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2026

JavaScript: Libraries and Packages

"The" language of the Web

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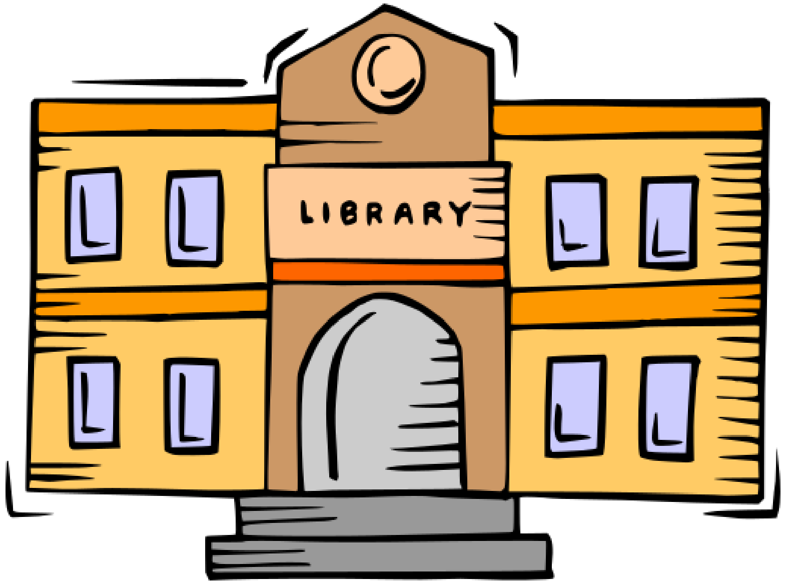


Outline

- Modules, libraries, packages
- Package manager
- Package example: handling dates
- Issues and security concerns

Definition

- **Module**: a Javascript file, having its own scope isolated from the rest
  - Will be described later in the course
- **Library**: a group of modules and/or scripts that implements a desired function (e.g., handling dates/times)
  - Similarly to other programming languages
- **Package**: one or more libraries organized so that they can be easily integrated into projects

Handling Packages

- **Registry:** a database of software packages that facilitates searching, download, and dependency management
- In the Javascript community: *NPM Registry* is the largest (2M+ packages)
  - https://www.npmjs.com

- **Package manager**: software tools to automate managing packages in a standardized manner
  - An assistant to the developer to install the packages required by the developer while automatically managing package versions and their dependencies
  - **Dependencies**: other packages (software and libraries) needed to run a package

Javascript Package Managers

- **`npm:`** the default for the node.js environment
  - npm is the "node package manager"
  - npm is also a "repo platform" now maintained by GitHub (owned by Microsoft)

In the rest of the course: we focus on **`npm`**

- **`yarn:`** alternative to npm developed by Facebook
  - faster, can work offline in certain cases, but some drawbacks: not compatible with older node versions, issues with native code packages
- **`pnpm:`** npm improvement ("performant npm")
  - Not so popular, compatibility issues with some packages

https://romanglushach.medium.com/comparing-npm-yarn-and-pnpm-package-managers-which-one-is-right-for-your-distributed-project-to-4d7de2f0db8e

How does a package manager work?

Example 1: Developer tells the package manager to import a new package in the project. The package manager **automatically**:

1. Queries a software registry to find the package
2. If found, obtains the information about to download it
3. Downloads it
4. Includes it in the project
   - Typically in a standardized form, e.g. in `package.json` for the case of `npm`
5. Checks dependencies, and restart from 2 until all dependencies are met

How does a package manager work?

Example 2: Developer tells the package manager to install all packages that are required by a project

1. The package manager reads the list of packages required by the project
   - From `package.json` for the case of `npm`
2. Then it proceeds to include them in the project as in previous example

The developer:

- share only the application code
- does not need to care about other code (packages) that will be managed automatically

Example: Day.js Package

DAY.JS https://day.js.org/

- Install (from command line)

```
# initialize the package manager files in the project
# if not already done (choose a name and default for the rest)
npm init

# download from registry, add to project package list
# make it available to the scripts in the project
npm install dayjs
```

package.json

```
{
  "name": "my-project",
  "version": "1.0.0",
  "main": "index.mjs",
  . . .
  "dependencies": {
    "dayjs": "^1.11.19"
  }
}
```

Folder Structure after running npm

```
my-project
├── node_modules
├── package.json
├── package-lock.json
└── index.mjs
```

- `my-project` is the project root
- `node_modules` is the folder where packages are installed. This is automatically managed/reconstructed by npm, do not touch!
- `package.json` contains (also) the list of packages needed by the project, with their minimum version
- `package-lock.json` contains the list of packages actually installed in the project, with more details (version, package hash)
- `index.mjs` is the code of the project
  - **Develop here!**
  - Insert the `import` statement here to use the package

Example: Day.js Package usage in node

- In the Javascript file, after the package has been installed

index.mjs

```
// import (using name of my choice)
import dayjs from 'dayjs';

// use (depends on the specific package)
let now = dayjs();
console.log(now.format());
```

Security and Critical Issues with External Code

Security: The package code is:

- running in your project
- with the **same privileges as your code**
- same possibility to access data
- how can it be trusted?

Availability: If the package and/or a specific package version is not available anymore:

- how can the project be run?

Checking for Bugs/Vulnerabilities

- **First**: do not forget to check for known bugs/vulnerabilities!

  `npm audit`

  NB: `npm audit fix` ONLY updates the package version(s)! https://docs.npmjs.com/cli/v10/commands/npm-audit

```
@babel/traverse  <7.23.2
Severity: critical
Babel vulnerable to arbitrary code execution when compiling specifically crafted malicious code - https://github.com/advisories/GHSA-67hx-
x53-jw92
fix available via `npm audit fix`
node_modules/@babel/traverse
```

…

```
vite  4.2.0 - 4.2.2
Severity: high
Vite Server Options (server.fs.deny) can be bypassed using double forward-slash (//) - https://github.com/advisories/GHSA-353f-5xf4-qw67
fix available via `npm audit fix`
node_modules/vite

4 vulnerabilities (2 moderate, 1 high, 1 critical)

To address all issues, run:
  npm audit fix
```

Security

How to trust packages written by others?

- By reading and checking it yourself or by some trusted entity (e.g. your organization / company)
- And by using formal verification tools
- And …
- <u>Do not rely only</u> on unknown / untrusted entities, and/or reputation

Result

- An *approved* package that can be securely used in your projects / organization / company

Secure distribution of packages

How to force package managers use only approved packages?

- Search/install only from a private registry containing only approved packages (serious companies always have one)
  - The private registry/database solves also the availability issue because:
    - the package is stored in computers systems you control thus it cannot disappear
    - the package cannot change its content due to malicious attacks
- A cryptographically secure hash applied to the package helps in checking if the content of the package changed (even if name and version are the same!)
  - `package-lock.json` contains both the hash and the version of the package

Forcing specific packages

- Always use `package-lock.json`, distribute it with your code
  - npm will always check hash, will always try to install dependencies whose version matches the ones listed in the `package-lock.json` file.
- Note the subtle differences in npm install commands

```
npm install
```

# if dependencies already exist in node_modules, use them; it creates package-lock.json if it doesn't exist, no hash/version check!

```
npm ci
```

# ci = clean install, for reproducible builds in automated environments: delete node_modules then start from scratch

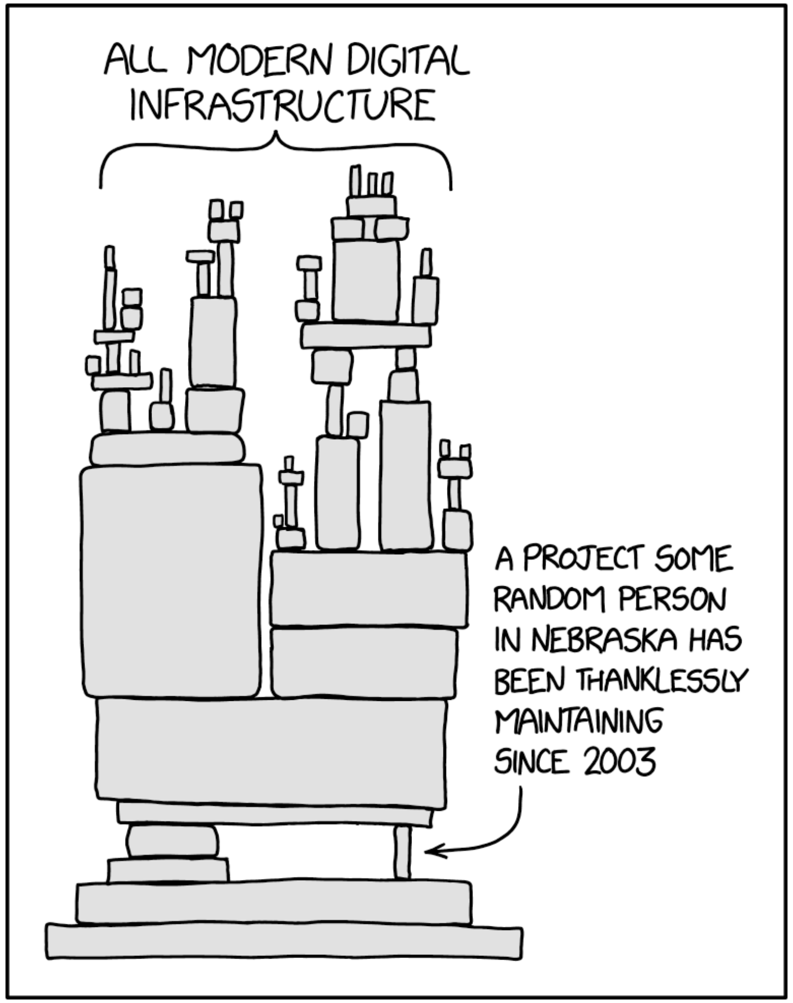
`package-lock.json`

```
{ "name": "my-project",
  . . .
  "packages": {
    . . .
    "node_modules/dayjs": {
      "version": "1.11.19",
      "resolved": "https://registry.npmjs.org/dayjs/-
                                                   /dayjs-1.11.19.tgz",
      "integrity": "sha512-t5EcLVS6QPBNqM2z8fakk/NKel+ … "
    }
} }
```

https://cheatsheetseries.owasp.org/cheatsheets/NPM_Security_Cheat_Sheet.html

Choosing libraries/packages

- Beware: before choosing libraries, packages, etc. consider:
  - Licensing
  - Community / long term support
  - Security
  - Documentation and code quality


ALL MODERN DIGITAL INFRASTRUCTURE
A PROJECT SOME RANDOM PERSON IN NEBRASKA HAS BEEN THANKLESSLY MAINTAINING SINCE 2003

https://xkcd.com/2347/

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