

Build Systems

CSE 403


What does a developer do?

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- Install dependencies
- Compile the code
- Run static analysis
- Generate documentation
- Run tests
- Create artifacts for customers
- Ship!

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Which should be
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NONE!

What to do instead?

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Orchestrate with a build system!

What is a build system?

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- A tool for orchestrating software engineering tasks

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- A tool for orchestrating software engineering tasks
 - Getting the source code
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**A good build system
handles all these**

What is a build system?

- A tool for orchestrating software engineering **tasks**

- Getting the source code
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All tasks!

Tasks

Tasks are code!

Tasks

Tasks are code!

- Should be checked into version control
- Should be code-reviewed
- Should be tested

Dependencies between tasks

```
> ls src/
```

```
Lib.java
```

```
LibTest.java
```

```
Main.java
```

```
SystemTest.java
```

Dependencies between tasks

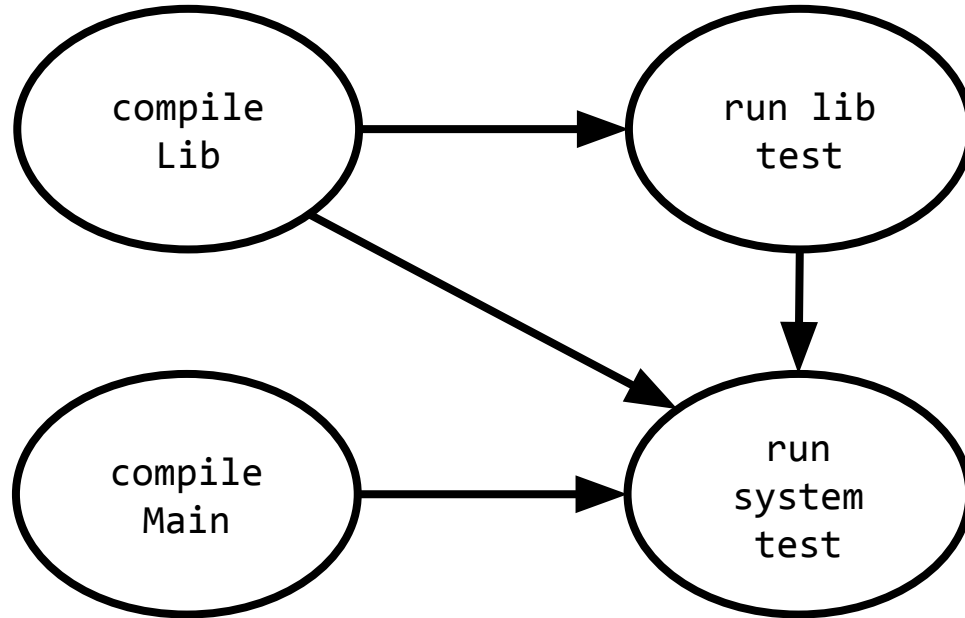
compile
Lib

run lib
test

compile
Main

run
system
test

Dependencies between tasks



Dependencies between tasks

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Determining task ordering

- Dependencies between tasks form a directed acyclic graph

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Topological sort!

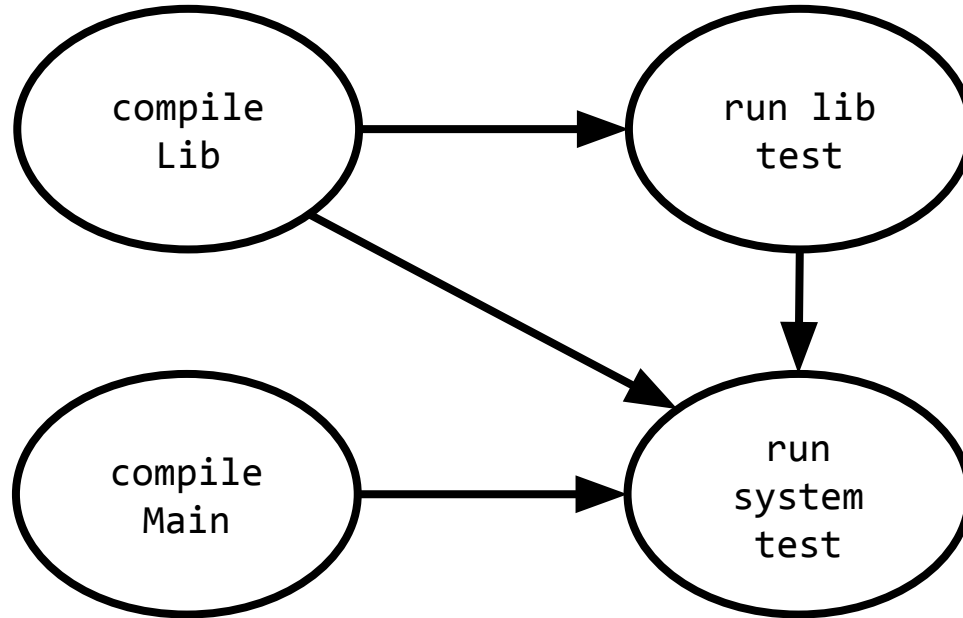
Topological sort

- Any ordering on the nodes such that all dependencies are satisfied

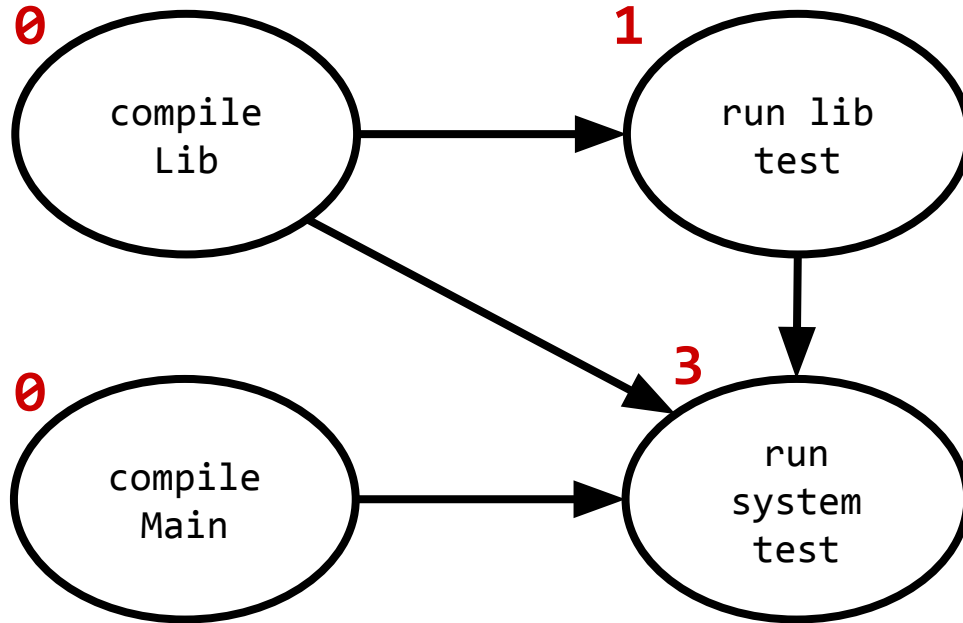
Topological sort

- Any ordering on the nodes such that all dependencies are satisfied
- Implement by computing *indegree* (number of incoming edges) for each node

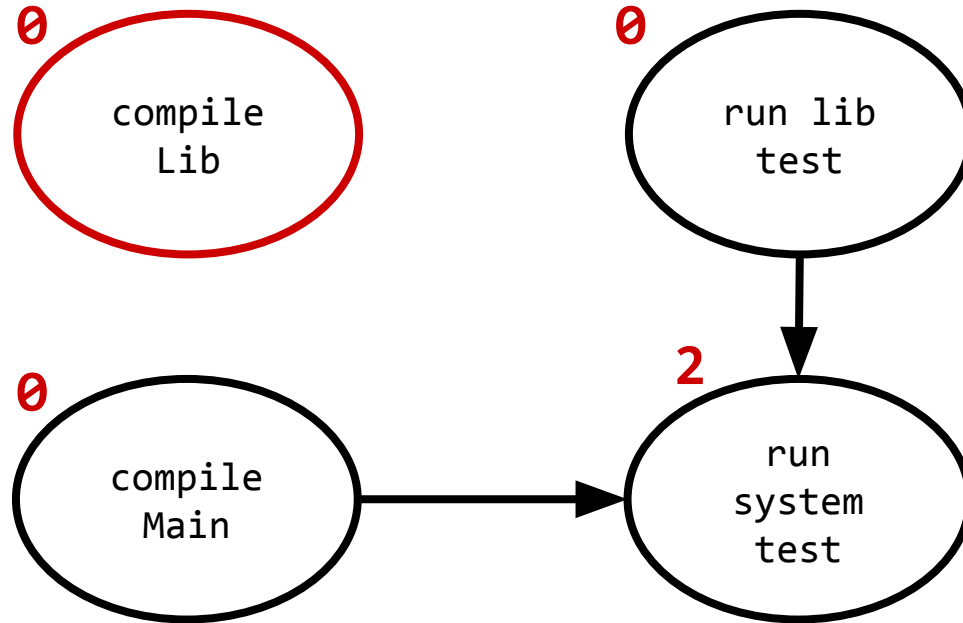
Topological sort



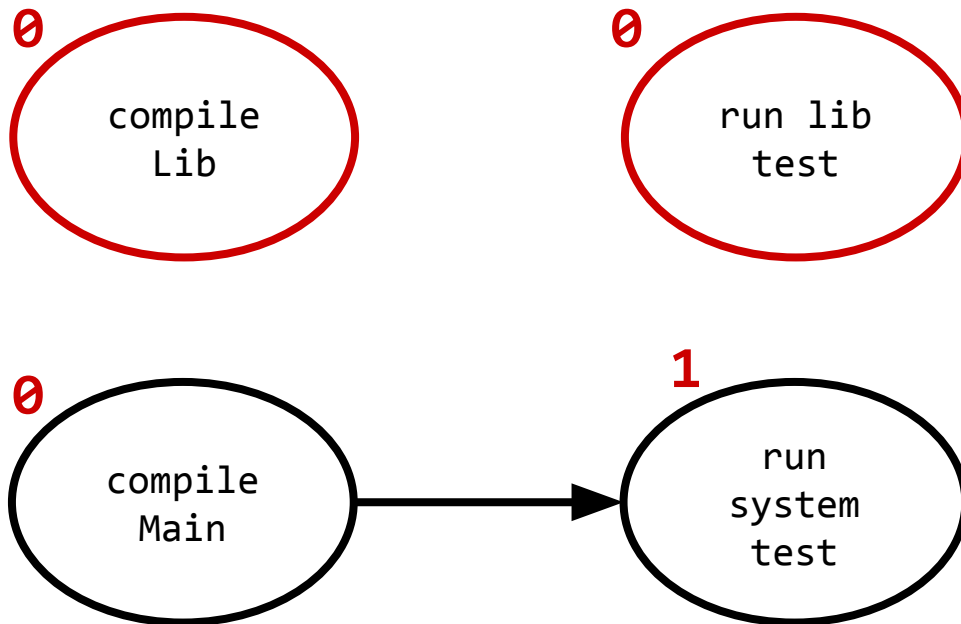
Topological sort



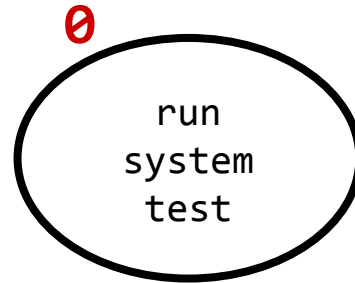
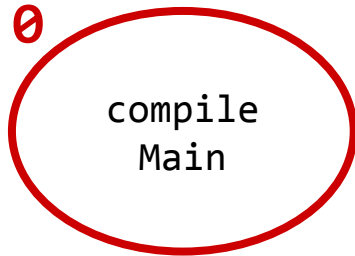
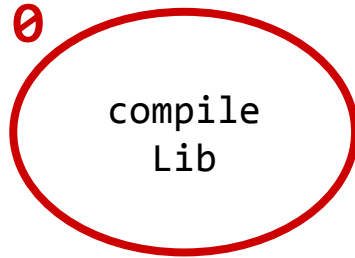
Topological sort



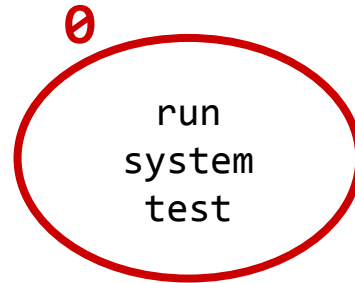
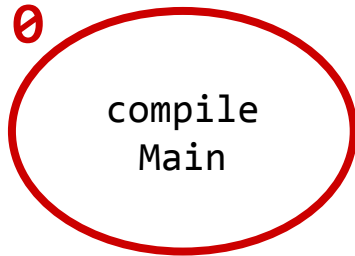
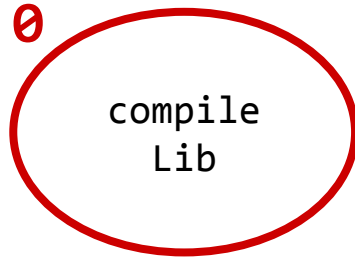
Topological sort



Topological sort



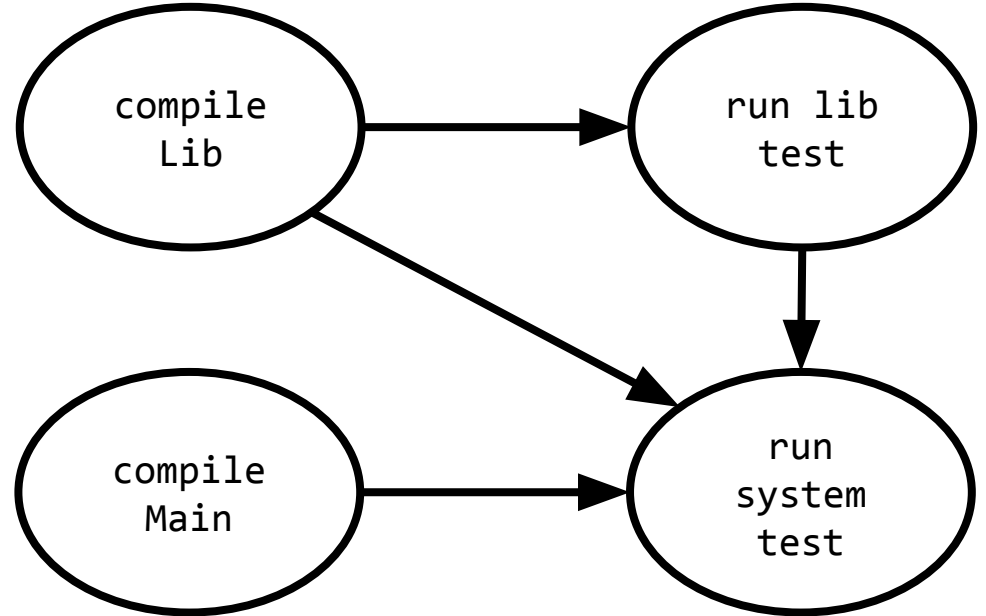
Topological sort



Topological sort

Valid sorts:

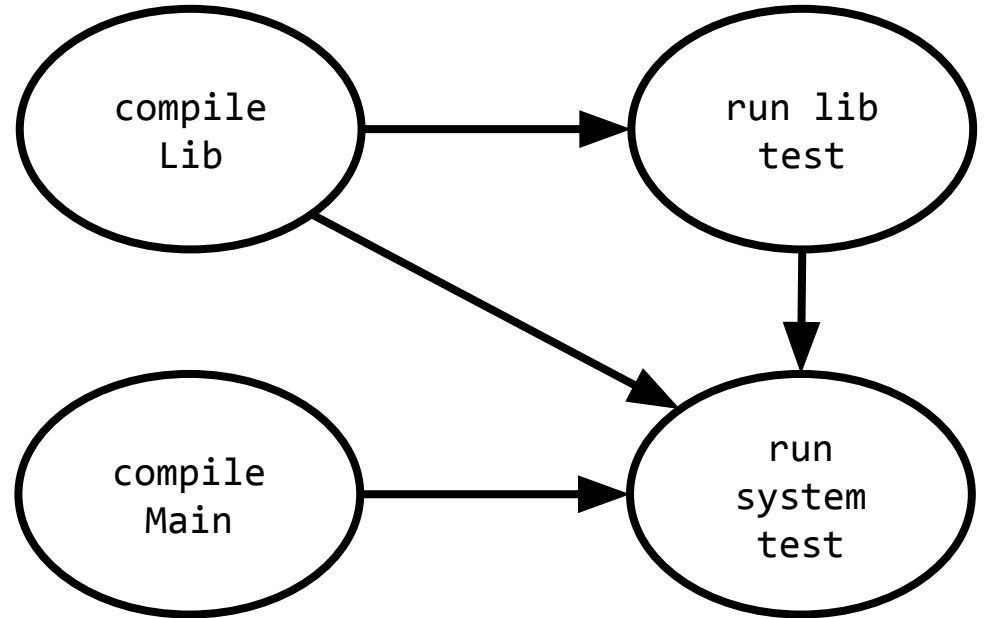
1. compile Lib, run lib test,
compile Main, run system test



Topological sort

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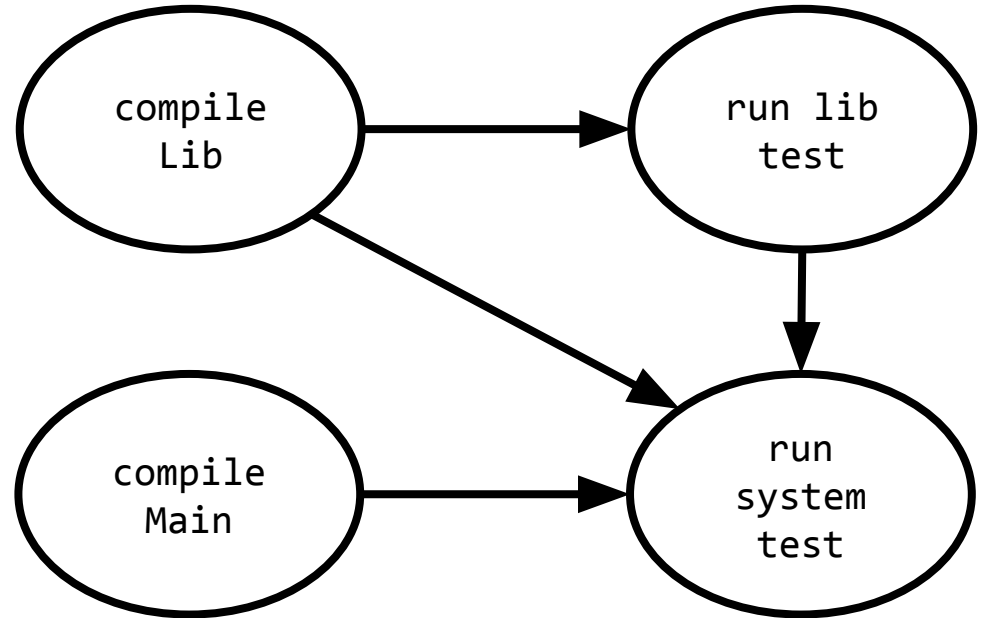
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Topological sort

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1. compile Lib, run lib test, compile Main, run system test
2. compile Main, compile Lib, run lib test, run system test
3. compile Lib, compile Main, run lib test, run system test



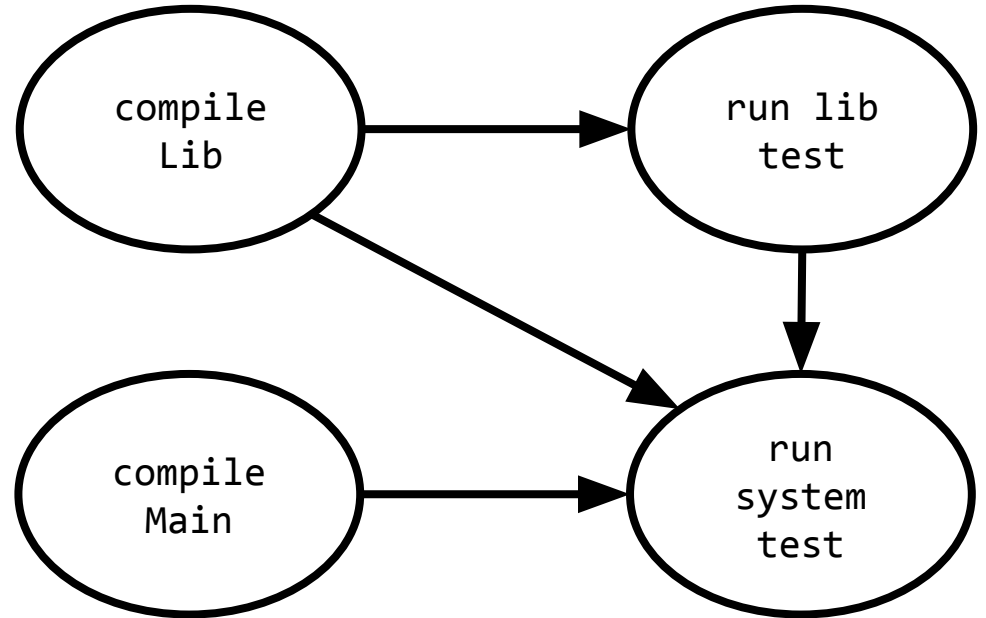
Topological sort

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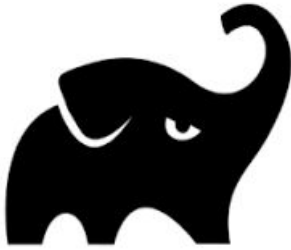
3. compile Lib, compile Main,
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Why is this order silly?

Examples of modern build systems

gradle



<https://gradle.org/>

Apache's open-source successor to ant, maven

bazel



<https://www.bazel.build/>

Google's internal build tool, open-sourced

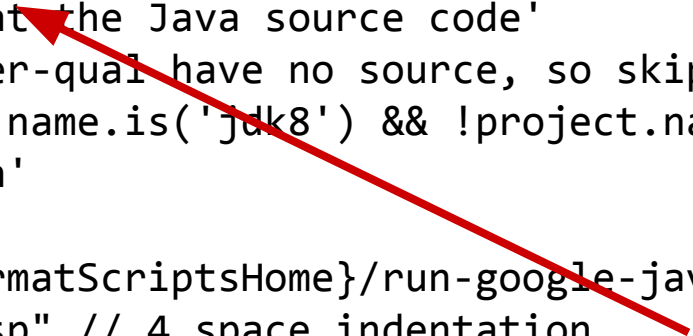
Example task: gradle

```
task reformat(type: Exec, dependsOn: getCodeFormatScripts, group: 'Format') {
    description 'Format the Java source code'
    // jdk8 and checker-qual have no source, so skip
    onlyIf { !project.name.is('jdk8') && !project.name.is('checker-qual') }
    executable 'python'
    doFirst {
        args += "${formatScriptsHome}/run-google-java-format.py"
        args += "--aosp" // 4 space indentation
        args += getJavaFilesToFormat(project.name)
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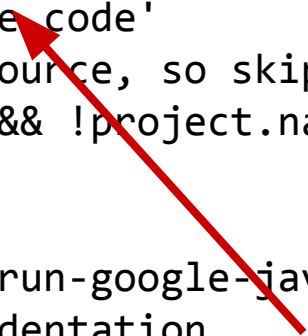
kind of rule



Example task: gradle


```
task reformat(type: Exec, dependsOn: getCodeFormatScripts, group: 'Format') {  
    description 'Format the Java source code'  
    // jdk8 and checker-qual have no source, so skip  
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    executable 'python'  
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explicitly specified dependencies



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code!

Example task: bazel

```
java_binary(  
    name = "dux",  
    main_class = "org.dux.cli.DuxCLI",  
    deps = ["@google_options//:compile",  
            "@checker_qual//:compile",  
            "@google_cloud_storage//:compile",  
            "@slf4j//:compile",  
            "@logback_classic//:compile"],  
    srcs = glob(["src/org/dux/cli/*.java",  
                "src/org/dux/backingstore/*.java"]),  
)
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Example task: bazel

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Example task: baze1

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explicitly specified
dependencies
(also bazel tasks)

External and internal dependencies

- A list of tasks (internal) or libraries (external)

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```

```
dependencies {  
    compile group:  
        'org.hibernate',  
        name: 'hibernate-core',  
        version: '3.6.7.Final'  
    testCompile group:  
        'junit',  
        name: 'junit',  
        version: '4.+'  
}
```


Why list dependencies?

- Reproducibility!

Why list dependencies?

- Reproducibility!
- *Hermetic builds*: “they are insensitive to the libraries and other software installed on the build machine”¹

¹<https://landing.google.com/sre/sre-book/chapters/release-engineering/>

Dependencies between tasks

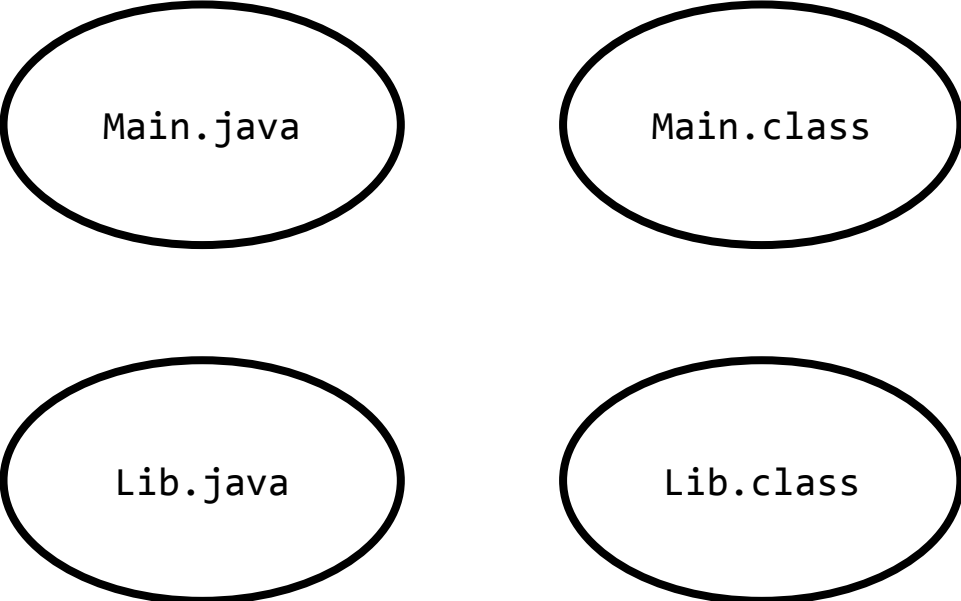
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How to speed up builds?

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- Incrementalize - only rebuild what you have to

Incrementalization



Main.java

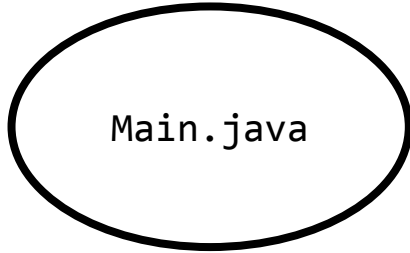
Main.class

Lib.java

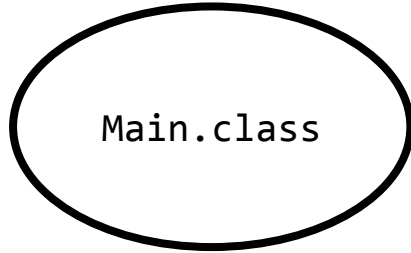
Lib.class

Incrementalization

modified 10:45 AM

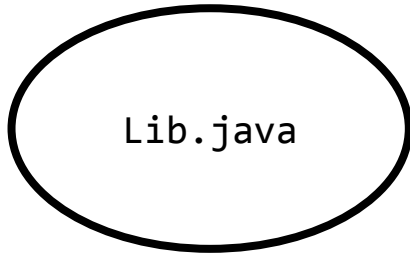


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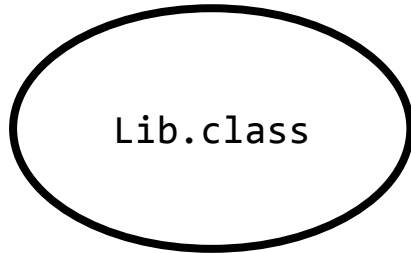


1:31 PM

modified 1:30 PM



modified 11:06 AM



Incrementalization

- Compute hash codes for inputs to each task
- When about to execute a task, check input hashes - if they match the last time the task was executed, skip it!

How to speed up builds?

- Incrementalize - only rebuild what you have to
- Execute many tasks in parallel
- Cache artifacts in the cloud

Best practices

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- Always use a build tool
- Have a build server that builds and tests your code on every commit (continuous integration)
- Don't depend on anything that's not in the build file (hermetic)
- Don't break the build