Principles of Software Construction: Objects, Design, and Concurrency

IDEs, Build system, Continuous Integration, Libraries

Christian Kästner      Vincent Hellendoorn
Outline

- On Homework 1
- Abstraction, Reuse, and Programming Tools
- For each in {IDE, Build systems, libraries, CI}:
  - What is it today?
  - What is under the hood?
  - What is next?
Homework 1

Welcome to the deep end!

- Java/TS + IDE + Maven/Npm + GitHub + Travis + linter!?
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- We’re here to help:
  - Recitation tomorrow, walks through all this setup
  - Find some clarifications on Piazza
    - E.g., only implement what is asked for; all other functionality (repeating, flipping question/answer) is already there.
  - Use office hours (see course calendar)
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  - Use office hours (see course calendar)
- **Actual coding effort is small -- reading & setting up is the point**
- **Small typo detected on Piazza in `mostmistakes.ts`; fixed now. Not essential to your HW.**
Mini-quiz

https://forms.gle/9tnB5BszVz9KTY7r5
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Automation Requires Abstraction
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We all treat familiar levels of abstraction as normal/natural

● That’s fine if you only drive your car
  ○ Not so much if you are a mechanic
  ○ How to debug a broken transmission?

● Also slow to evolve
  ○ Conf. people adamantly refusing to use an automatic

● Engineers seek out abstractions that simplify their work, help focus on the hard parts
  ○ They also know what is beneath the abstractions
Automation Requires Abstraction

Today’s “normal”:

- Integrated-development environments (IDEs) galore
  - Web-based too! Press “.” on a GitHub (file) page 😐
- Frequent build, test, release
  - In some companies, every commit is a “release”
- Never write code for which there is a useful library
  - Define “useful” (we will)
- All of the above, entangled
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Today’s toolchain: a quick overview

IDEs:

● Integrated Development Environments, bundle development workflows in a single UI
  ○ Editing, refactoring, running & debugging, adding dependencies, compiling, deploying, plugins, you name it
  ○ They often try to be everything, with mixed results
  ○ Leverage them to the fullest extent, to automate and check your work
Today’s toolchain: a quick overview

IDEs:

- Eclipse was the dominant player in Java for 20-odd years, owing to its powerful backbone and plugin architecture
Today’s toolchain: a quick overview

IDEs:

- Recently, IntelliJ has been more dominant
  - Packs a lot of “recipes” to create certain types of projects (e.g., web-app with Spring & Maven)
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● VSCode is surging in popularity
  ○ Local & web, lightweight but with a massive plugin ecosystem
    ■ Quick tangent: if you can build either a large product or a platform, build a platform
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  - Packs a lot of “recipes” to create certain types of projects (e.g., web-app with Spring & Maven)
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  - Local & web, lightweight but with a massive plugin ecosystem
    - Quick tangent: if you can build either a large product or a platform, build a platform
- But choose based on need!
  - You can relearn key-bindings; “killer features” are rare and temporary
  - E.g., Android: might want Android Studio (itself built on IntelliJ) since Google supports it
  - For this homework, choose what you’d like. We suggest IntelliJ for Java, VSCode for TS
Today’s toolchain: a quick overview

Build Systems:

- How does this happen?
Today’s toolchain: a quick overview

Build Systems:

- Compiling is “easy” when all your source code is here
  - (Please don’t tell a compiler expert I said that)

- Nowadays, your code is not “here”
  - Even libraries that you use in the IDE!
  - Interfaces make that possible
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- **Study the Travis log:**
  - What is it doing?
  - Downloading, compiling, running checks
  - Most of this is “building”, using Maven
  - More on Travis later
Today’s toolchain: a quick overview

Build Systems:

- Has a few basic tasks:
  - Compiling & linking, to produce an executable
  - Creating secondary *artifacts*, e.g. documentation-pages, linter reports, test suite reports
  - Different levels of “depth” may be appropriate, for large code bases (e.g. Google)
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- Popular options:
  - For Java: Maven and Gradle -- historically Ant.
    - You could do any homework in either; we’re not attached to one
  - For JS/TS: Node(JS)
    - Generally coupled with the Node Package Manager (NPM)
  - Often built into IDEs, as plugins
Today’s toolchain: a quick overview

Libraries:

- Myriad. Publicly hosted on various package managers
  - Often tied, but not inextricably linked, to build tools, and languages
  - Maven/Gradle for Java, NPM for JS/TS, Nuget for C#, ...
  - Registries of managers, e.g., GitHub Packages
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- **Releases are generally fast-paced or frigid**
  - Almost all volunteer-based, so support waivers, as does documentation quality
  - Often open-source, so you can check out the status & details on GitHub
  - Beware of vulnerabilities and bugs, esp. with minor-releases and nightly’s, old packages
Today’s toolchain: a quick overview

Libraries:

● A Case-Study:
  ○ ‘pac-resolver’ (3M weekly downloads) has a major security vulnerability
    ■ Uses ‘degenerator’ (same author), which misuses a Node module
    ■ “The vm module is not a security mechanism. Do not use it to run untrusted code.”
    ■ (a mistake that’s been made before: people rarely read disclaimers)
  ○ ‘pac-proxy-agent’ (2M weekly downloads, same author) uses the above
    ■ Is widely popular, the main reason people use ‘degenerator’
    ■ Most people using this package have never heard of the latter -- many never will
Today’s toolchain: a quick overview

Continuous Integration:

- Automates standard build, test, deploy pipelines
  - Technically, the latter is “CD”
  - Typically builds from scratch in a clean container
  - Often tied to code-review; triggers on new commits, pull requests
    - Ideally, official releases pass the build
  - Produces (long) logs with debugging outputs
Today’s toolchain: a quick overview

Not mentioned:

- Docker: containerize applications for coarse-grained reuse
- Cloud: deploy and scale rapidly, release seamlessly
- Bug/Issue trackers, often integrated with reviews
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Behind the Abstraction

First, a bit of nuance:

- Automation vs. Reuse
  - We tend to automate common chains of actions
    - Gear-up := \{Press clutch, switch gear, release clutch while accelerating\}
  - To facilitate reusing such “subroutines”, we introduce abstractions
    - Accelerate in ‘D’ => Gear-up when needed
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- **Reuse vs. Interfaces**
  - Interfaces facilitate reuse through abstraction
    - Allow upgrading implementation without breaking things
    - Provide explicit & transparent contract
Behind the Abstraction

First, a bit of nuance:

● Most tools are abstractions of common commands
  ○ Typically operated via GUI and/or a DSL
  ○ Obvious for Travis: just read the Yaml
    ■ Script-like languages are common
    ■ Involving a vocabulary of “targets”
    ■ E.g., `mvn site`
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    - E.g., `mvn site`
- Abstraction can also “trap” us
  - When/how do we leave the abstraction?
  - Command-line comes built into IDEs for a reason
  - Non-trivial in general! May require switching/“patching” libraries
    - E.g., Maven → Gradle for more unusual build routines
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IDEs

Automate common programming actions:

- Handy refactorings, suggestions
  - E.g., just press `alt+enter` in IntelliJ while highlighting nearly any code
    - Keyboard shortcuts are super useful: explore your IDE!
  - These can make you a better programmer: encode a lot of best-practices
    - Though, don’t read into them too much
IDEs

- The engine: continuous parsing, building
  - Key feature: most partial programs don’t parse, but IDEs make sense of them
  - That allows quickly relaying compile warnings/errors and useful suggestions
  - Same with API resolution

- Powered by rapid incremental compilation
  - Only build what has been updated
    - Virtually every edit you make triggers a compilation, re-linking
    - Of just the changed code and its dependencies
  - Works because very little of the code changes most of the time
    - But no free lunch: tends to drop optimizations (mostly fine), may struggle with big projects
  - Just try it: call an API with the wrong parameters & see how fast it triggers an alert; contrast with running a full Maven build (e.g., with `mvn install`)
IDEs

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IDEs

- IDE designers spend a lot of time automating common development tasks
  - Sometimes they get a little too helpful (modifying pom's)
  - Many plugins provide customized experience
  - Mostly evolve with new tools, prioritizing emerging routines
- Useful to know how these actions work
  - Often not much more than invoking commands for you
    - VSCode, IntelliJ are very explicit about this in the terminal -- great for customization

```
"C:\Program Files\Java\jdk-16.0.1\bin\java.exe" -ea -Didea.test.cyclic.buffer.size=1048576 "-javaagent:C:\Program Files\JetBrains\IntelliJ IDEA 2019.3\lib\idea-agent.jar"
```

Process finished with exit code 0
Build Systems

- These days: intricately tied with IDEs, package managers
- Projects often come with a build config file or two
  - ‘pom.xml’ for Maven
  - ‘tsconfig.json’ + ‘package.json’ for TypeScript+NPM -- the second deals with packages
  - These can be nested, one per (sub-)directory, to compose larger systems
    - On GitHub, you can create links across repositories
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  - Specifies:
    - Compilation source and target version
    - High-level configuration options
    - Targets for various phases in development
      - "lifecycle" in Maven; e.g. ‘compile’, ‘test’, ‘deploy’
    - Often involving plugins
    - Dependencies with versions
      - Not shown: in package.json

```json
1  {
2   "compilerOptions": {
3     "target": "es2016",
4     "module": "commonjs",
5     "sourceMap": true,
6     "strict": true,
7     "esModuleInterop": true,
8     "moduleResolution": "node",
9     "outDir": "dist"
10  }
11 }
```
Libraries & Frameworks

Packages can be either:

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  - A set of classes and methods that provide reusable functionality
  - Typically: programmer calls, library returns data, that’s it.
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- **Frameworks:**
  - Reusable skeleton code that can be customized into an application
  - Framework calls back into client code
    - The Hollywood principle: “Don’t call us. We’ll call you.”
  - E.g., Android development: you declare your UI elements, activities to be composed
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  ○ Principle: inversion of control

● **You typically use zero/one framework and many libraries**
  ○ Frameworks might be especially constraining, but for good reason.
  ○ Some tools are a bit of both, and not all frameworks quite invert control
Libraries & Frameworks

Which kind is a command-line parsing package?

http://tom.lokhorst.eu/2010/09/why-libraries-are-better-than-frameworks`
Libraries & Frameworks

Which kind is a command-line parsing package?

How about a tool that runs tests based on annotations you add in your code?

- More on Thursday

http://tom.lokhorst.eu/2010/09/why-libraries-are-better-than-frameworks`
Libraries

Look into:

● **Stated Goal:**
  ○ A simple interface (“get started in one line!”) also means lots of abstraction
  ○ That’s neither good nor bad; know what you need
  ○ Docs with “advanced use cases” are always neat

● **Maintenance:**
  ○ Active release cycle, recent updates to documentation
  ○ GitHub build status, issue tracker (filled with unmerged ‘dependabot’ PRs?)
  ○ Lots of companies deliberately lag by one minor (or even major) version

● **Recursive dependencies**
  ○ Myriad, beyond inspection. Using OSS in corporate environments is a headache
Frameworks

Whitebox:

- Extension via subclassing and overriding methods
- Common design pattern(s):
  - Template method
- Subclass has main method but gives control to framework

Blackbox:

- Extension via implementing a plugin interface
- Common design pattern(s):
  - Command
  - Observer
- Plugin-loading mechanism loads plugins and gives control to the framework
Continuous Integration

Defines a series of actions to be run in a clean build:

- Actions start from the very top:
  - Clone repository, checkout branch
  - Download & install Java/Node
  - Invoke commands with timeouts

- Travis allocates a new (Docker) container for each build
  - Think of this like a fresh, temporary computer
  - Usually with a few default libraries present (i.e., based on an image)

- That means: fully replicable builds
163 Installing SSH key from: default repository key
164 Using /home/travis/.netrc to clone repository.

167 $ git clone --depth=50 --branch=TypeScript https://github.com/CMU-17-214/template-21f-hw1.git CMU-17-214/template-21f-hw1
168 Cloning into 'CMU-17-214/template-21f-hw1'...
169 remote: Enumerating objects: 117, done.
170 remote: Counting objects: 100% (117/117), done.
171 remote: Compressing objects: 100% (73/73), done.
172 remote: Total 117 (delta 58), reused 184 (delta 37), pack-reused 0
173 Receiving objects: 100% (117/117), 69.89 KiB | 2.25 MiB/s, done.
174 Resolving deltas: 100% (58/58), done.
175 $ cd CMU-17-214/template-21f-hw1
176 $ git checkout -qf 8d657225c8cbdd52751c2f88527f937f4099b041e

179 $ nvm install 16
180 Downloading and installing node v16.8.0...
181 Downloading https://nodejs.org/dist/v16.8.0/node-v16.8.0-linux-x64.tar.xz...
182 Computing checksum with sha256sum
183 Checksums matched!
184 Nvm using node v16.8.0 (npm v7.21.0)

186 Setting up build cache
193 $ node --version
194 v16.8.0
197 $ npm --version
198 7.21.0
199 $ nvm --version
200 0.38.0
281 $ npm ci
292 $ timeout 5m npm run compile
210 > hw1-flashcards@1.0.0 compile
213 > tsc
Continuous integration – Travis CI

Automatically builds, tests, and displays the result
Continuous integration – Travis CI

You can see the results of builds over time.
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What’s Next

Anyone care to guess?

• Can be based on something you’ve seen, but think will boom
What’s Next

AI Powered Programming

● Easier in Web IDEs
  ○ Which are themselves “next”
What’s Next

Collaborative online coding

- Think: Google Docs for code
- E.g. VS Life Share
- How will this change “commits”?
What’s Next

Tighter IDE-to-cloud integration

- Google Cloud is pushing on this with VSCode
- We will (lightly) touch on Containers & Clouds in this course
Summary

- Programming Tools are abundant, and rapidly evolving
  - Learn multiple; you will have to inevitably
- They rely on abstractions through interfaces to facilitate reuse
  - Which come in many shapes: GUI, API, DSL
  - And can be a limitation -- choose wisely
- Your HW1 toolchain sets you up for all homeworks
  - With modest variations (frameworks, new build targets)
  - Self-discovery is a big asset
  - Tomorrow’s recitation offers help