        progress_message = "Typesetting %s as pdf" \
                           % ctx.label,
    )
```

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  (also changing the script, now expecting an arguments file)

```
def _latex_impl(ctx):
    ...
    args = ...
    ctx.action(...)
```

- Additional benefits
  - Proper quoting for free
  - Meaningful progress messages

Providers

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- file_action is simple

```
includefile = rule(...)
def _includefile_impl(ctx):
  output = ctx.new_file(ctx.label.name + ".tex")
  deps = depset(ctx.files.srcs)
  includes = ["\\input{%s}\n" % f.short_path
                for f in deps]
  ctx.file_action(output = output,
                  content = "".join(includes))
```

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```

Using this new file implicitly depends on the sources!

Providers

- Start to collect macro definitions, organized in file groups
- Want to `\input` such a file group. . .
- `file_action` plus provider

```
LtxInfo = provider()
includefile = rule(...)
def _includefile_impl(ctx):
  output = ctx.new_file(ctx.label.name + ".tex")
  deps = depset(ctx.files.srcs)
  includes = ["\\input{%s}\n" % f.short_path
              for f in deps]
  ctx.file_action(output = output,
                   content = "".join(includes))
  return [LtxInfo(refd = depset([output])|deps)]
```

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def _includefile_impl(ctx):
    ...
    return [LtxInfo(refd = depset([output])|deps)]
```

- Consuming rules can use it

```
def _latex_impl(ctx):
      inputs = depset(ctx.files.srcs) \
                   | depset(ctx.files.main)




      ...
```

Providers

- Start to collect macro definitions, organized in file groups
- Want to `\input` such a file group…
- `file_action` plus provider

```
def _includefile_impl(ctx):
  ...
  return [LtxInfo(refd = depset([output])|deps)]
```

- Consuming rules can use it

```
def _latex_impl(ctx):
    inputs = depset(ctx.files.srcs) \
             | depset(ctx.files.main)
    for i in ctx.attr.srcs:
        if LtxInfo in i:
            inputs = inputs | i[LtxInfo].refd
    ...
```

Providers

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def _latex_impl(ctx):
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    for i in ctx.attr.srcs:
        if LtxInfo in i:
            inputs = inputs | i[LtxInfo].refd
    ...
```

Summary

- declarative `BUILD` files
- generic tool: can bring your own rules
  (Python-like extension language; can start easy)
- *all* dependencies tracked ⇝ correctness
  (sandboxes to ensure all I/O is known)
- full knowledge enables fast builds
  (caching of actions, remote execution, parallelism, . . .)
- open-source

Try Bazel

Try Bazel yourself.

- Homepage `https://bazel.build/`
- Mailing lists
  - `bazel-discuss@googlegroups.com`
  - `bazel-dev@googlegroups.com`
- Repository and issue tracker
  `https://github.com/bazelbuild/bazel`
- IRC `#bazel` on `irc.freenode.net`
- Release key fingerprint
  `71A1 D0EF CFEB 6281 FD04 37C9 3D59 19B4 4845 7EE0`

Thanks for your attention. Questions?