Software Archaeology

17-313: Foundations of Software Engineering

https://cmu-313.github.io

Michael Hilton and **Chris Timperley**

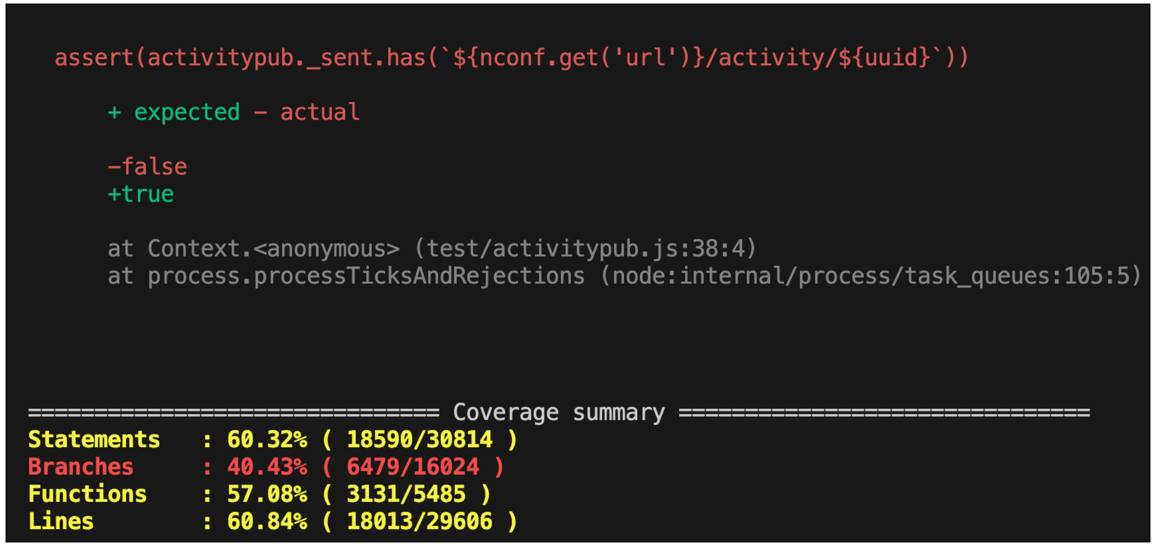
Fall 2025

Administrivia (1/4)

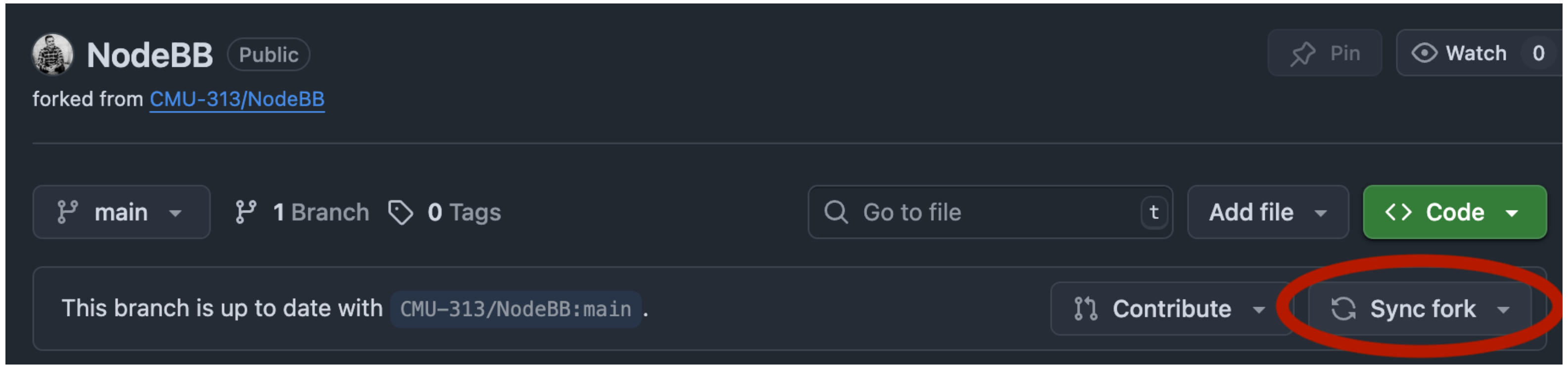
- Project 1(a) is due Friday, August 29th, 11:59pm.
- If you haven't: **PLEASE FILL OUT TEAMWORK SURVEY!**
- Get started early, ask for help, and check the **#technical-support** channel; chances are your questions have been asked by others!

Administrivia (2/4)

- Initial NodeBB repository had some failing tests (see error on right)
- We have disabled the failing tests
- To make sure that you have the latest changes, you can hit **"Sync fork"** on your repository.



```
assert(activitypub._sent.has(`${nconf.get('url')}/activity/${uuid}`))

    + expected - actual

    -false
    +true

    at Context.<anonymous> (test/activitypub.js:38:4)
    at process.processTicksAndRejections (node:internal/process/task_queues:105:5)



=============================== Coverage summary ===============================
Statements   : 60.32% ( 18590/30814 )
Branches     : 40.43% ( 6479/16024 )
Functions    : 57.08% ( 3131/5485 )
Lines        : 60.84% ( 18013/29606 )
```

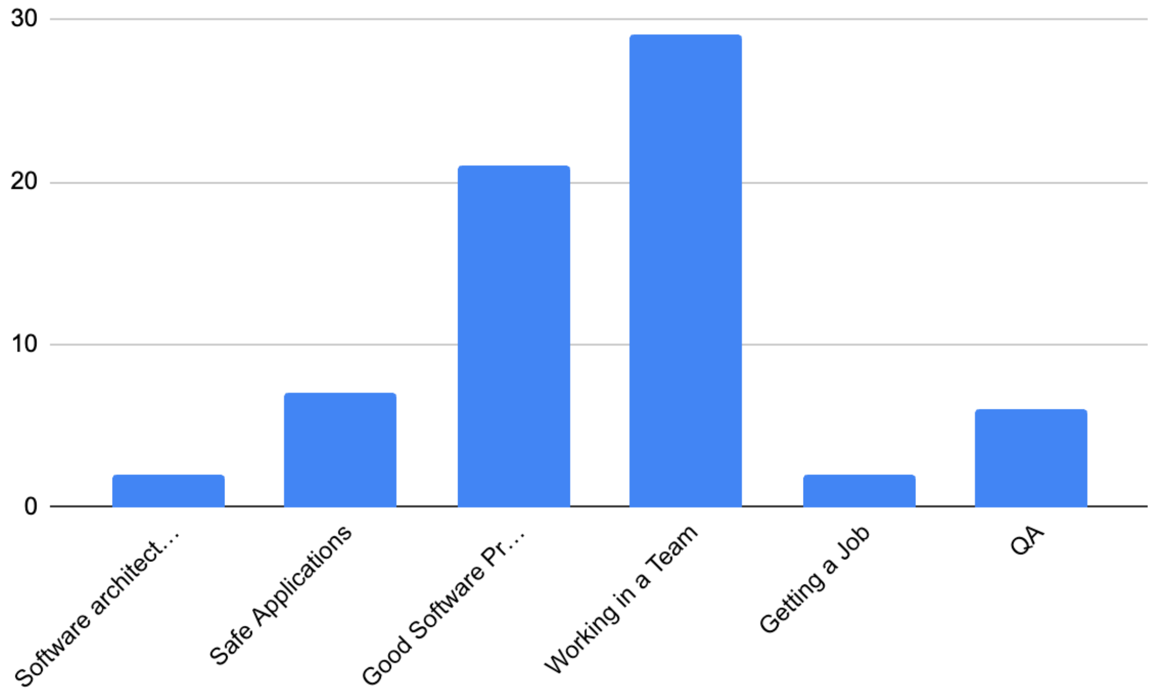


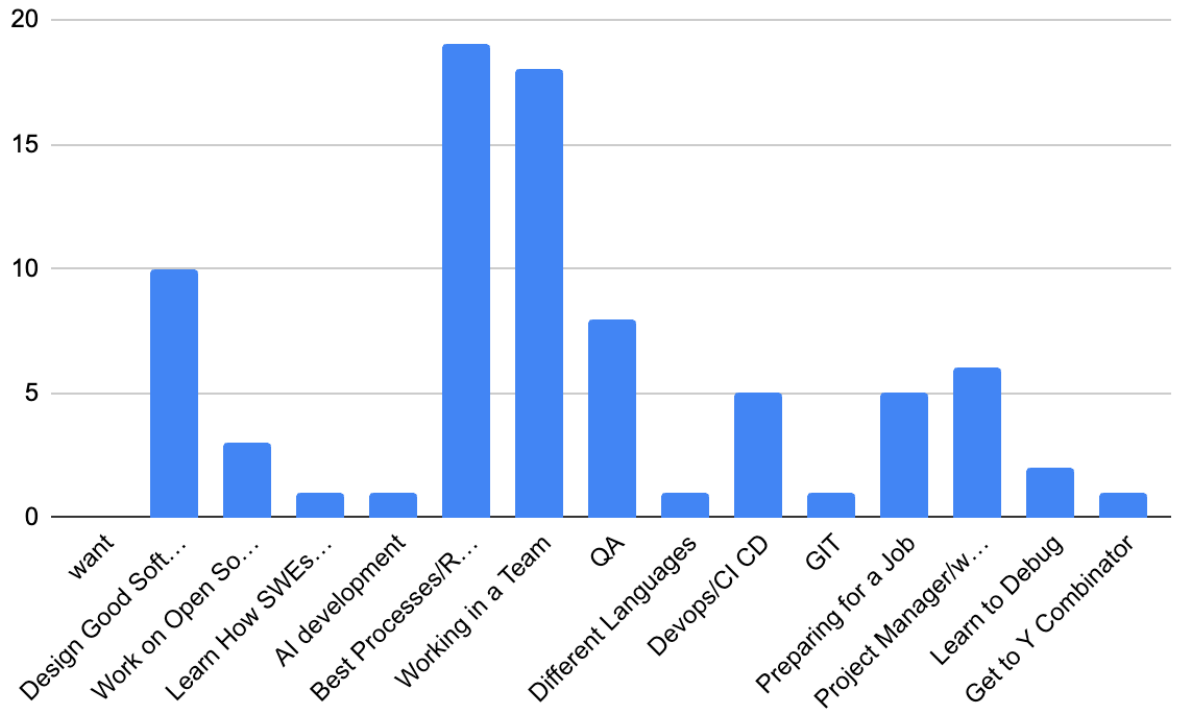
NodeBB Public

forked from CMU-313/NodeBB

This branch is up to date with CMU-313/NodeBB:main.

Administrivia (3/4): Survey Results





Administrivia (4/4): Slack

Lots of great help for each other on #technicalsupport, keep up the good work!

- use ✅ emoji to signal thread is answered

We also have: #f25-announcements

Please Search before asking new questions

Please put a picture of your face!!

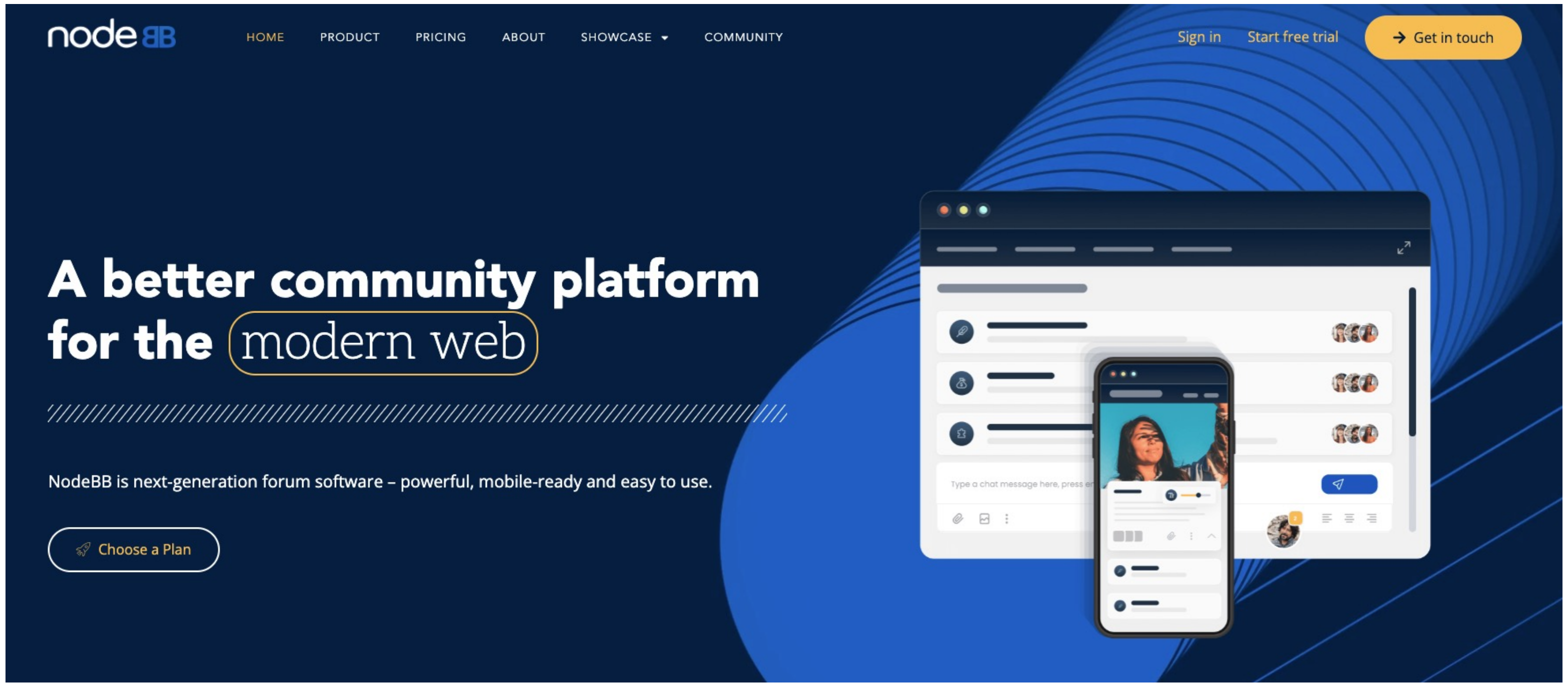
We don't guarantee round the clock availability

Smoking Section

- Last full row

Context: big ole pile of code

- … do something with it!



A better community platform for the modern web

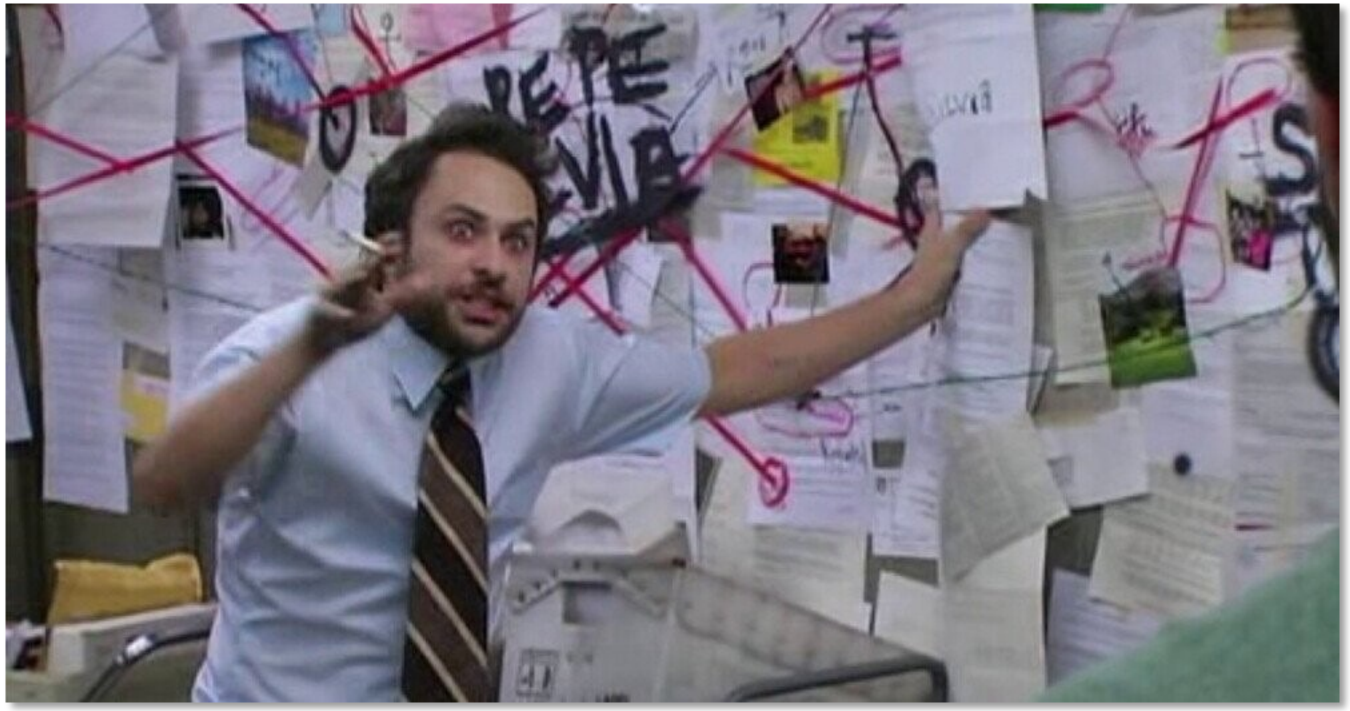
NodeBB is next-generation forum software – powerful, mobile-ready and easy to use.

Participation Activity: Part 1

- Take out a piece of paper (or ask for one)
- Write down the **challenges you've faced trying to understand someone else's code**
- Pair with your neighbor and discuss your answers. Do you agree?
- Share with the class!
- Write your own andrewID on the paper; leave it at the end of class.

You will never understand the entire system!

Challenge: How do I tackle this codebase?



Participation Activity: Part 2

- Write down **strategies to understand a large codebase that is unfamiliar to you**

Challenge: How do I tackle this codebase?

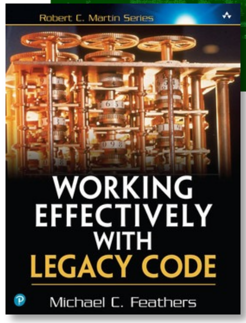
- Leverage your previous experiences (languages, technologies, patterns)
- Consult documentation, whitepapers
- Talk to experts, code owners
- **Follow best practices to build a working model of the system**

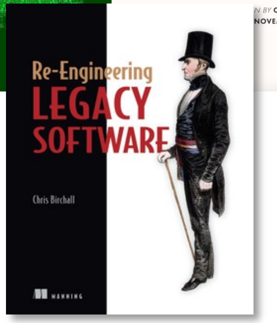
Bad news: There are few helpful resources!

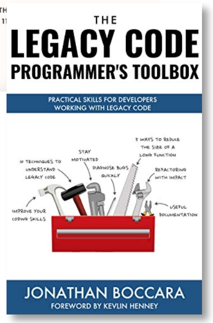
- **Working Effectively with Legacy Code**
  Michael C. Feathers. 2004
- **Re-Engineering Legacy Software**
  Chris Birchall. 2016
- **The Legacy Code Programmer's Toolbox**
  Jonathan Boccara. 2019

The Code That Controls Your Money

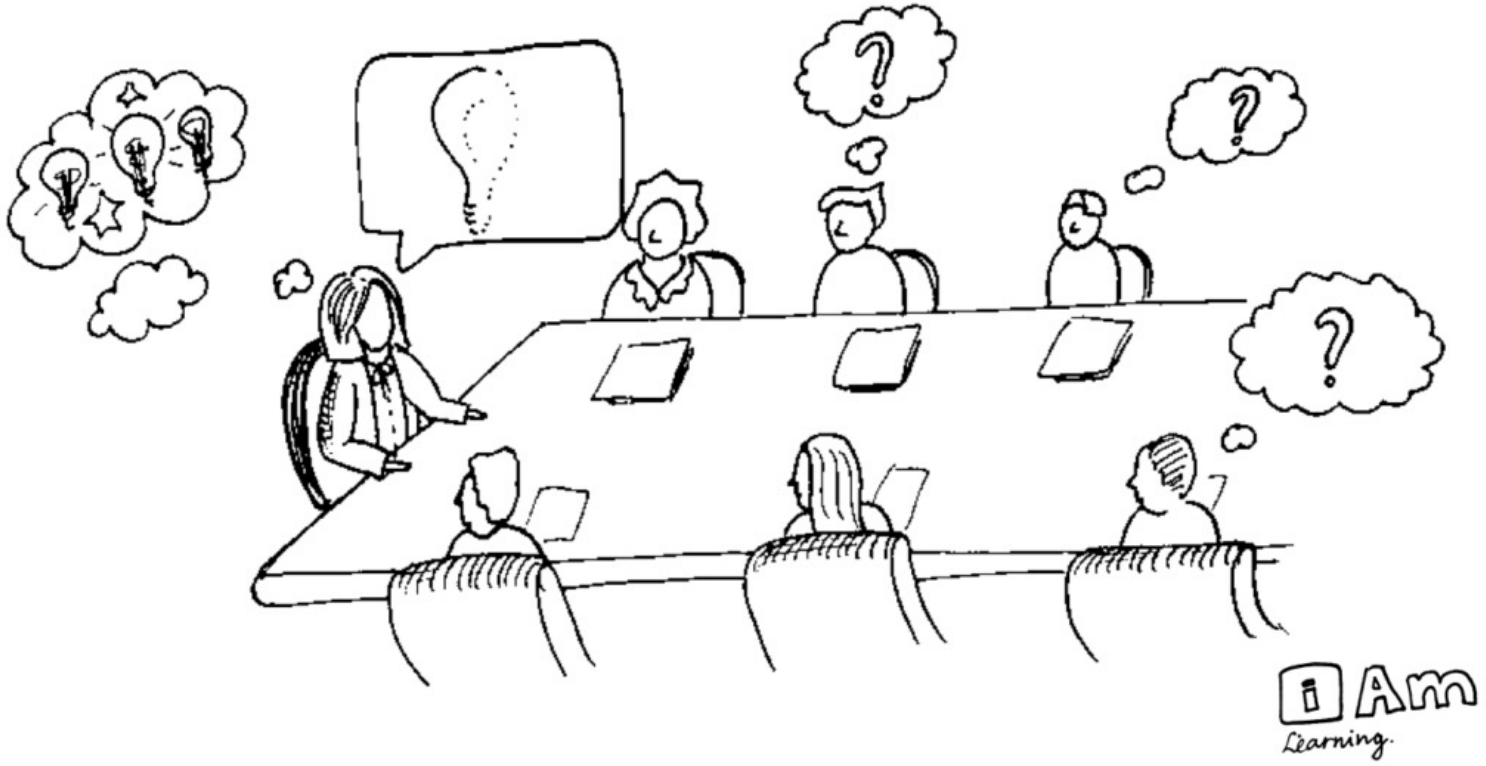
COBOL is a coding language older than Weird Al Yankovic. The people who know how to use it are often just as old. It underpins the entire financial system. And it can't be removed. How a computer language controls the financial life of the world.






THE
LEGACY CODE
PROGRAMMER'S TOOLBOX
PRACTICAL SKILLS FOR DEVELOPERS WORKING WITH LEGACY CODE
JONATHAN BOCCARA
FOREWORD BY KEVLIN HENNEY

Why? Because of Tacit Knowledge

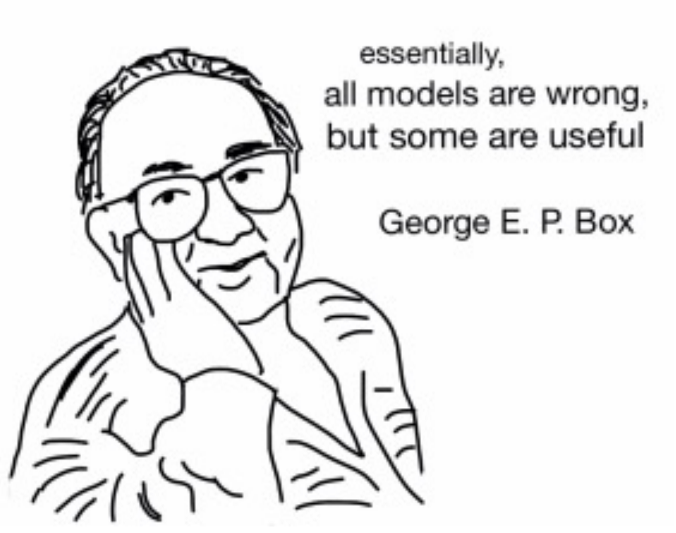


Today: How to Tackle New Codebases

- **Goal:** develop and test a working model about how (part of) a system works

- **Working Model:** an understanding of the pieces of the system (components), and their interactions (connections)

- How to quickly **build, test and refine** models
  - explore various tools, tips, and techniques



Program comprehension strategies

Novice

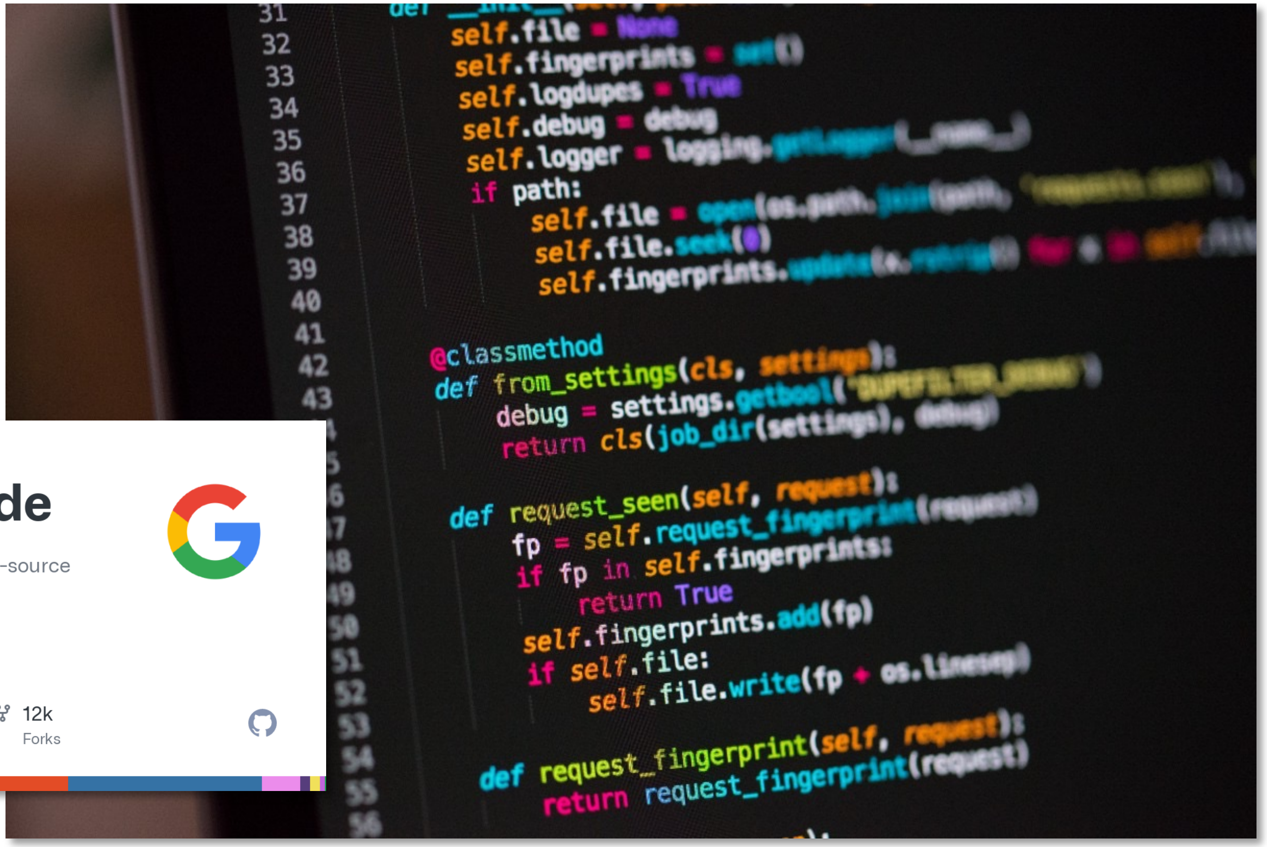
- Reads code line by line
- Revisits same code repeatedly
- Trial and error
- Only tests “happy path”

Expert

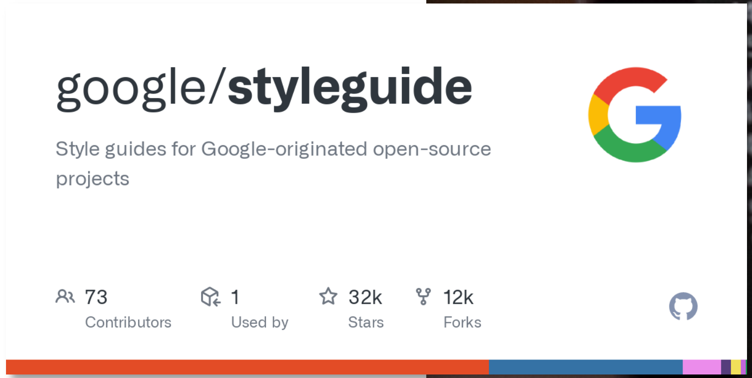
- “Top down”
- Recognizes patterns
- Forms hypotheses
- Checks up/downstream consequences

Observation: Software is full of patterns

- File structure
- System architecture
- Code structure
- Names
- …



```
    self.file = None
    self.fingerprints = set()
    self.logdupes = True
    self.debug = debug
    self.logger = logging.getLogger(__name__)
    if path:
        self.file = open(os.path.join(path, 'requests.seen'), 'a+')
        self.file.seek(0)
        self.fingerprints.update(x.rstrip() for x in self.file)

@classmethod
def from_settings(cls, settings):
    debug = settings.getbool('DUPEFILTER_DEBUG')
    return cls(job_dir(settings), debug)

def request_seen(self, request):
    fp = self.request_fingerprint(request)
    if fp in self.fingerprints:
        return True
    self.fingerprints.add(fp)
    if self.file:
        self.file.write(fp + os.linesep)

def request_fingerprint(self, request):
    return request_fingerprint(request)
```



google/**styleguide**

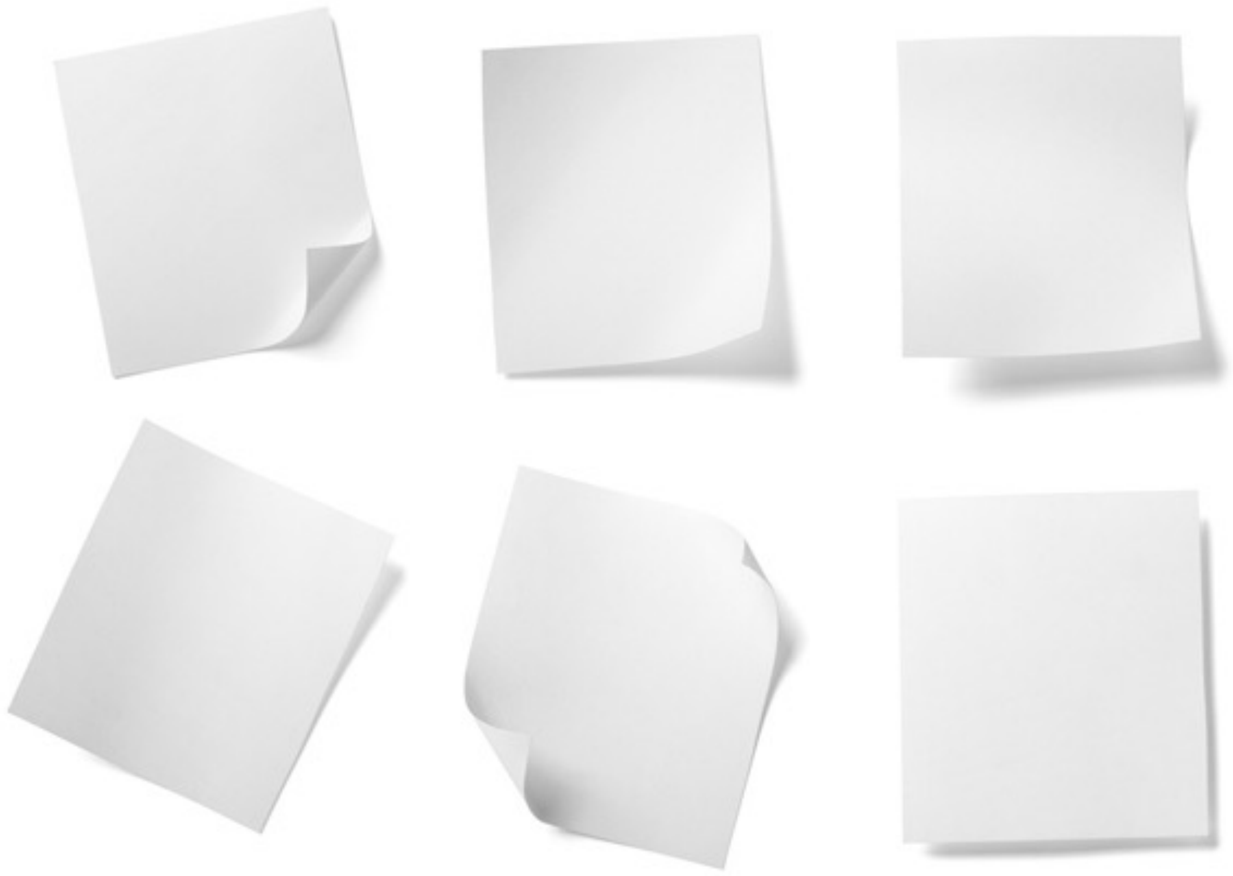
Style guides for Google-originated open-source projects

73 Contributors · 1 Used by · 32k Stars · 12k Forks

Observation: Software is massively redundant

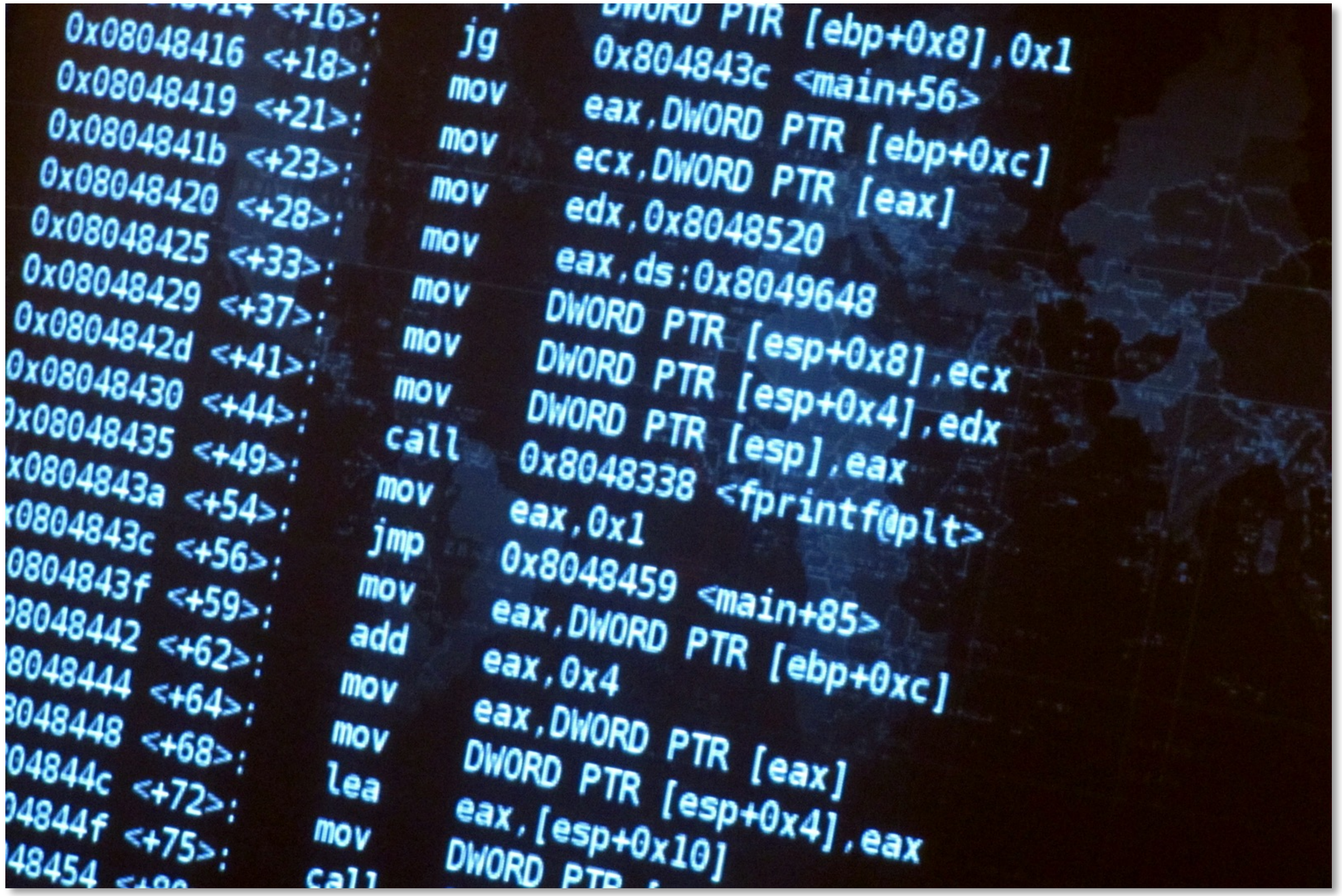
- There’s always something to copy/use as a starting point!

Observation: Code must run to do stuff…



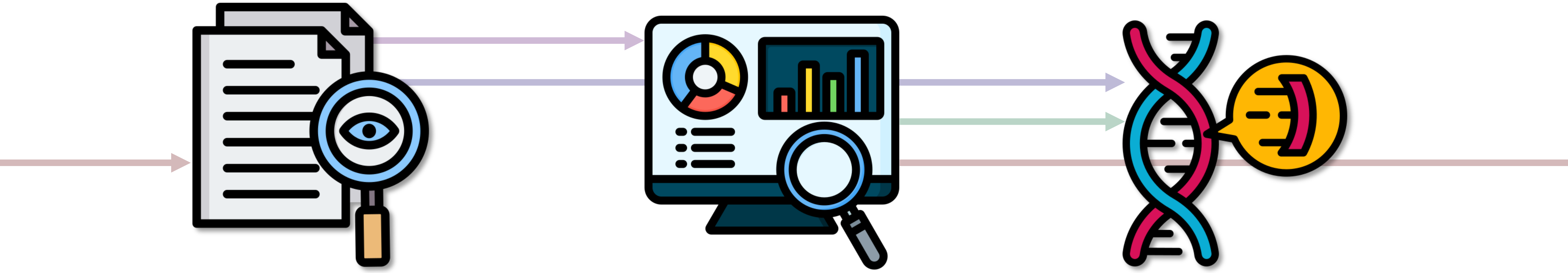
Observation: If code runs, it must have a beginning…

Observation: If code runs, it must exist…



```
            <+16>:         DWORD PTR [ebp+0x8],0x1
0x08048416 <+18>:   jg     0x804843c <main+56>
0x08048419 <+21>:   mov    eax,DWORD PTR [ebp+0xc]
0x0804841b <+23>:   mov    ecx,DWORD PTR [eax]
0x08048420 <+28>:   mov    edx,0x8048520
0x08048425 <+33>:   mov    eax,ds:0x8049648
0x08048429 <+37>:   mov    DWORD PTR [esp+0x8],ecx
0x0804842d <+41>:   mov    DWORD PTR [esp+0x4],edx
0x08048430 <+44>:   mov    DWORD PTR [esp],eax
)x08048435 <+49>:   call   0x8048338 <fprintf@plt>
x0804843a <+54>:    mov    eax,0x1
(0804843c <+56>:    jmp    0x8048459 <main+85>
0804843f <+59>:     mov    eax,DWORD PTR [ebp+0xc]
08048442 <+62>:     add    eax,0x4
8048444 <+64>:      mov    eax,DWORD PTR [eax]
3048448 <+68>:      mov    DWORD PTR [esp+0x4],eax
04844c <+72>:       lea    eax,[esp+0x10]
04844f <+75>:       mov    DWORD PTR
48454
```

How to build, test, and refine mental models

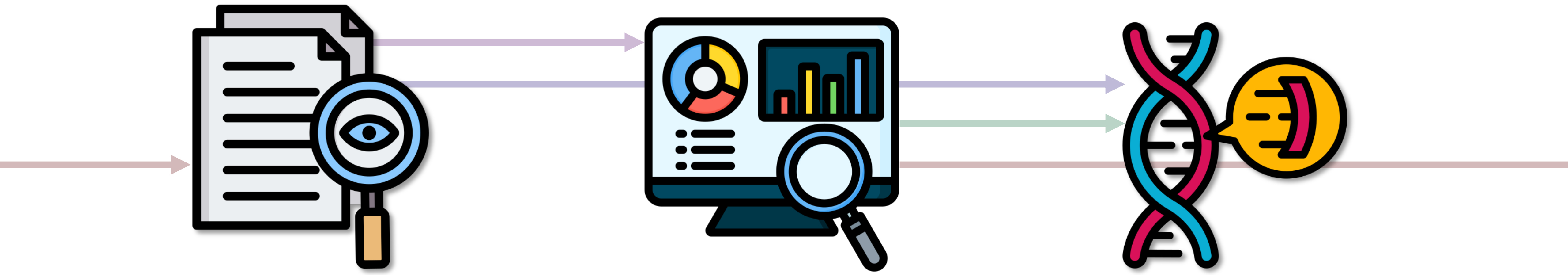


Examine
artifacts without running code

Probe
running system to observe behavior

Modify
code, rebuild, and assess impact

How to build, test, and refine mental models



Examine
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Probe
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Modify
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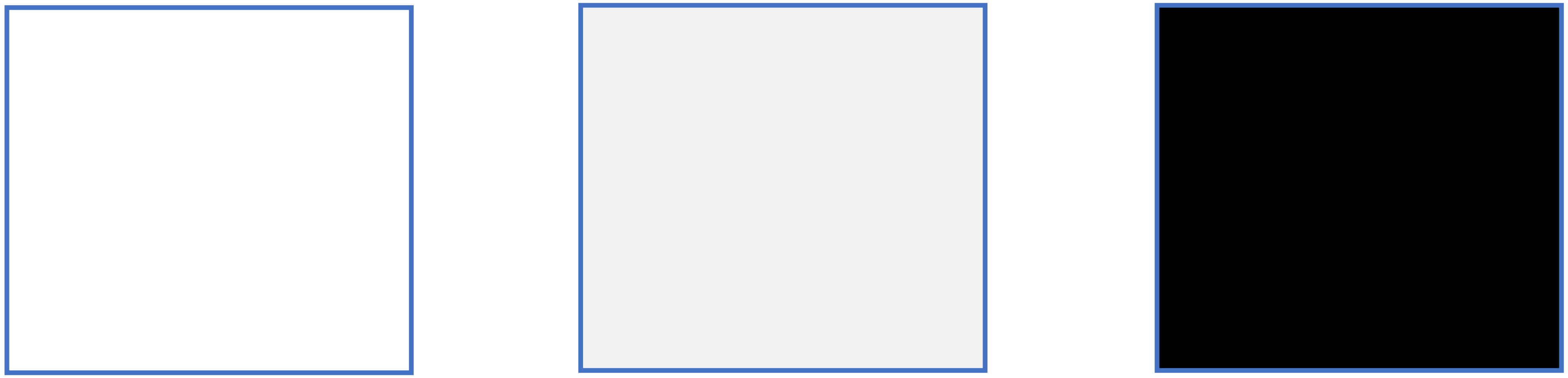
Can code be examined, probed, and modified?

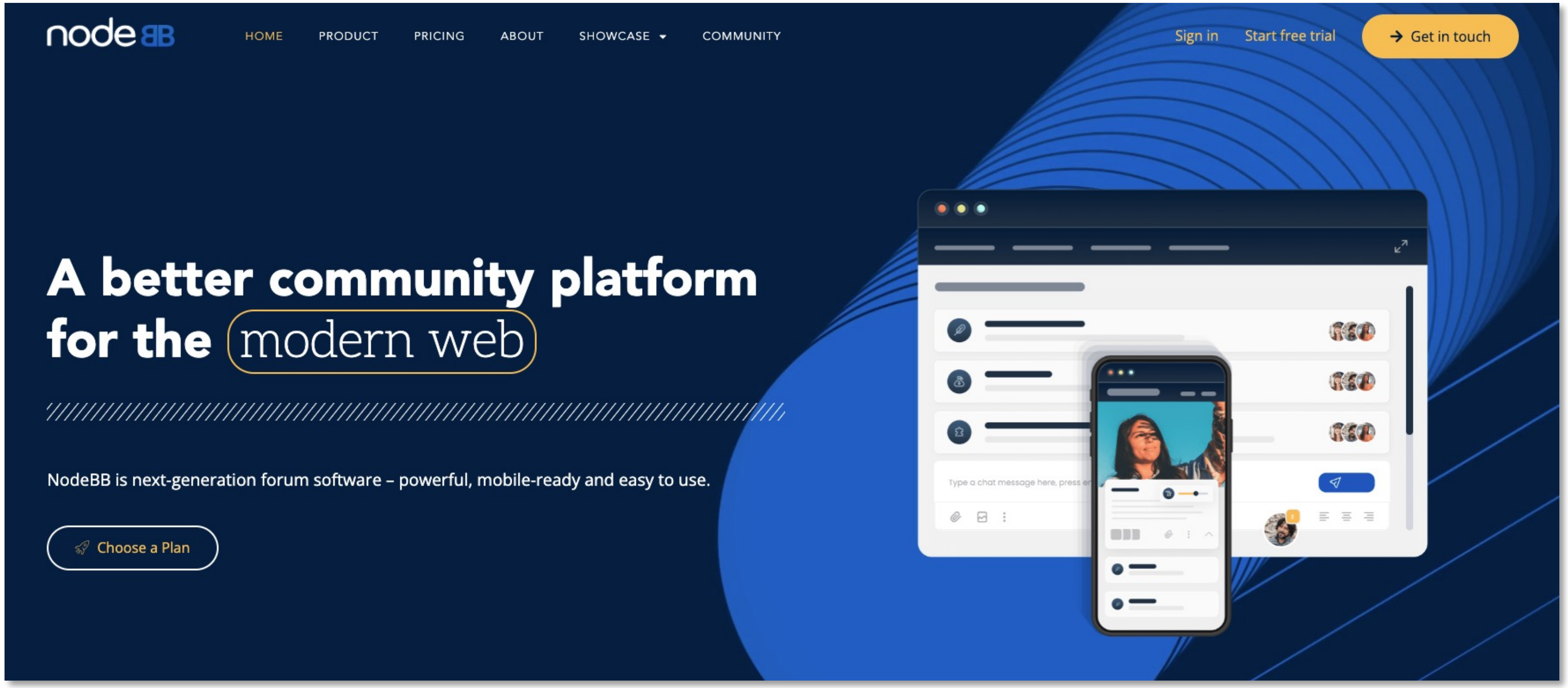


White-box	Grey-box		Black-box	
Source code built locally	Binaries running locally		Server-side apps running remotely	
	Open Source	Closed Source	Open Source	Closed Source
✓ examine	✓ examine	✗ examine	✓ examine	
✓ probe	✓ probe	✓ probe	? probe	Talk to NSA
✓ modify	✗ modify *	✗ modify *	✗ modify	

Creating a model of unfamiliar code

Source code built locally

Live Demonstration: NodeBB



A better community platform for the modern web

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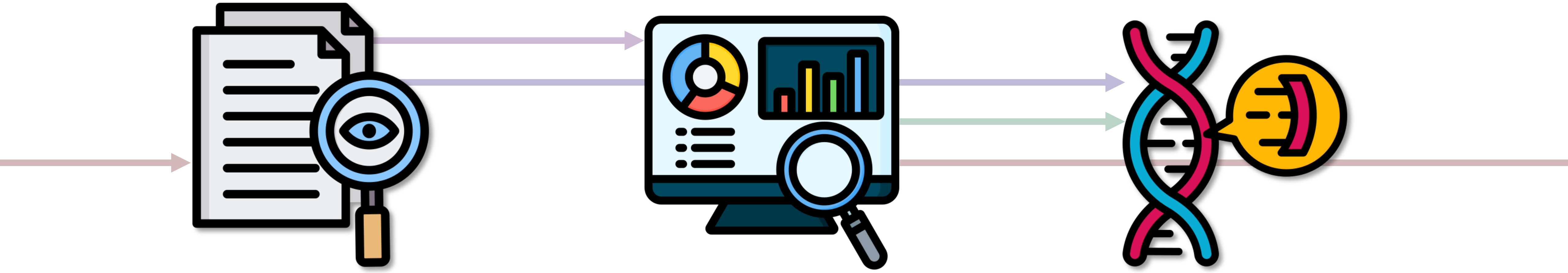
How to build, test, and refine mental models



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How to build, test, and refine mental models

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Examine artifacts to build a mental model

🧐 Ask

- How do we build / test / run it?
- How is this system structured?
  - Where are the entrypoints?
  - Where are the seams?
    Can we probe them?
  - Where is data persisted?
- What technologies does it use?
- What are its stated features? Limitations?
- Is the project active?

🔎 Scan

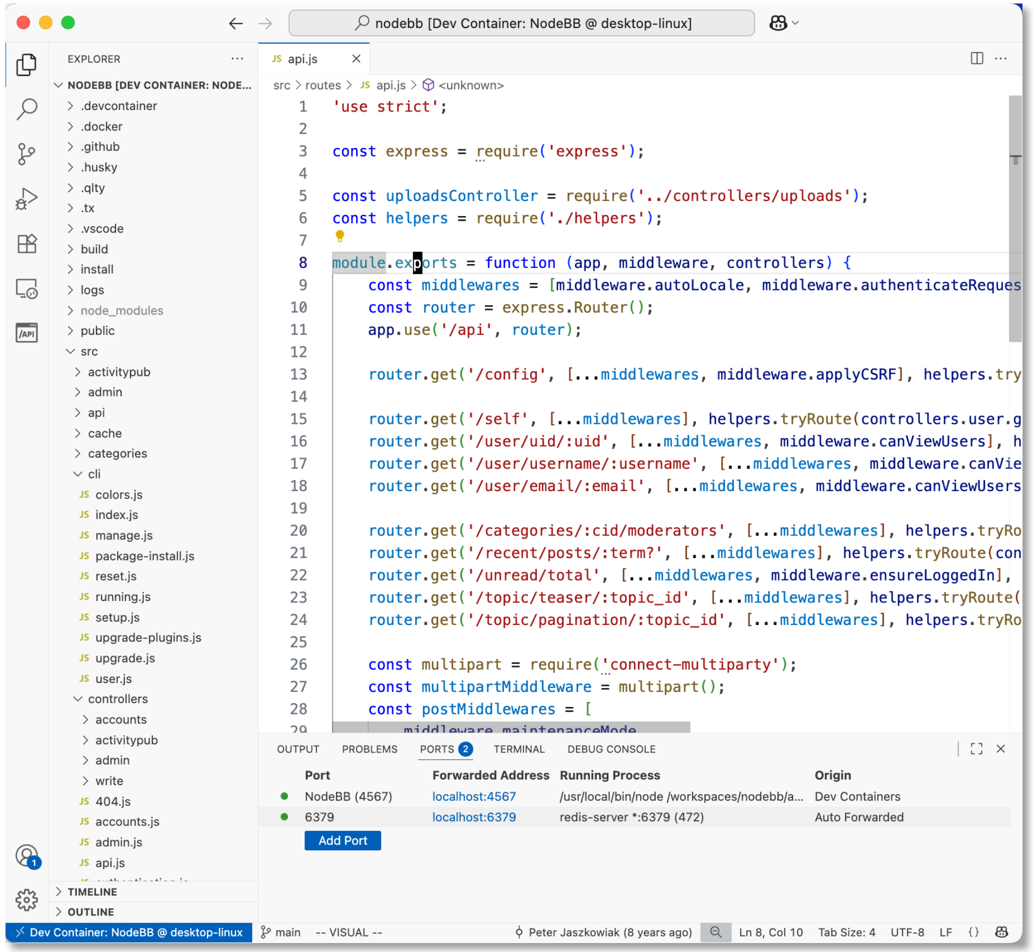
- Source: code
- Build/CI: package.json, Docker, workflows
- Config: env vars, config.json, …
- Docs: README, Documentation
- History: commits, issues, PRs, projects

🏆 Goal

- a **build/run** command
- an **entry point** that you can target
- a **seam** that you can probe

Tip: Configure and use your IDE to its full potential

- We will provide support for **DevContainers** in VSCode in this course
  - bundles together everything you need into a Docker image that behaves like a native install
- **Right click** on code to learn more
  - variables, functions, classes, modules, …
  - `Go to Definition`, `Go to References`, `Rename Symbol`, `Refactor`, …
- Install and explore IDE **Extensions**
  - Redis, ESLint, OpenAPI Editor, LiveShare, …



nodebb [Dev Container: NodeBB @ desktop-linux]

EXPLORER

```
NODEBB [DEV CONTAINER: NODE...
> .devcontainer
> .docker
> .github
> .husky
> .qlty
> .tx
> .vscode
> build
> install
> logs
> node_modules
> public
v src
  > activitypub
  > admin
  > api
  > cache
  > categories
  v cli
    colors.js
    index.js
    manage.js
    package-install.js
    reset.js
    running.js
    setup.js
    upgrade-plugins.js
    upgrade.js
    user.js
  v controllers
    > accounts
    > activitypub
    > admin
    > write
    404.js
    accounts.js
    admin.js
    api.js
> TIMELINE
> OUTLINE
```

api.js

src > routes > api.js > <unknown>

```javascript
'use strict';

const express = require('express');

const uploadsController = require('../controllers/uploads');
const helpers = require('./helpers');

module.exports = function (app, middleware, controllers) {
    const middlewares = [middleware.autoLocale, middleware.authenticateReques
    const router = express.Router();
    app.use('/api', router);

    router.get('/config', [...middlewares, middleware.applyCSRF], helpers.try

    router.get('/self', [...middlewares], helpers.tryRoute(controllers.user.g
    router.get('/user/uid/:uid', [...middlewares, middleware.canViewUsers], h
    router.get('/user/username/:username', [...middlewares, middleware.canVie
    router.get('/user/email/:email', [...middlewares, middleware.canViewUsers

    router.get('/categories/:cid/moderators', [...middlewares], helpers.tryRo
    router.get('/recent/posts/:term?', [...middlewares], helpers.tryRoute(con
    router.get('/unread/total', [...middlewares, middleware.ensureLoggedIn],
    router.get('/topic/teaser/:topic_id', [...middlewares], helpers.tryRoute(
    router.get('/topic/pagination/:topic_id', [...middlewares], helpers.tryRo

    const multipart = require('connect-multiparty');
    const multipartMiddleware = multipart();
    const postMiddlewares = [
        middleware.maintenanceMode
```

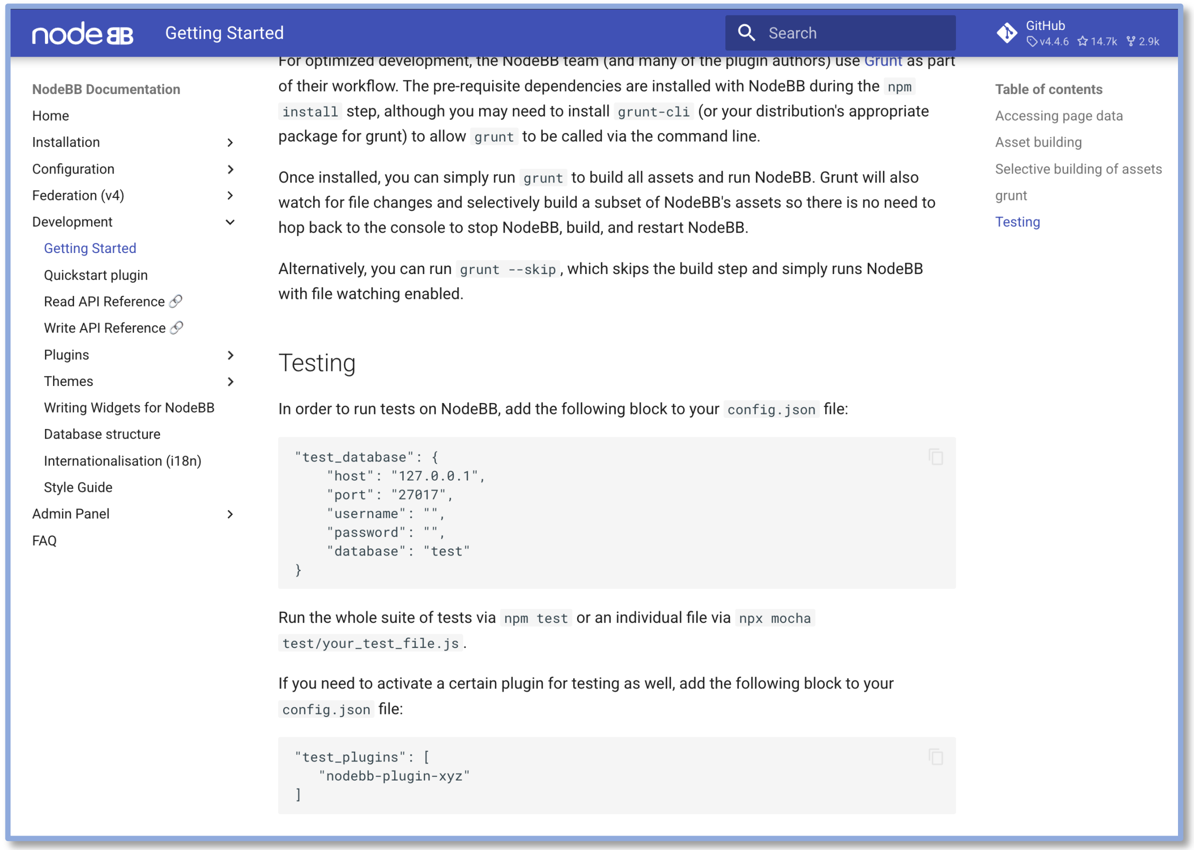
Port	Forwarded Address	Running Process	Origin
● NodeBB (4567)	localhost:4567	/usr/local/bin/node /workspaces/nodebb/a...	Dev Containers
● 6379	localhost:6379	redis-server *:6379 (472)	Auto Forwarded

Dev Container: NodeBB @ desktop-linux | main | -- VISUAL -- | Peter Jaszkowiak (8 years ago) | Ln 8, Col 10 | Tab Size: 4 | UTF-8 | LF

Tip: Consider documentation and tutorials judiciously

- Info on how to build the system, its dependencies, and how to use it
- Great for finding entry points
- Can tell you about the overall system architecture; more on that topic later in the semester

- ⚠️ **Often out of date!** Treat as a starting point rather than truth



For optimized development, the NodeBB team (and many of the plugin authors) use Grunt as part of their workflow. The pre-requisite dependencies are installed with NodeBB during the `npm install` step, although you may need to install `grunt-cli` (or your distribution's appropriate package for grunt) to allow `grunt` to be called via the command line.

Once installed, you can simply run `grunt` to build all assets and run NodeBB. Grunt will also watch for file changes and selectively build a subset of NodeBB's assets so there is no need to hop back to the console to stop NodeBB, build, and restart NodeBB.

Alternatively, you can run `grunt --skip`, which skips the build step and simply runs NodeBB with file watching enabled.

Testing

In order to run tests on NodeBB, add the following block to your `config.json` file:

```
"test_database": {
    "host": "127.0.0.1",
    "port": "27017",
    "username": "",
    "password": "",
    "database": "test"
}
```

Run the whole suite of tests via `npm test` or an individual file via `npx mocha test/your_test_file.js`.

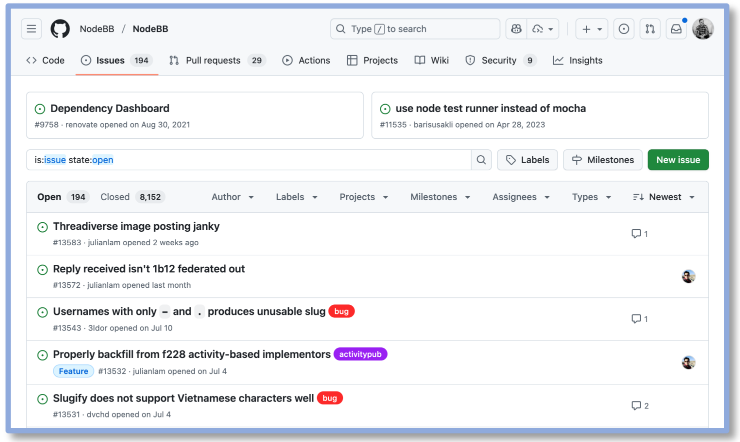
If you need to activate a certain plugin for testing as well, add the following block to your `config.json` file:

```
"test_plugins": [
   "nodebb-plugin-xyz"
]
```

Tip: Use discussion boards and issue trackers

- Are features unimplemented?
- Is the project still being maintained?
- Is someone else having the same issue?

- Found an issue with the code? **File a GitHub issue**
- Having a hard time getting some to work? Trying to change something? **Post to the NodeBB forums**
- Have a question about {Node, Redis, Express, …}? **Post to StackOverflow or Slack.**



Dependency Dashboard
#9758 · renovate opened on Aug 30, 2021

use node test runner instead of mocha
#11535 · barisusakli opened on Apr 28, 2023

is:issue state:open

Open 194 Closed 8,152

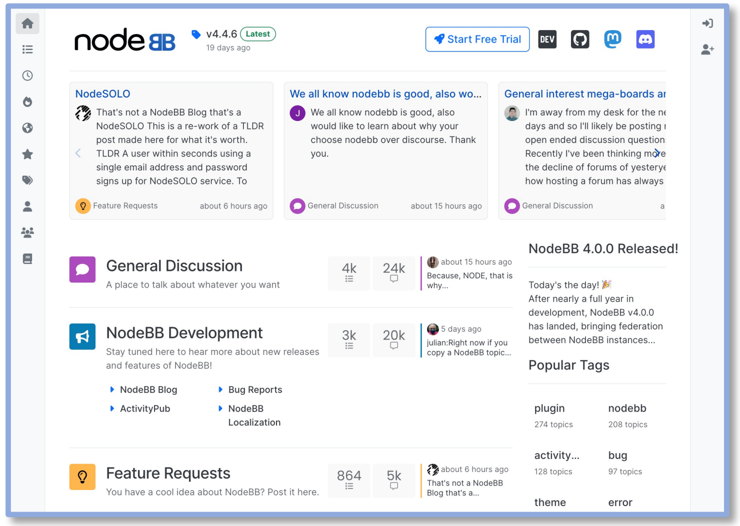
Threadiverse image posting janky
#13583 · julianlam opened 2 weeks ago 1

Reply received isn't 1b12 federated out
#13572 · julianlam opened last month

Usernames with only - and . produces unusable slug bug
#13543 · 3ldor opened on Jul 10 1

Properly backfill from f228 activity-based implementors activitypub
Feature #13532 · julianlam opened on Jul 4

Slugify does not support Vietnamese characters well bug
#13531 · dvchd opened on Jul 4 2



NodeSOLO
That's not a NodeBB Blog that's a NodeSOLO This is a re-work of a TLDR post made here for what it's worth. TLDR A user within seconds using a single email address and password signs up for NodeSOLO service. To
Feature Requests about 6 hours ago

We all know nodebb is good, also wo…
We all know nodebb is good, also would like to learn about why your choose nodebb over discourse. Thank you.
General Discussion about 15 hours ago

General interest mega-boards ar
I'm away from my desk for the ne days and so I'll likely be posting open ended discussion question Recently I've been thinking more the decline of forums of yesterye how hosting a forum has always
General Discussion a

General Discussion
A place to talk about whatever you want
4k 24k
about 15 hours ago
Because, NODE, that is why…

NodeBB Development
Stay tuned here to hear more about new releases and features of NodeBB!
3k 20k
5 days ago
julian:Right now if you copy a NodeBB topic…
NodeBB Blog
Bug Reports
ActivityPub
NodeBB Localization

Feature Requests
You have a cool idea about NodeBB? Post it here.
864 5k
about 6 hours ago
That's not a NodeBB Blog that's a…

NodeBB 4.0.0 Released!
Today's the day! 🎉
After nearly a full year in development, NodeBB v4.0.0 has landed, bringing federation between NodeBB instances…

Popular Tags
plugin 274 topics
nodebb 208 topics
activity… 128 topics
bug 97 topics
theme
error

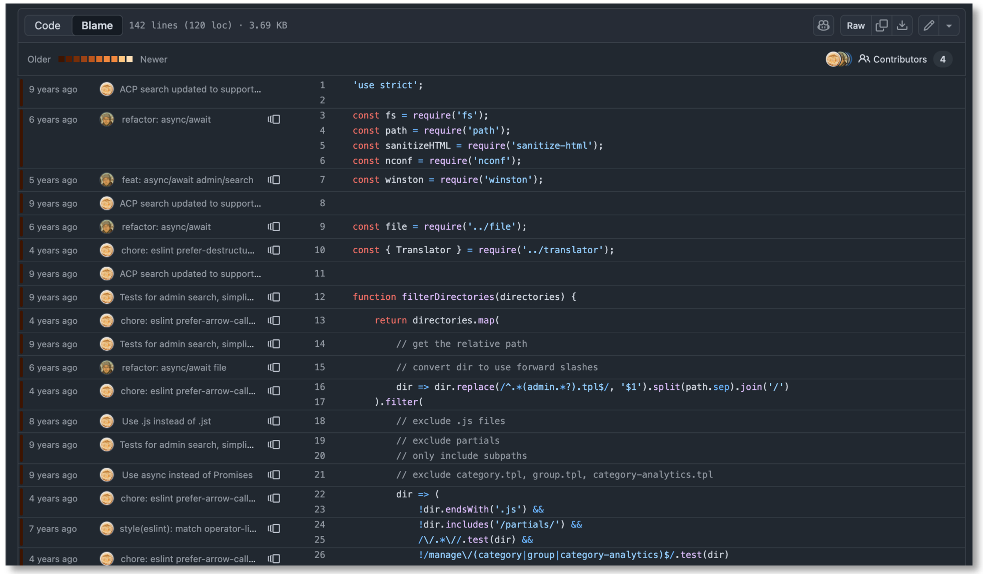
Tip: Use AI to explain parts of the code — but be careful

- Used carefully, AI tools can help you quickly tackle new codebases
- These tools fail confidently; expect errors and omissions, and cross-check against code, docs, and tests before trusting results.

- We will have a **whole lecture** on this new, emerging skill later in the course — for now, **experiment with AI**, **but don’t rely on it**

Tip: Look at file structure, ownership, and history

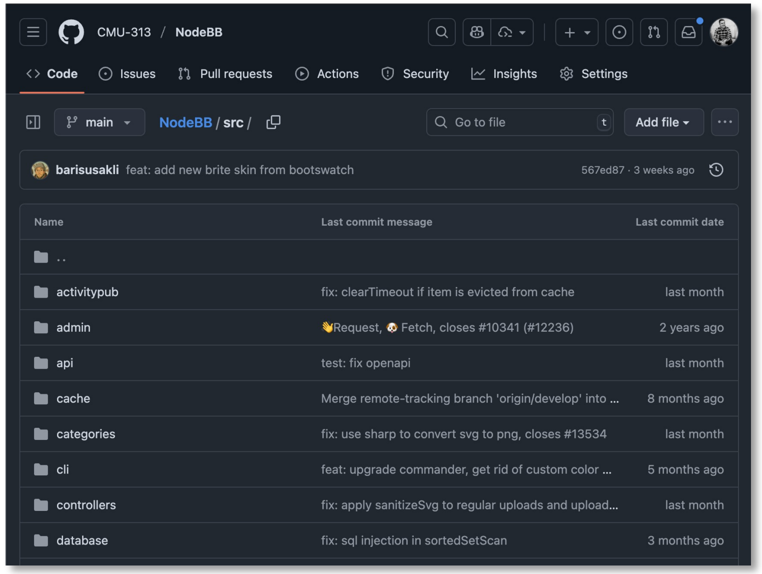
- Files are not randomly named and organized. Directory structures and naming conventions reveal patterns.
- Inspect history to learn ownership and stability: identify contributors, recency of changes, and churn. Treat stale or recently rewritten files with caution.



142 lines (120 loc) · 3.69 KB

```
9 years ago  ACP search updated to support...       'use strict';

6 years ago  refactor: async/await                   const fs = require('fs');
                                                     const path = require('path');
                                                     const sanitizeHTML = require('sanitize-html');
                                                     const nconf = require('nconf');
5 years ago  feat: async/await admin/search          const winston = require('winston');
9 years ago  ACP search updated to support...
6 years ago  refactor: async/await                   const file = require('../file');
4 years ago  chore: eslint prefer-destructu...       const { Translator } = require('../translator');
9 years ago  ACP search updated to support...
9 years ago  Tests for admin search, simpli...       function filterDirectories(directories) {
4 years ago  chore: eslint prefer-arrow-call...          return directories.map(
9 years ago  Tests for admin search, simpli...              // get the relative path
6 years ago  refactor: async/await file                     // convert dir to use forward slashes
4 years ago  chore: eslint prefer-arrow-call...             dir => dir.replace(/^.*(admin.*?).tpl$/, '$1').split(path.sep).join('/')
                                                         ).filter(
8 years ago  Use .js instead of .jst                        // exclude .js files
9 years ago  Tests for admin search, simpli...              // exclude partials
                                                            // only include subpaths
9 years ago  Use async instead of Promises                  // exclude category.tpl, group.tpl, category-analytics.tpl
4 years ago  chore: eslint prefer-arrow-call...             dir => (
                                                                !dir.endsWith('.js') &&
7 years ago  style(eslint): match operator-li...               !dir.includes('/partials/') &&
                                                                /\/.*\//.test(dir) &&
4 years ago  chore: eslint prefer-arrow-call...                 !/manage\/(category|group|category-analytics)$/.test(dir)
```



barisusakli feat: add new brite skin from bootswatch 567ed87 · 3 weeks ago

Name	Last commit message	Last commit date
..		
activitypub	fix: clearTimeout if item is evicted from cache	last month
admin	👋Request, 🐶 Fetch, closes #10341 (#12236)	2 years ago
api	test: fix openapi	last month
cache	Merge remote-tracking branch 'origin/develop' into ...	8 months ago
categories	fix: use sharp to convert svg to png, closes #13534	last month
cli	feat: upgrade commander, get rid of custom color ...	5 months ago
controllers	fix: apply sanitizeSvg to regular uploads and upload...	last month
database	fix: sql injection in sortedSetScan	3 months ago

How to build, test, and refine mental models

Examine
artifacts without running code

Probe
running system to observe behavior

Modify
code, rebuild, and assess impact

Probe to test your mental model

🧪 Hypothesis → Experiment

- Introduce a probe to observe the system at a given seam or entry point
- Use the observed behavior to confirm or refute your hypothesis
- Gradually build confidence in your understanding of system behavior
- **Example:**
  When I click X, handler Y runs
  → Set a breakpoint in Y then trigger X

🔬 Probes & Triggers

- Add breakpoints, logpoints, and step
- Logging: ./nodebb dev
- Print statements
- Bruno / Postman / curl / httpie
- Database viewers

🏆 Goal

- One confirmed or refuted hypothesis
- One short note (trigger → code path → signal)
- One next probe or modification

Tip: Instrument the source code

- **Print debugging**

```
console.log('Administrator found, skipping Admin setup');
```

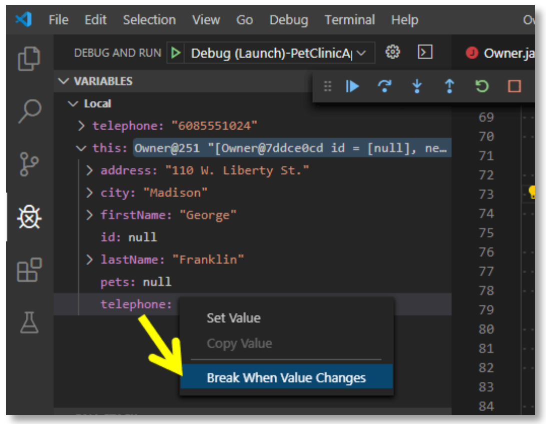
  - Quick and easy
  - Cons: need to rebuild + restart; easy to commit by accident

- **Structured logging**

```
winston.warn(`Flooding detected! Calls : ${socket.callsPerSecond}, Duration : ${socket.elapsedTime}`);
```

  - Add levels, timestamps, and context; better for collecting data in deployment
  - Cons: need to rebuild + restart

- **Debuggers**
  - Inspect locals, call stack, evaluate expressions
  - Add breakpoints as you go; no need to rebuild + restart
  - No changes to the code means no risk of accidental changes
  - We will explore the debugger in more depth later in the course



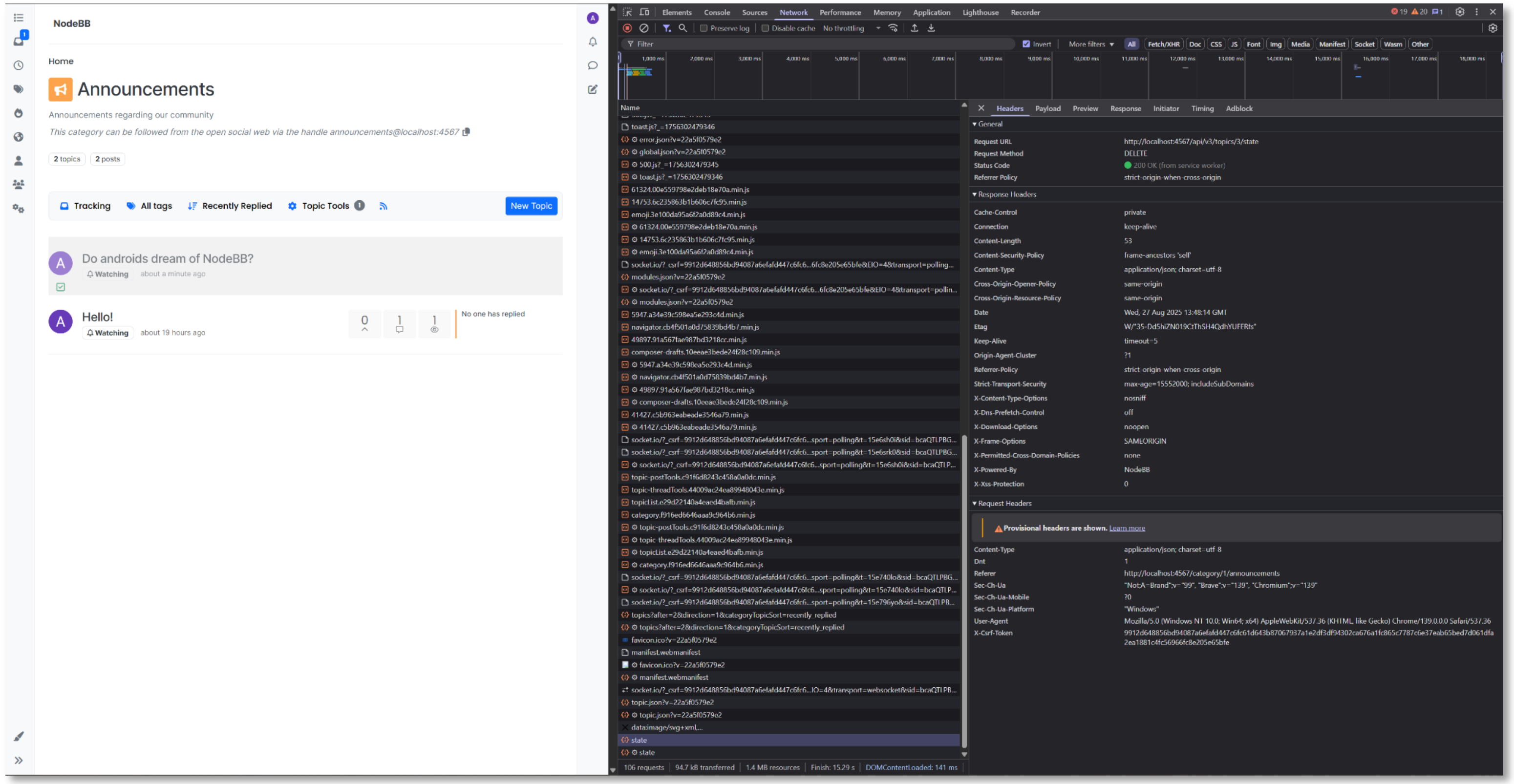
```
telephone: "6085551024"
this: Owner@251 "[Owner@7ddce0cd id = [null], ne…
  address: "110 W. Liberty St."
  city: "Madison"
  firstName: "George"
  id: null
  lastName: "Franklin"
  pets: null
  telephone:
```

Tip: Use developer tools in the browser to spy on traffic

- Spy on web traffic while you use the app

- Chrome DevTools (also used by Brave)
- Firefox Dev Tools
- Safari Web Inspector

- **Bonus:** Use Bruno, Postman, httpie, or curl to trigger API requests



Announcements

Announcements regarding our community

This category can be followed from the open social web via the handle announcements@localhost:4567

2 topics · 2 posts

Do androids dream of NodeBB? — Watching — about a minute ago

Hello! — Watching — about 19 hours ago — 0 · 1 · 1 — No one has replied

```
Name
toast.js?_=1756302479346
error.json?v=22a5f0579e2
global.json?v=22a5f0579e2
500.js?_=1756302479345
toast.js?_=1756302479346
61324.00e559798e2deb18e70a.min.js
14753.6c235863b1b606c7fc95.min.js
emoji.3e100da95a6f2a0d89c4.min.js
61324.00e559798e2deb18e70a.min.js
14753.6c235863b1b606c7fc95.min.js
emoji.3e100da95a6f2a0d89c4.min.js
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...6fc8e205e65bfe&EIO=4&transport=polling...
modules.json?v=22a5f0579e2
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...6fc8e205e65bfe&EIO=4&transport=pollin...
modules.json?v=22a5f0579e2
5947.a34e39c598ea5e293c4d.min.js
navigator.cb4f501a0d75839bd4b7.min.js
49897.91a567fae987bd3218cc.min.js
composer-drafts.10eeae3bede24f28c109.min.js
5947.a34e39c598ea5e293c4d.min.js
navigator.cb4f501a0d75839bd4b7.min.js
49897.91a567fae987bd3218cc.min.js
composer-drafts.10eeae3bede24f28c109.min.js
41427.c5b963eabeade3546a79.min.js
41427.c5b963eabeade3546a79.min.js
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e6sh0i&sid=bcaQTLPBG...
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e6srk0&sid=bcaQTLPBG...
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e6sh0i&sid=bcaQTLP...
topic-postTools.c91f6d8243c458a0a0dc.min.js
topic-threadTools.44009ac24ea89948043e.min.js
topicList.e29d22140a4eaed4bafb.min.js
category.f916ed6646aaa9c964b6.min.js
topic-postTools.c91f6d8243c458a0a0dc.min.js
topic-threadTools.44009ac24ea89948043e.min.js
topicList.e29d22140a4eaed4bafb.min.js
category.f916ed6646aaa9c964b6.min.js
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e740lo&sid=bcaQTLPBG...
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e740lo&sid=bcaQTLP...
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...sport=polling&t=15e796yo&sid=bcaQTLPB...
topics?after=2&direction=1&categoryTopicSort=recently_replied
topics?after=2&direction=1&categoryTopicSort=recently_replied
favicon.ico?v=22a5f0579e2
manifest.webmanifest
favicon.ico?v=22a5f0579e2
manifest.webmanifest
socket.io/?_csrf=9912d648856bd94087a6efafd447c6fc6...IO=4&transport=websocket&sid=bcaQTLPB...
topic.json?v=22a5f0579e2
topic.json?v=22a5f0579e2
data:image/svg+xml,...
state
state

106 requests | 94.7 kB transferred | 1.4 MB resources | Finish: 15.29 s | DOMContentLoaded: 141 ms
```

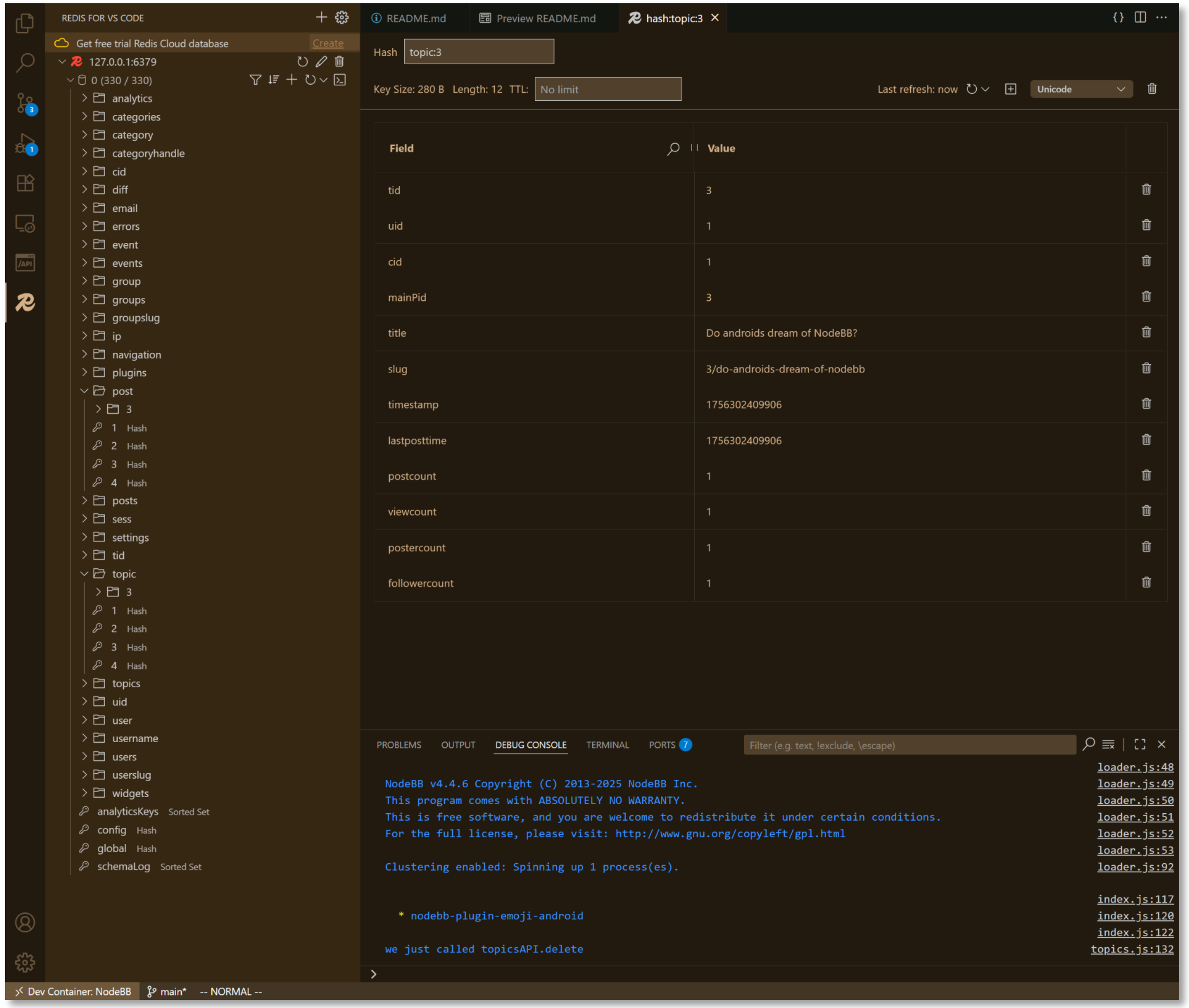
```
▼ General
Request URL                       http://localhost:4567/api/v3/topics/3/state
Request Method                    DELETE
Status Code                       200 OK (from service worker)
Referrer Policy                   strict-origin-when-cross-origin

▼ Response Headers
Cache-Control                     private
Connection                        keep-alive
Content-Length                    53
Content-Security-Policy           frame-ancestors 'self'
Content-Type                      application/json; charset=utf-8
Cross-Origin-Opener-Policy        same-origin
Cross-Origin-Resource-Policy      same-origin
Date                              Wed, 27 Aug 2025 13:48:14 GMT
Etag                              W/"35-Dd5hiZN019CtThSH4QdhYUFERfs"
Keep-Alive                        timeout=5
Origin-Agent-Cluster              ?1
Referrer-Policy                   strict-origin-when-cross-origin
Strict-Transport-Security         max-age=15552000; includeSubDomains
X-Content-Type-Options            nosniff
X-Dns-Prefetch-Control            off
X-Download-Options                noopen
X-Frame-Options                   SAMEORIGIN
X-Permitted-Cross-Domain-Policies none
X-Powered-By                      NodeBB
X-Xss-Protection                  0

▼ Request Headers
Provisional headers are shown. Learn more
Content-Type                      application/json; charset=utf-8
Dnt                               1
Referer                           http://localhost:4567/category/1/announcements
Sec-Ch-Ua                         "Not;A=Brand";v="99", "Brave";v="139", "Chromium";v="139"
Sec-Ch-Ua-Mobile                  ?0
Sec-Ch-Ua-Platform                "Windows"
User-Agent                        Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/139.0.0.0 Safari/537.36
X-Csrf-Token                      9912d648856bd94087a6efafd447c6fc61d643b87067937a1e2df3df94302ca676a1fc865c7787c6e37eab65bed7d061dfa
                                  2ea1881c4fc56966fc8e205e65bfe
```

Tip: Peek at the database

- Use the **Redis extension** that's provided with the DevContainer
- Perform an action (e.g., create or delete a topic) and watch which keys / fields change
    - filter by **prefix** to keep things manageable (topic:*, post:*, user:*)
- Use to confirm or refute your hypotheses about data flow



```
127.0.0.1:6379
  0 (330 / 330)
    analytics
    categories
    category
    categoryhandle
    cid
    diff
    email
    errors
    event
    events
    group
    groups
    groupslug
    ip
    navigation
    plugins
    post
      3
      1  Hash
      2  Hash
      3  Hash
      4  Hash
    posts
    sess
    settings
    tid
    topic
      3
      1  Hash
      2  Hash
      3  Hash
      4  Hash
    topics
    uid
    user
    username
    users
    userslug
    widgets
    analyticsKeys  Sorted Set
    config  Hash
    global  Hash
    schemaLog  Sorted Set
```

Hash: topic:3

Key Size: 280 B Length: 12 TTL: No limit   Last refresh: now   Unicode

Field	Value
tid	3
uid	1
cid	1
mainPid	3
title	Do androids dream of NodeBB?
slug	3/do-androids-dream-of-nodebb
timestamp	1756302409906
lastposttime	1756302409906
postcount	1
viewcount	1
postercount	1
followercount	1

```
                                                                                         loader.js:48
NodeBB v4.4.6 Copyright (C) 2013-2025 NodeBB Inc.                                        loader.js:49
This program comes with ABSOLUTELY NO WARRANTY.                                          loader.js:50
This is free software, and you are welcome to redistribute it under certain conditions. loader.js:51
For the full license, please visit: http://www.gnu.org/copyleft/gpl.html                loader.js:52
                                                                                         loader.js:53
Clustering enabled: Spinning up 1 process(es).                                           loader.js:92

                                                                                         index.js:117
  * nodebb-plugin-emoji-android                                                          index.js:120
                                                                                         index.js:122
we just called topicsAPI.delete                                                          topics.js:132
>
```

How to build, test, and refine mental models

Examine
artifacts without running code

Probe
running system to observe behavior

Modify
code, rebuild, and assess impact

Modify code to validate your model

🏗️ Plan and execute your change

- What **behavior** should change if your model is correct?
- What's the **simplest change** that you can make?
- What **signal** can you observe? (user interface, API, logs, database, test case)

- Rebuild the code and see what happens!
- Tip: **delete debugging** is a powerful tool

📈 Assess impact

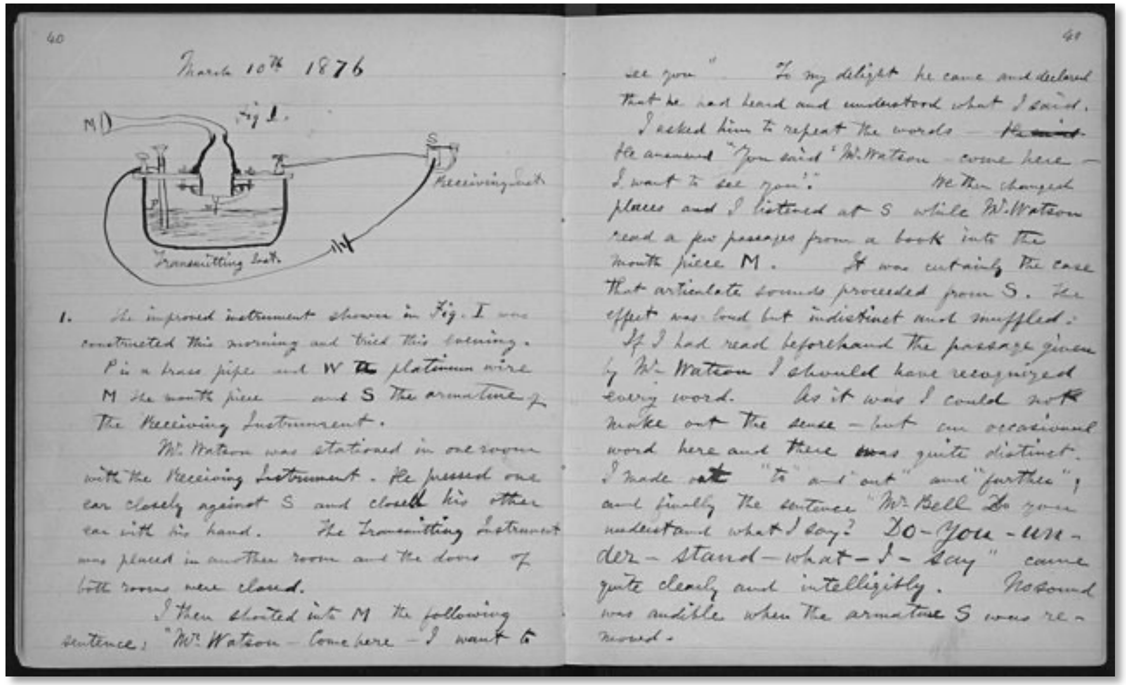
- Did the **predicted signal** change?
- If yes, your model **holds** for now.
- If not, you need to **revise** it.

🏆 Goal

- One change with a clear effect
- A note of what it confirms or refutes
- A next step (examine, probe, modify)

Document and share your findings!

- Update README and docs
  - Or better: use a **Developer Wiki**
  - Use Mermaid for diagrams
- Collaborate with others
  - use LiveShare to debug, explore, and program collaboratively
- Include negative results, too!



40

March 10th 1876

M
Fig 1.
S
Receiving Inst.
P
W
Transmitting Inst.

1. The improved instrument shown in Fig. I was constructed this morning and tried this evening.
P is a brass pipe and W the platinum wire M the mouth piece and S the armature of the Receiving Instrument.
Mr. Watson was stationed in one room with the Receiving Instrument. He pressed one ear closely against S and closed his other ear with his hand. The Transmitting Instrument was placed in another room and the doors of both rooms were closed.
I then shouted into M the following sentence: "Mr. Watson – Come here – I want to

41

see you." To my delight he came and declared that he had heard and understood what I said.
I asked him to repeat the words – ~~He said~~ He answered "You said 'Mr. Watson – come here – I want to see you.'" We then changed places and I listened at S while Mr. Watson read a few passages from a book into the mouth piece M. It was certainly the case that articulate sounds proceeded from S. The effect was loud but indistinct and muffled.
If I had read beforehand the passage given by Mr. Watson I should have recognized every word. As it was I could not make out the sense – but an occasional word here and there was quite distinct. I made out "to" and "out" and "further"; and finally the sentence "Mr. Bell Do you understand what I say? Do-you-un-der-stand-what-I-say" came quite clearly and intelligibly. No sound was audible when the armature S was removed.

Next Time: 737-MAX Case Study