CSE 403

Software Engineering

Winter 2023

Build systems

This week

- Build systems
  - What is a build system?
  - Best practices
  - Gradle live demo
- Testing and Continuous Integration (CI)
- Code review

What does a developer do?

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

Which of these tasks should be handled manually?

What does a developer do?

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

Which of these tasks should be handled manually?

NONE!

How to automate these tasks?

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

Orchestrate tasks with a build system!

What is a build system (build tool)?

A tool for automating software engineering **tasks**:

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

Build systems: tasks

Tasks are code!

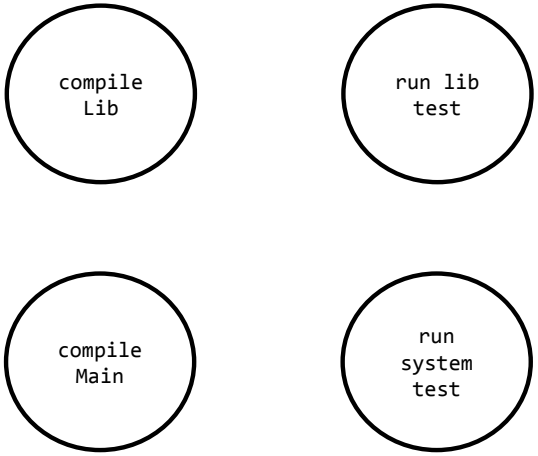
- Should be checked into version control
- Should be code-reviewed
- Should be tested

Build systems: dependencies between tasks

Example code and corresponding tests:

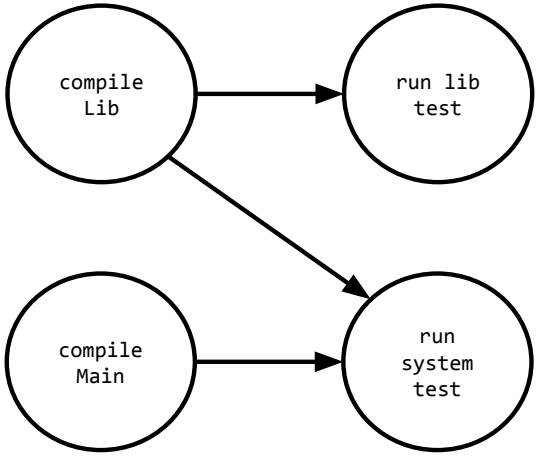
```
> ls src/

Lib.java   LibTest.java   Main.java    SystemTest.java
```

Build systems: dependencies between tasks

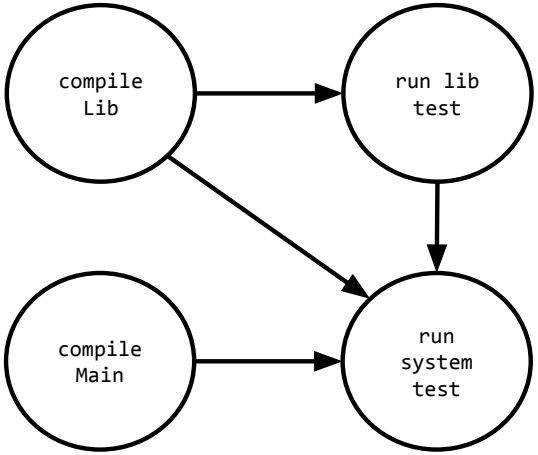


What are the dependencies between these tasks?

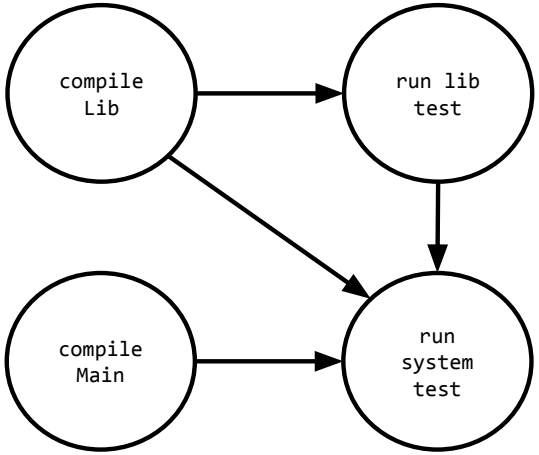
Build systems: dependencies between tasks



Build systems: dependencies between tasks



Build systems: dependencies between tasks



In what order should we run these tasks?

Build systems: determining task order

Large projects have thousands of tasks

- Dependencies between tasks form a directed acyclic graph.

Build systems: determining task order

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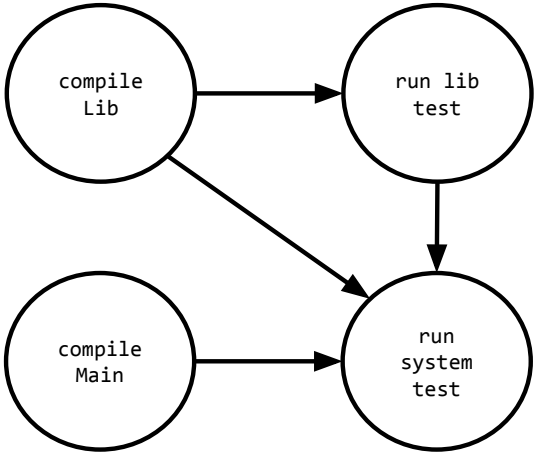
Topological sort

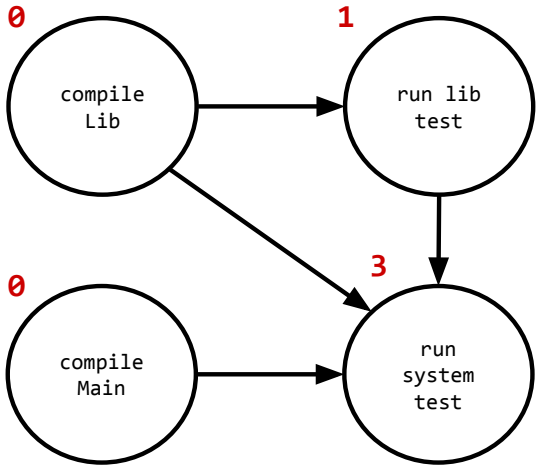
- Order nodes such that all dependencies are satisfied
- **Implemented by computing indegree**
  (number of incoming edges) for each node

Build systems: topological sort

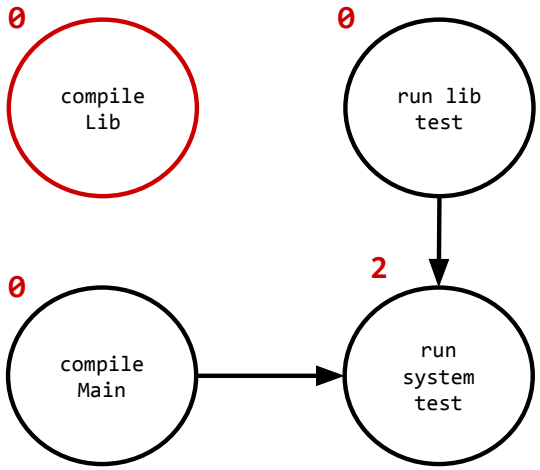


What's the indegree of each node?

Build systems: topological sort



Build systems: topological sort



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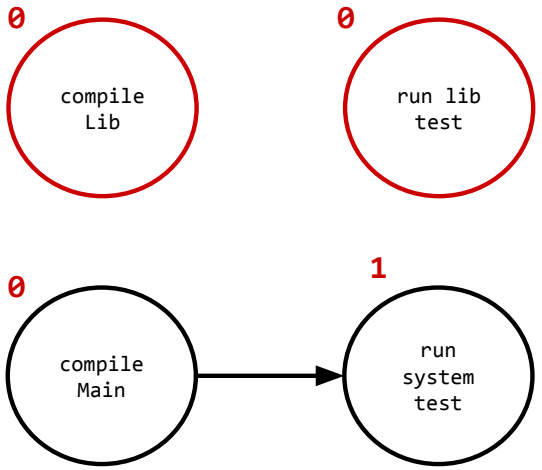

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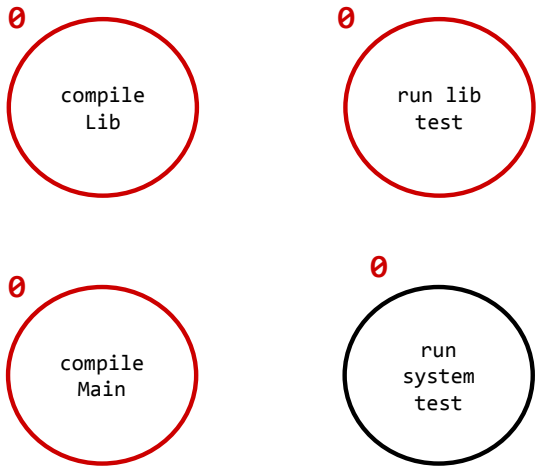

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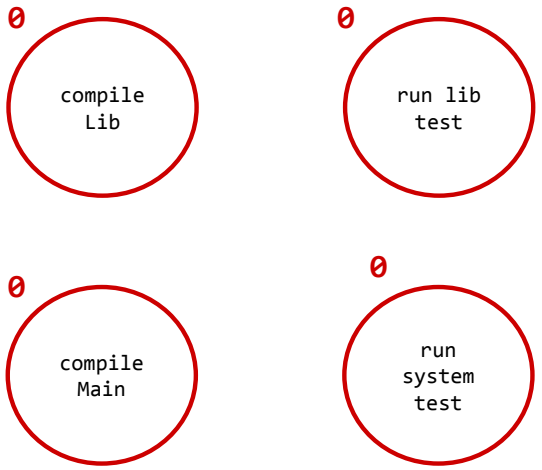
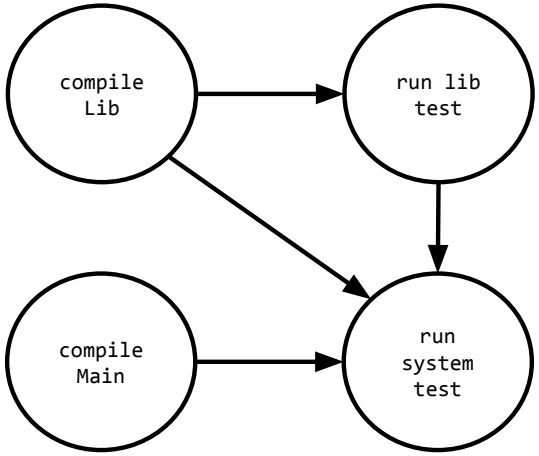


Build systems: topological sort

Valid sorts:

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



Build systems: topological sort

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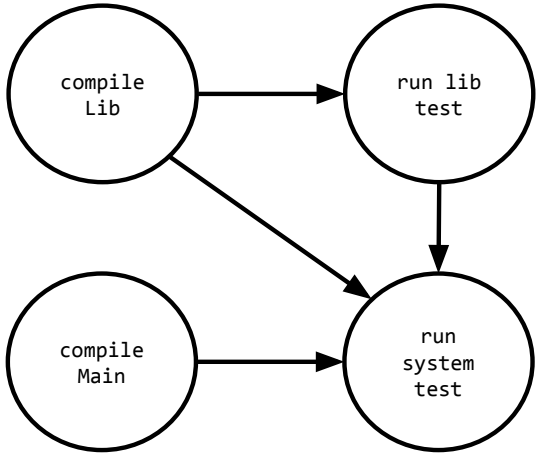

Build systems: topological sort

Valid sorts:

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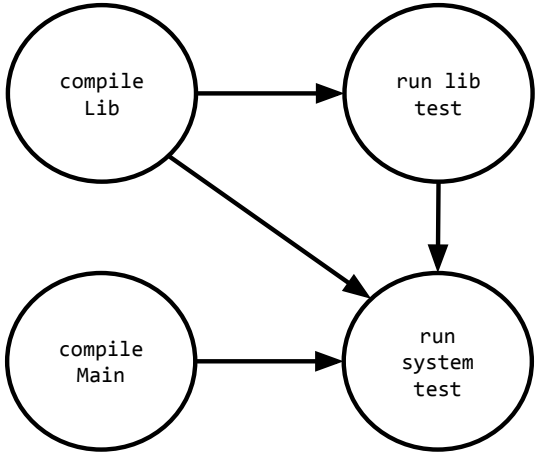

Which of these sorts is preferable?

Build systems: examples

gradle 

Open-source successor to ant and maven

- Groovy/Kotlin DSL (vs. xml)
- Many defaults for (maven) conventions
- Can query Maven Central for dependency resolution

bazel 

Open-source version of Google's internal build tool (blaze)

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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explicitly specified dependencies

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```

actual source code (no xml)!

In many cases, following conventions and using built-in tasks is sufficient!

Best practices

- Automate everything (one-step build)!
- Always use a build tool.
- Use CI to build and test your code on every commit.
- Don’t depend on anything that’s not in the build file (hermetic)!
- Don’t break the build!

Live demo: Build systems

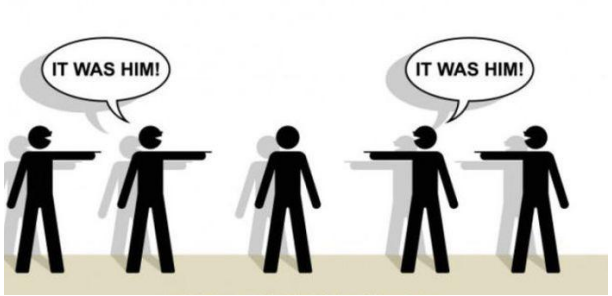
Set up:

1. Two clones of the basic-stats repo (cloned from Bitbucket).
2. Goal: migrate from Ant to Gradle.

Two scenarios:

1. Bad: Breaking the build on master
2. Good: New hermetic build on a branch

Live demo Part 1: Breaking the build



René breaking the build on master

Ben making a small change

Live demo Part 2: New hermetic build

- Development on a branch
- Hermetic build
- Backward compatibility
- Testing and code review