Lecture 5

Build Systems

SOEN 6441, Summer 2018

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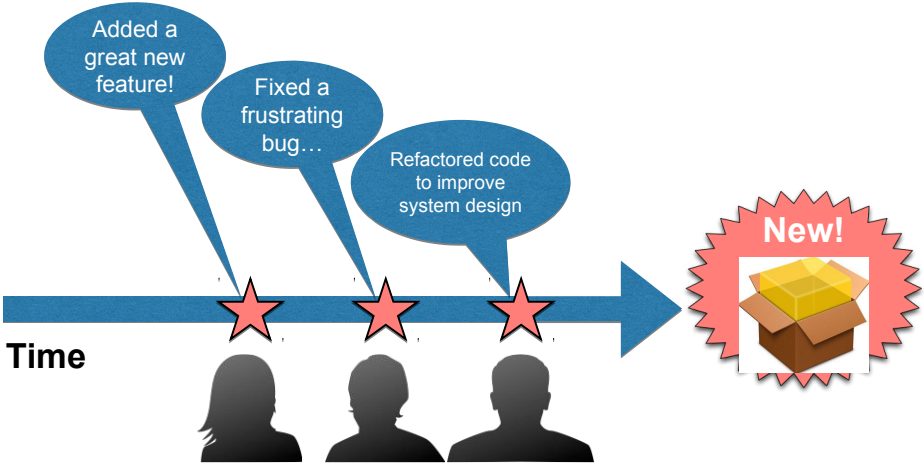
Outline

What is a software release?



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The rapid release cycle of modern software systems

Often release several times in one day!

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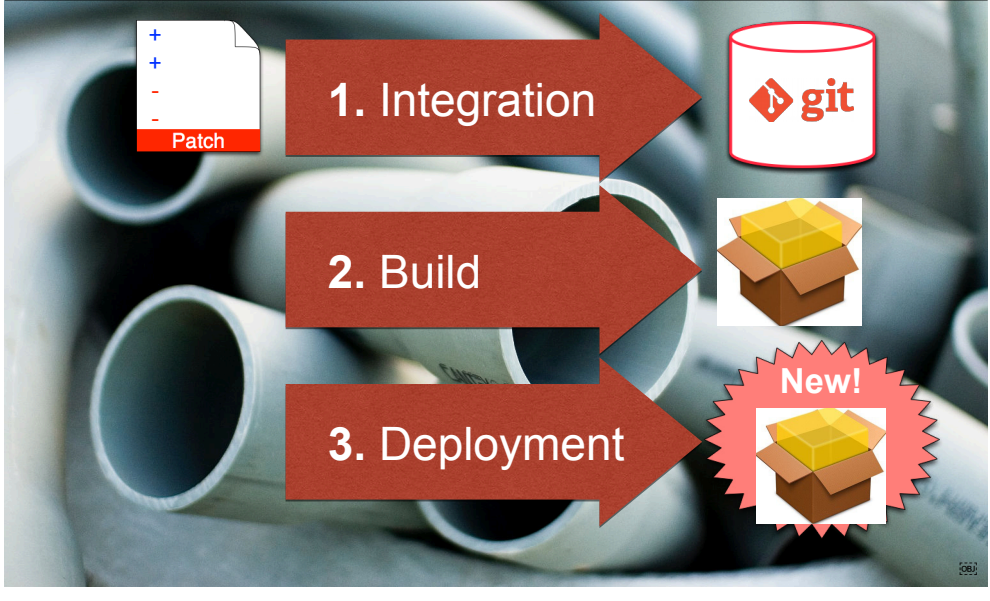
Release pipelines: How organizations deliver new content



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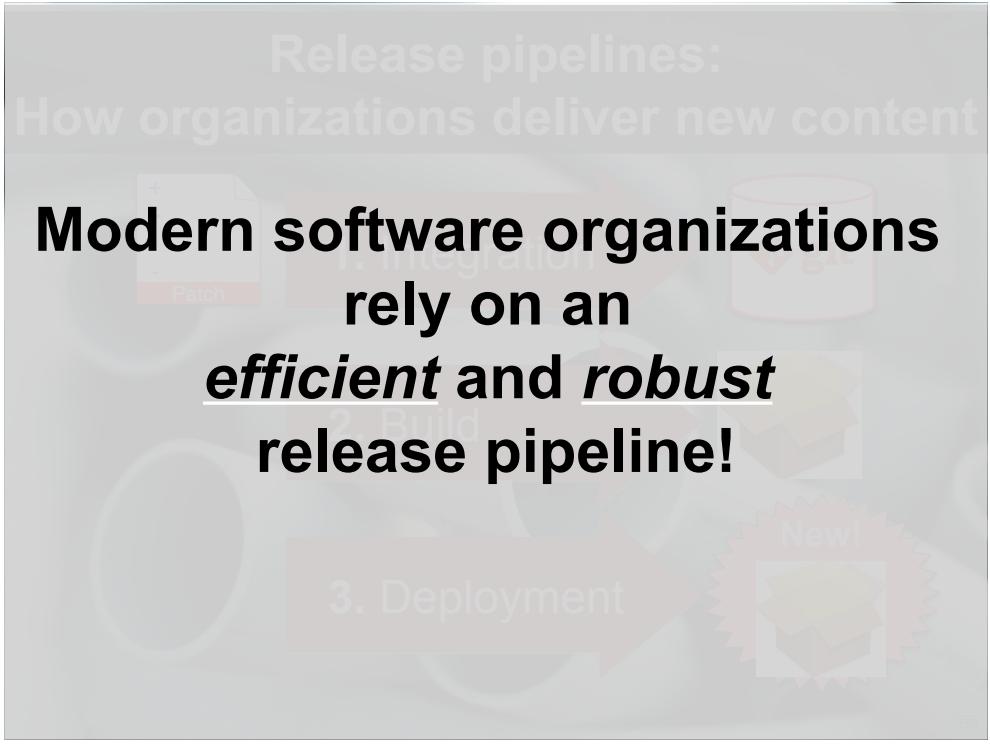

Modern software organizations rely on an *efficient* and *robust* release pipeline!

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Release engineers increase the market potential of software organizations

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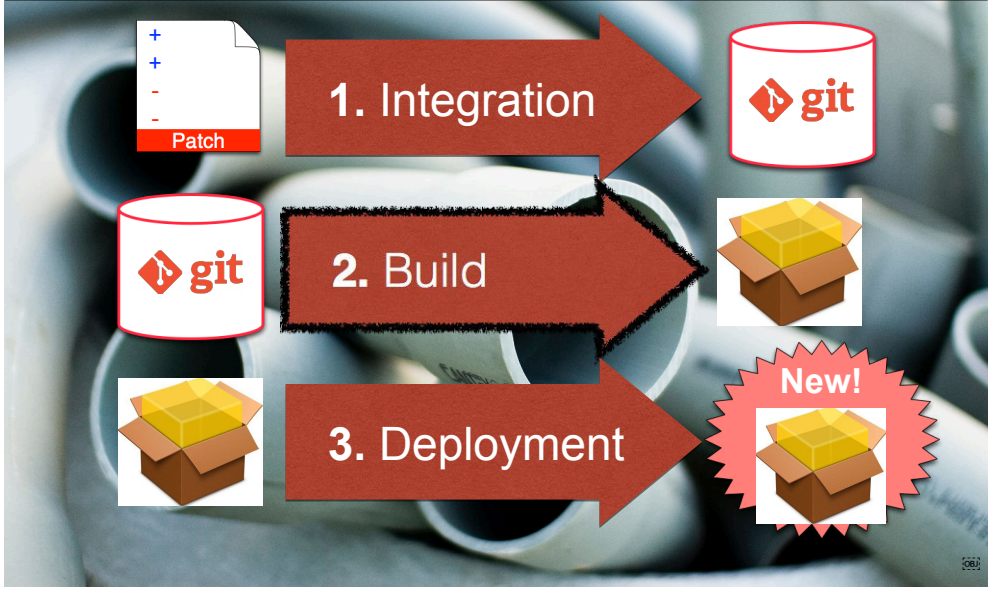
The rapid release cycle creates new software engineering challenges



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What is a build system?

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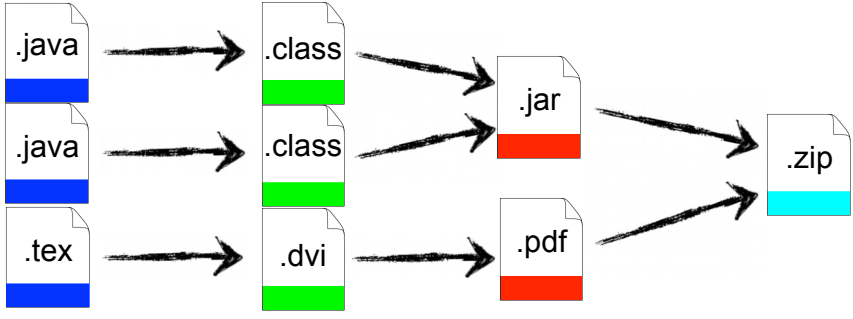

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Random number generating functions

User input handling functions

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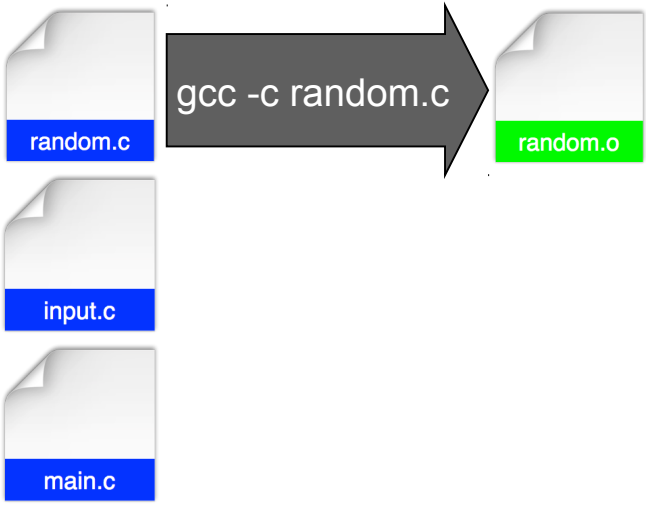
Main function, calls input and random functions



Compiling random.c

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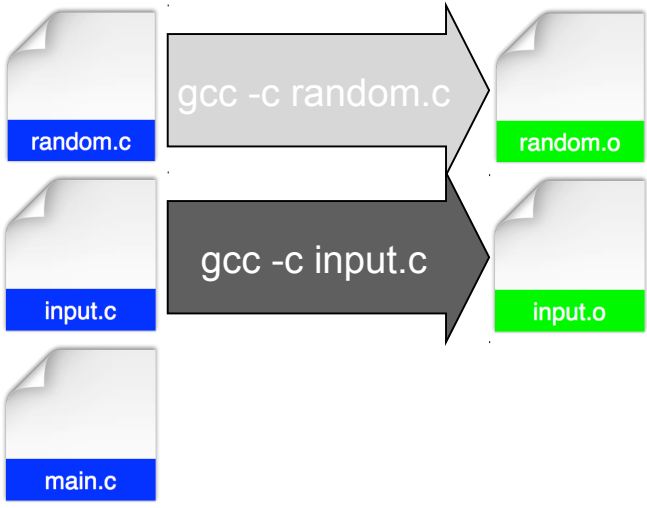
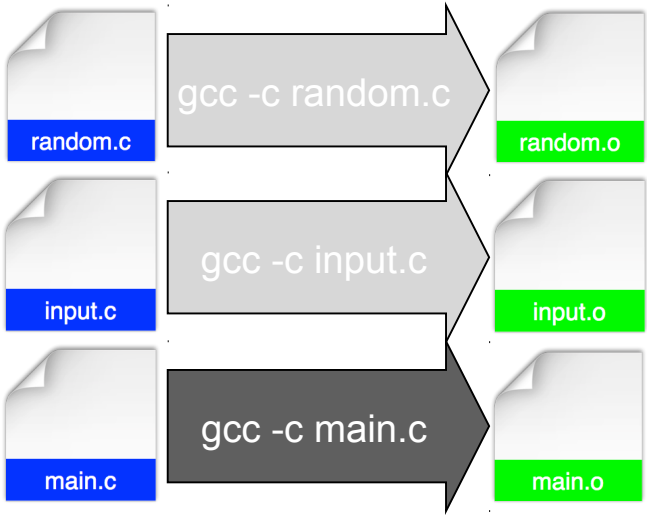


Compiling input.c



Compiling main.c

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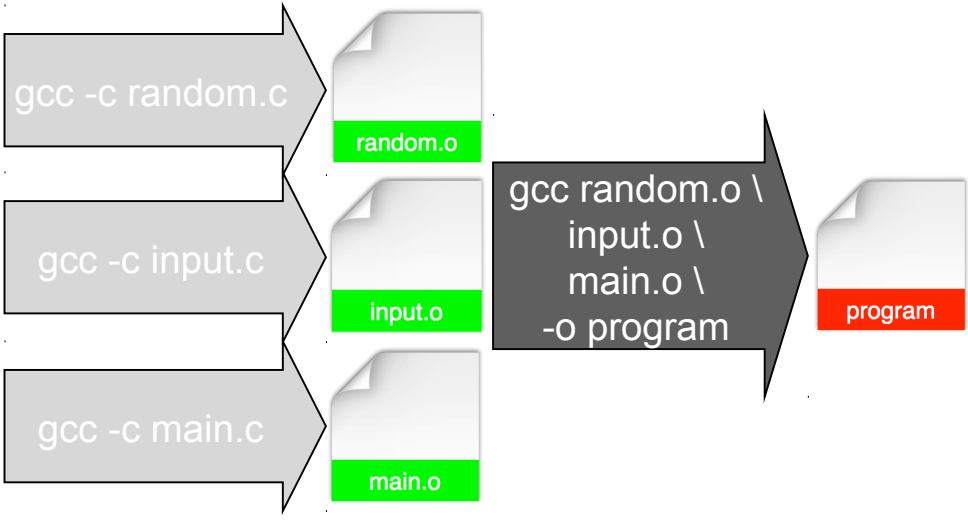

Link them together to complete the program

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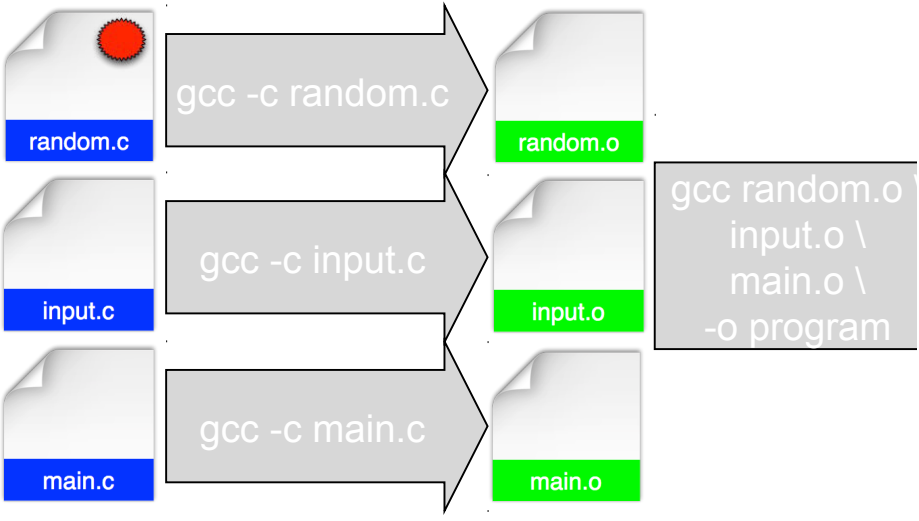

D’oh! We need to fix a bug in random.c!

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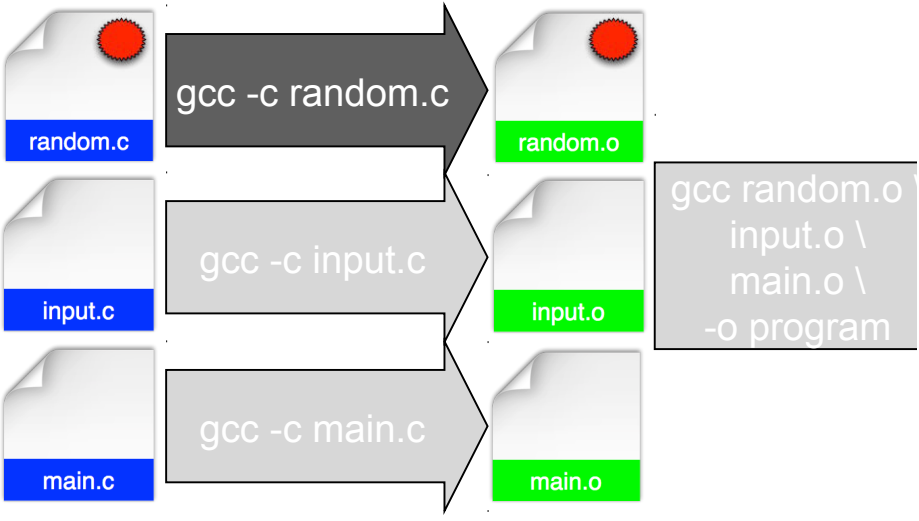

Recompile random.c

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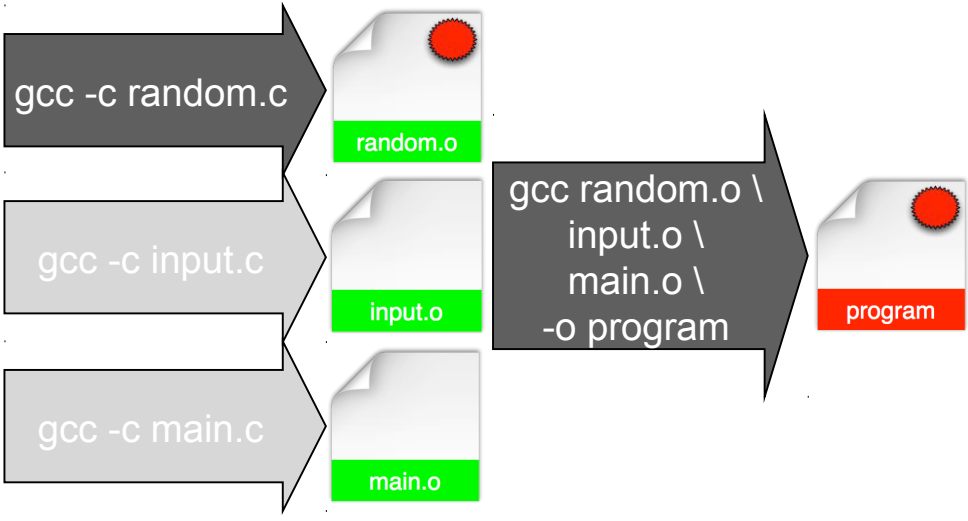
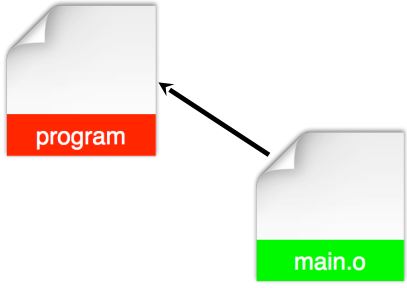
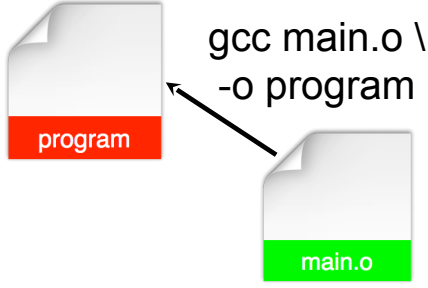


Relink the objects together

make **to the rescue**





Step 1 - Expressing dependencies

Step 2 - Writing recipes

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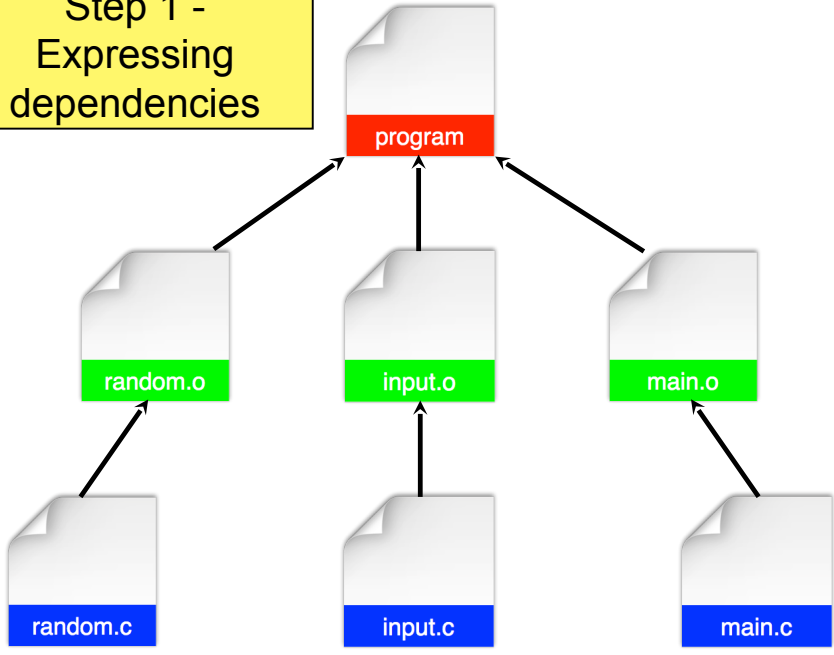
Step 1 - Expressing dependencies



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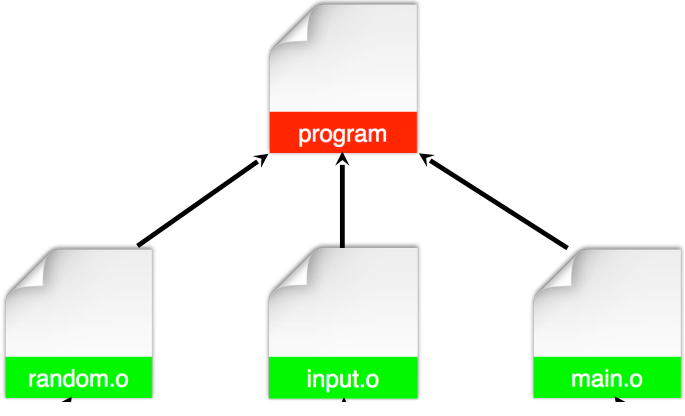
Step 1 - Expressing dependencies

This is a **Makefile**

```
program : random.o input.o main.o
```



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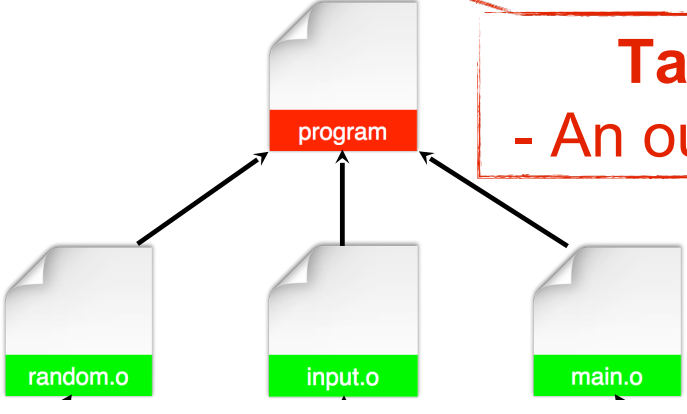
Step 1 - Expressing dependencies

```
program : random.o input.o main.o
```



Target
- An output file

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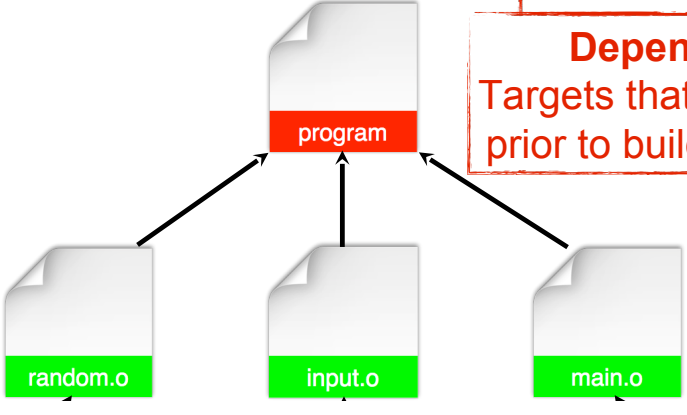
Step 1 - Expressing dependencies

```
program : random.o input.o main.o
```



Dependencies
Targets that must be built prior to building this one

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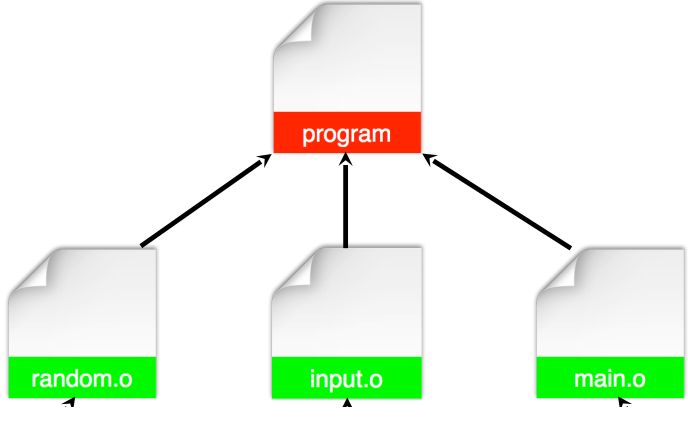
Step 2 - Writing recipes

```
program : random.o input.o main.o
<tab>gcc -o program random.o input.o main.o
```



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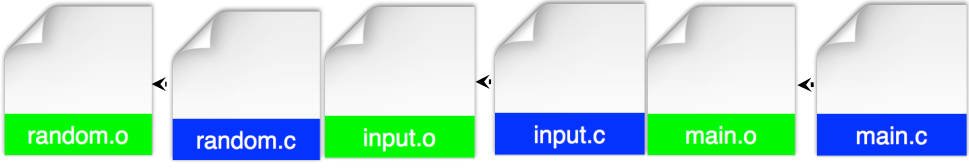
Step 2 - Writing recipes

```
program : random.o input.o main.o
<tab>gcc -o program random.o input.o main.o
random.o : random.c
<tab>gcc -c random.c
input.o : input.c
<tab>gcc -c input.c
main.o : main.c
<tab>gcc -c main.c
```



Step 2 -
Writing recipes

Splitting long lines

```
program : random.o input.o main.o
<tab>gcc -o program random.o input.o main.o
```


```
program : random.o
program : input.o
program : main.o
program :
<tab>gcc -o program random.o input.o main.o
```

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Step 2 -
Writing recipes

Merging short lines

```
random.o : random.c
<tab>gcc -c random.c
```


```
random.o : random.c ; gcc -c random.c
```

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Variables

```
my_command = “gcc -c random.c”
random.o : random.c
<tab>$(my_command)
```

Variable assignment

```
my_filename = “random.c”

#Lazy set
my_command = “gcc -c $(my_filename)”
#Immediate set
my_command :=  “gcc -c $(my_filename)”
#Set if absent
my_command ?= “gcc -c $(my_filename)”
#Append
my_command += “gcc -c $(my_filename)”
```

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Watch out for lazy evaluation!

```
my_filename = “random.c”
my_command = “gcc -c $(my_filename)”
my_filename = “another_file.c”

random.o : random.c
<tab>$(my_command)
```

When random.o is built, the my_command is gcc -c another_file.c

Immidiate set

```
my_filename = “random.c”
my_command := “gcc -c $(my_filename)”
my_filename = “another_file.c”# this line
#does not impact $(my_command)

random.o : random.c
<tab>$(my_command)
```

Generates: gcc –c random.c

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Remember our Makefile?

```
program : random.o input.o main.o
<tab>gcc -o program random.o input.o main.o

random.o : random.c
<tab>gcc -c random.c

input.o : input.c
<tab>gcc -c input.c

main.o : main.c
<tab>gcc -c main.c
```

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make **command reads the** makefile

Terminal

```
$ make
gcc -c random.c
gcc -c input.c
gcc -c main.c
gcc -o program random.o input.o main.o
$
```

Rebuilds first target expressed in the makefile

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Alternatively…

Terminal

```
$ rm program random.o input.o main.o
$ make random.o
gcc -c random.c
$
```

Specify a target to be built

Alternatively…

Terminal

```
$ rm program random.o input.o main.o
$ make -f my_makefile
gcc -c random.c
gcc -c input.c
gcc -c main.c
gcc -o program random.o input.o main.o
$
```

Use -f flag to read from other files

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make Incremental Builds!

Terminal

```
$ vim random.c
...
$ make
gcc -c random.c
gcc -o program random.o input.o main.o
$
```

Only the out-of-date targets are rebuilt!

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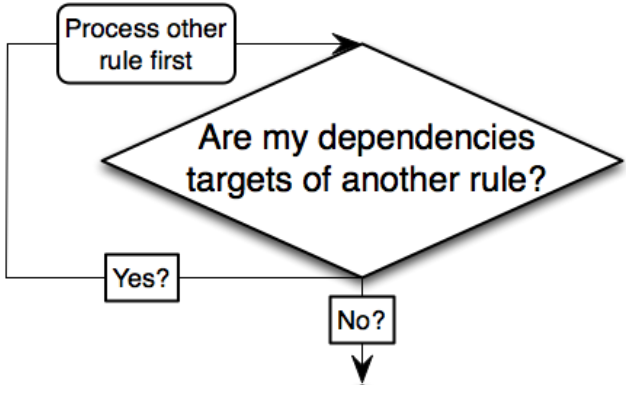
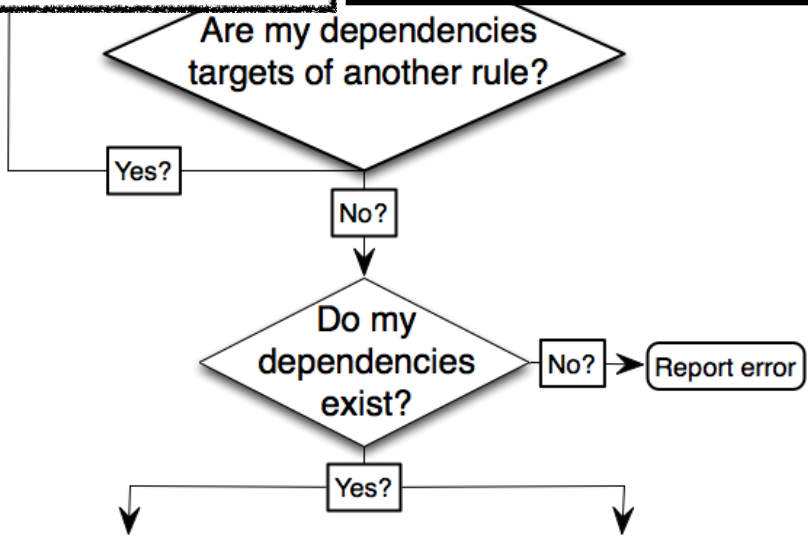
How does make work?

```
program : main.o
<tab>gcc -o program main.o
main.o : main.c
<tab>gcc -c main.c
```



How does make work?

```
program : main.o
<tab>gcc -o program main.o
main.o : main.c
<tab>gcc -c main.c
```



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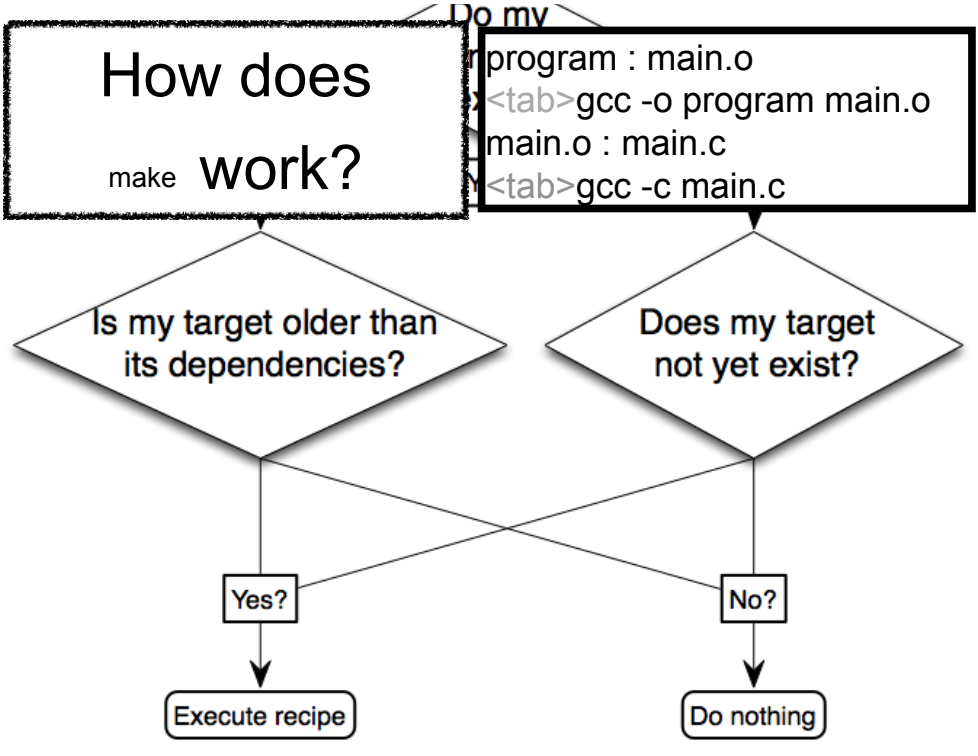
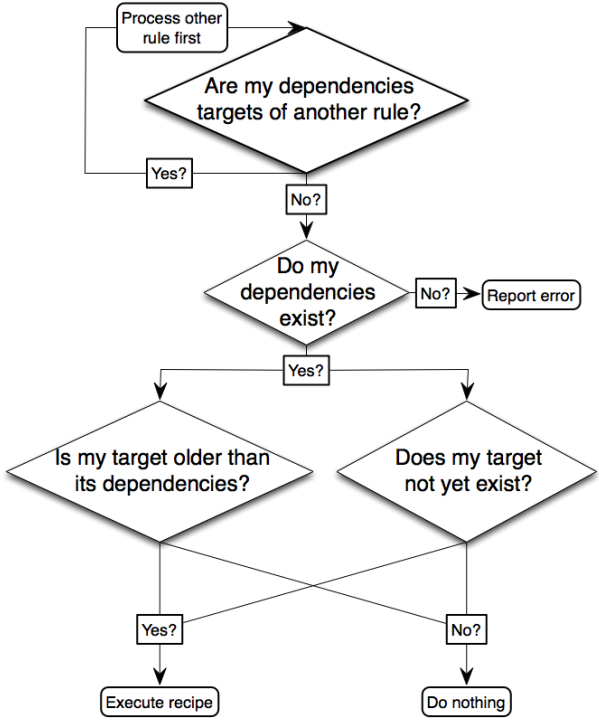
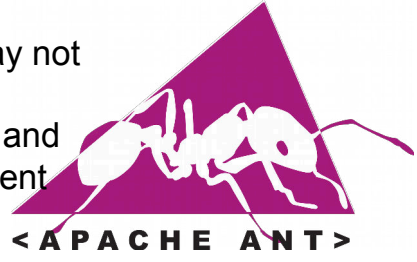

How does
make work?
program : main.o
<tab>gcc -o program main.o
main.o : main.c
<tab>gcc -c main.c
Is my target older than its dependencies?
Does my target not yet exist?
Yes?
No?
Execute recipe
Do nothing


Process other rule first
Are my dependencies targets of another rule?
Yes?
No?
Do my dependencies exist?
No?
Report error
Yes?
Is my target older than its dependencies?
Does my target not yet exist?
Yes?
No?
Execute recipe
Do nothing

Introduction to Apache Ant

A make **replacement for Java systems:**

- Java compiler may recompile several files at once!
  - For example, javac foo.java may recompile bar.java, too!
  - The make tool is not good at recognizing side effects of commands like this
- Make recipes are written in platform-specific shell scripts
- If a recipe works on OS X, it may not
  - work on windows
  - Ant tasks are Java programs and
  - are mostly platform independent



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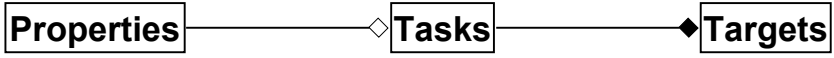
Key Ant programming concepts

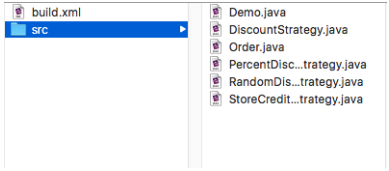


- Store and retrieve frequently used values
- Like variables in Java

- Correspond to commands that are executed
- Like issuing a call to a library or Java API

- A grouping of tasks that relate to a logical event
- Like grouping statements into methods in Java

Let’s see an Ant system!



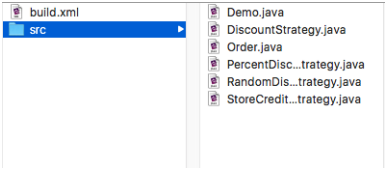
- Compile everything:

```
<target name=“compile”>
        <javac srcdir="src" destdir="${classdir}" />
</target>
```

- Specifying output directory

```
<target name=“init”>
<mkdir dir=“${blddir}” />
<mkdir dir=“${classdir}” />
</target>
```

Let’s see an Ant system!



- Compile everything:

```
<target name=“compile”>
  <javac srcdir=“src” destdir=“${classdir}” />
</target>
```

- Specifying output directory

```
<target name=“init”>
<mkdir dir=“${blddir}” />
<mkdir dir=“${classdir}” />
</target>
```

- Specifying properties

```
<property name="blddir" location="build" />  <property name="classdir" location="${blddir}/classes" />
</target>
```

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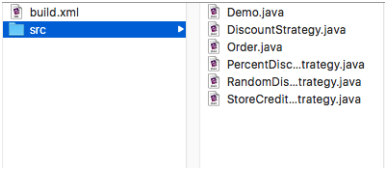
Let’s see an Ant system!



- Compile everything:

```
<target name=“compile”>
  <javac  srcdir=“src”
destdir=“${classdir}”
depends="init" />
</target>
```

- Specifying output directory

```
 <target name=“init”>
<mkdir dir=“${blddir}” />
<mkdir dir=“${classdir}” />
</target>
```

- Specifying properties

```
 <property name="blddir"
location="build" />  <property
name="classdir" location="$
{blddir}/classes" />
</target>
```

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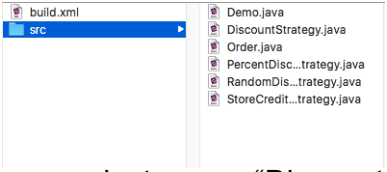
Let’s see an Ant system!




```
<project name=“DiscountStrategy” default=“compile”>
    <property name=“blddir” location=“build” />
    <property name=“classdir” location=“${blddir}/classes” />
<target name=“init”>
    <mkdir dir=“${blddir}” />
    <mkdir dir=“${classdir}” />
</target>
<target name=“compile” depends=“init”>
    <javac      srcdir=“src”      destdir=“${classdir}” />
</target>
</project>
```

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Modern Build Systems

Make/Makefiles
- 1976
- (additional tools for Makefile generation etc: automake, iMake, ...)

Apache Ant:
- 2000

Apache Ivy:
- 2004
- Dependency management for ant

Apache Maven:
- 2004
- Project and dependency management

Gradle:
- 2007

Platform-specific tools
- sbt (Scala), rake (Ruby), Grunt (Javascript), buildr, Perforce Jam, ...

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Apache Ivy

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Dependency Management

- Your great new software needs library X
- (possibly in a specific major/minor version)
- but library X also needs library Y...

Automatically resolving these dependencies is an important part of modern software development

Apache Ivy to the rescue!

Apache Ivy (http://ant.apache.org/ivy/) is a sub-project of ant:

- Managing project dependencies
- XML-driven declaration of project dependencies and JAR repositories
- Automatic retrieval of transitive dependency definitions and resources
- Automatic integration to publicly available artifact repositories
- Resolution of dependency closures
- Configurable project state definitions, which allow for multiple dependency-set definitions
- Publishing of artifacts into a local enterprise repository

Ivy Example

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ivy.xml

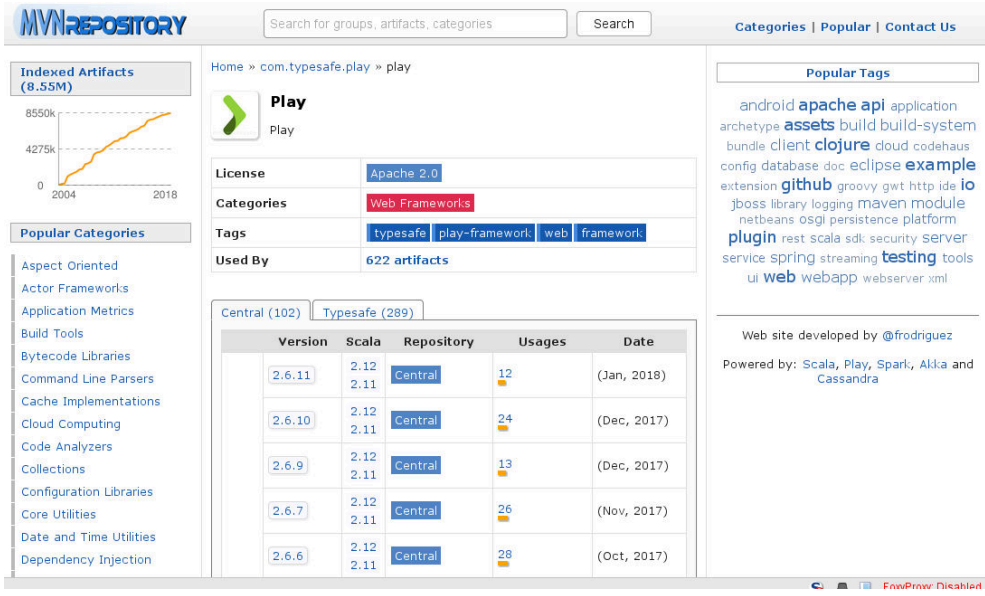
```
<ivy-module version="2.0">
  <info organisation="org.apache" module="hello-ivy"/>
  <dependencies>
    <dependency org="commons-lang" name="commons-lang" rev="2.0"/>
    <dependency org="commons-cli" name="commons-cli" rev="1.0"/>
  </dependencies>
</ivy-module>
```

build.xml

```
<project xmlns:ivy="antlib:org.apache.ivy.ant" name="hello-ivy" default="run">
    ...
    <!-- ================================
          target: resolve
         ================================ -->
    <target name="resolve" description="--> retrieve dependencies with ivy">
        <ivy:retrieve />
    </target>
</project>
```

Note: version numbers generally follow Semantic Versioning rules, see https://semver.org/

Maven Central, https://mvnrepository.com/repos/central



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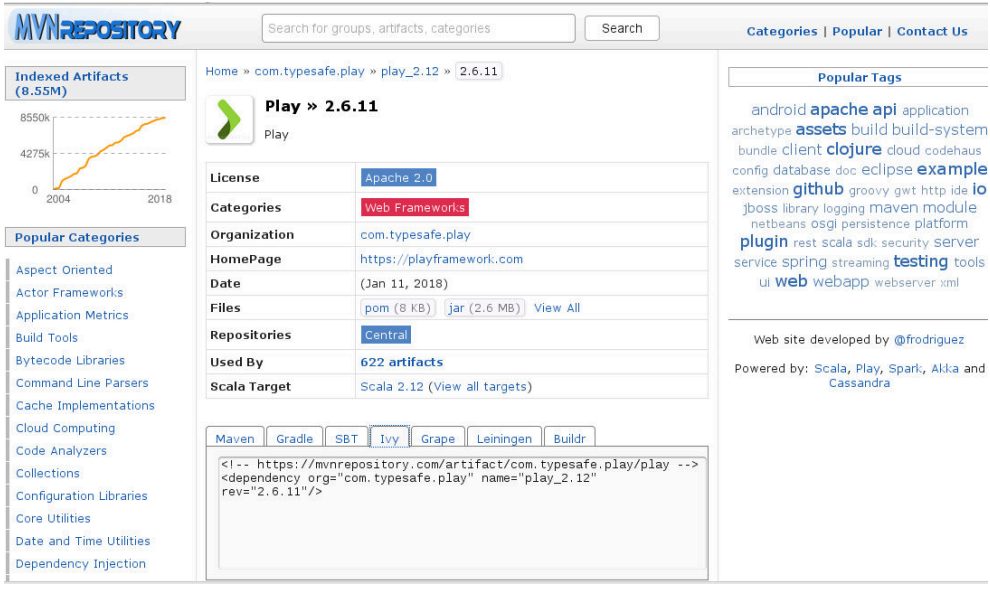
Play in Maven Central

René Witte



Outline

Reading Material

Supplementary

- [Som16, Chapter 25] (Configuration Management)

References

[Som16] Ian Sommerville.
Software Engineering.
Pearson, 10th edition, 2016.
http://software-engineering-book.com.