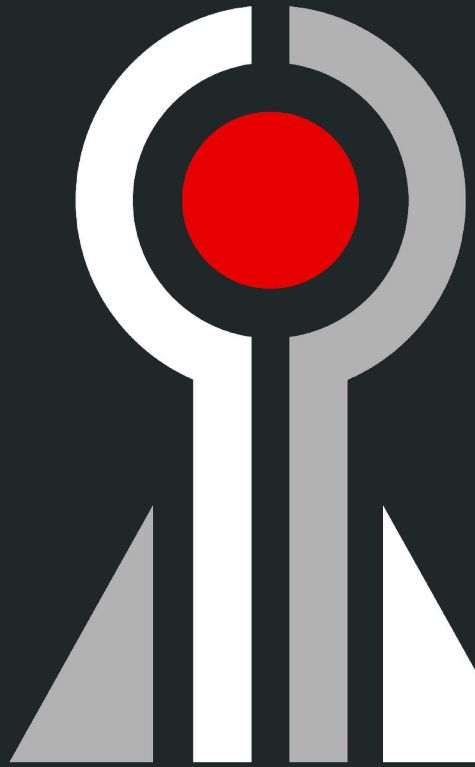
Hands On Secure Code Review

February 2020

Introductions - Seth

Once known as the “King of Cola”, he ruled the mighty Carbonators during the pre-century, west-coast Soda Wars. His rule was cut short when HFCS was outlawed by California and the sugar prohibition era began. He led the first manned mission to Mars via a hot air balloon. Without hot air. Or the balloon. He speaks 14 languages, 12 of them based on the science fiction show “Star Trek”, 1 he made up with his imaginary friend Sharzazzle, and really - really poor Ol’ Timey English.

@sethlaw



Redpoint Security

Overview

- Repeat after me:
  - Reviewing code is excellent!
  - Finding vulnerabilities is excellent!

Workshop Agenda

- Establish Groups
- Pick a project
- Discuss Approach
  - Template - Follow the framework approach
  - App Overview/Info Gathering
  - Build Checklists
- Find Some Bugs!

Philosophy

- Increase the likelihood of success.
  Not “find every bug imaginable”.
- Language Agnostic Methodology
- Repeatable process

Let’s talk about approach

Several types of reviews:

- You decide how much time you spend on the review (ideal world)
- You have no time at all (real world)
- Consulting middleground where you have a set time and scoped (hopefully) well or at least semi “okay”

NONE OF THESE TYPES MEAN “RUN A SCANNER AND ANALYZE THE RESULTS”

First, let’s talk about what we’re doing here

This course is intended to do the following, at a high level:

1. Learn where to look - Source to Sink
2. Learn what to look for, examples:
    a. AuthZ/AuthN
    b. Vulns specific to the type of app
    c. General/OWASP AppSec vulns
3. Show where automation fits in the source code review process
4. Show some validation and remediation of the issues

Also, let’s talk about what we aren’t doing

This course is not intended to:

1. Teach you the OWASP Top 10
2. Review web vulnerabilities
3. Cover techniques for finding vulnerabilities in running applications
4. Be a primer on building secure applications
5. Cover all the ways that vulnerabilities manifest in code.

Get to know each other

- Form a group (3-4)
- Decide on an open-source project
- Download the project, open in IDE

Possible Open-Source Projects

- https://github.com/zactly/handouts - templates
- https://github.com/IMA-WorldHealth/bhima - Node App
- https://github.com/JD-Software/JDeSurvey - Java App
- https://github.com/pglombardo/PasswordPusher - Ruby
- https://github.com/electerious/Lychee - PHP

OWASP

- How does the OWASP Top 10 relate?
- What resources does OWASP provide?
- How does this course differ from the OWASP Code Review Methodology?

Secure Code Review Methodology

Overview

Secure Code Review Methodology

1. Application Overview & Risk Assessment
2. Information Gathering
3. Checklist Creation
4. Perform Reviews

Checklists/Reviews

- Authorization
- Authentication
- Auditing
- Injection
- Cryptography
- Configuration

The Circle-K Framework

1. Open a file, take notes :-)
2. Get to know the application purpose
3. Map the application
4. Brainstorm risks to the application
5. **Build list of review items**
6. Perform reviews
7. Double back (3-6)

General Principles

- Give yourself adequate time
- Work in small chunks
- Stay on task with current objective
- Don’t make it personal
- Ask questions
- Framework/Code documentation is your friend
- Build the code
- Run the tests

Focus on what's important

NOTE TAKING

NOTE TAKING

- Typical Format
  - Commit #
  - Action Findings
  - Notes from Review
- Findings at the end
  - Description / Recommendation
  - Optional (or not) - Impact/Risk
  - Links to the code in question and/or screenshots
  - Reproduction steps if possible

- Review Notes
  a. App Overview
  b. Brainstorming/Risks
     i. PAIR WITH OTHERS!!
  c. Route Mapping
  d. Checklist of items based on the threat model but also normal “things”

Note Taking - Example

We assessed commit `#74e64e1ccb617c83ba1db4cbbb24a33051e169f8`

Notes for you/your team

Behavior

- What does it do? (business purpose)

  Task Manager

- Who does it do this for? (internal / external customer base)

  Internal Employees & External Customers

- What kind of information will it hold?

  Tasks, Notes, Projects.. could be sensitive Date of Birth of users

Brainstorming / Risks

- XSS - notes, projects and tasks
- Appears to use MD5 for passwords?
- TM employees using the product for managing their own products... ramific
- noticed file uploads for profile pics - file access/handling
- What if sensitive pics are uploaded to the projects - CONFIRMED THAT PR(
- Image processing... RCE? Something else like traversal/LFI/RFI?

Checklist of things to review based on Brainstorm

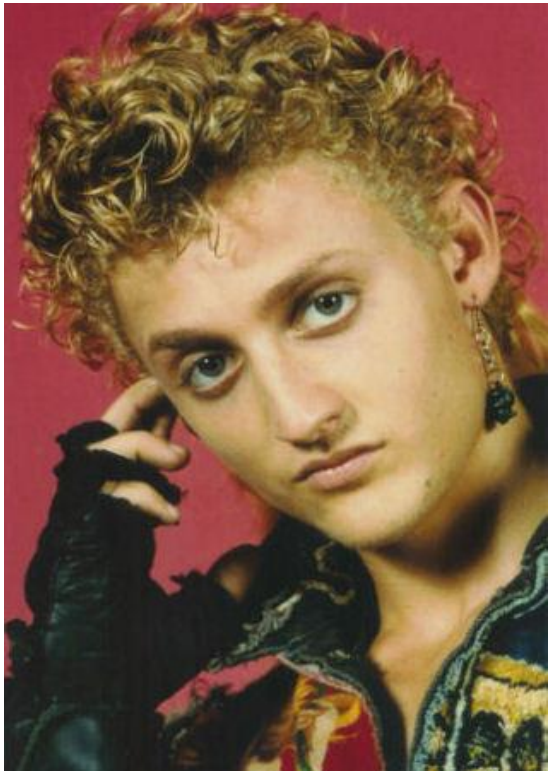
- [ ] Command Injection: system, call, popen, stdout, stderr, import os
- [ ] SQL Injection: raw, execute, select, where
- [ ] XSS: Autoescape, |safe, escapejs
  - [ ] Take a look at filenames and see if we render those unsafely anywhere
- [ ] File handling: `File` , `django.core.files`
- [x] CSRF on the password change?
- [ ] IDOR on Projects/Notes/Tasks/Profile

Application Overview & Risk Assessment

Application Overview & Risk Assessment

Build a portrait of the application

- Behavior Profile
- Technology Stack
- App Archeology
- Brainstorm Risks



Behavior Profiling

- What does it do? (business purpose)
- Who does it do this for? (internal / external customer base)
- What kind of information will it hold?
- What are the different types of roles?
- What aspects concern your client/customer/staff the most?

Technology Stack

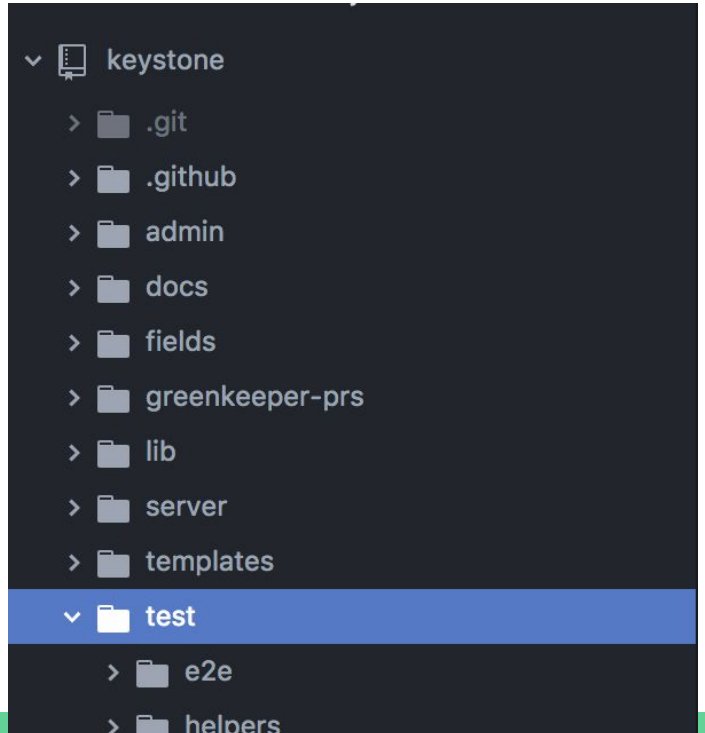
- Framework & Language - Rails/Ruby, Django/Python, mux/Golang
- 3rd party components, Examples:
  - Billing libraries (rubygem, npm, jar, etc.)
  - JavaScript widgets - (marketing tracking, sales chat widget)
  - Reliant upon other applications - such as receiving webhook events
- Datastore - Postgresql, MySQL, Memcache, Redis, Mongodb, etc.

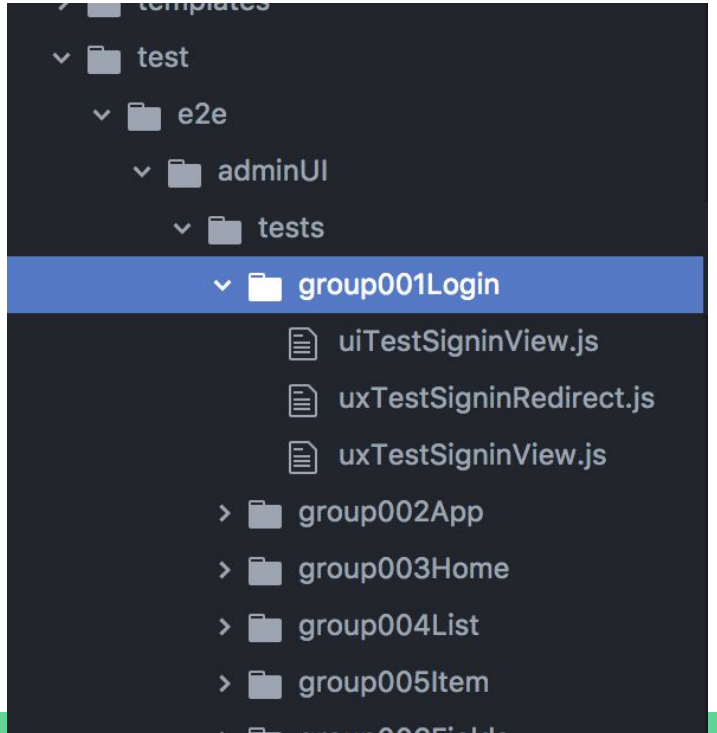
Application Archeology

- Look at the documentation. Examples:
  - Using SSO? SAML/OAuth?
  - What third-party elements does communicate with? (eg: external reporting, billing)
  - Custom authentication schemas - for instance - different auth for API versus web interface
- Git allows you to do a little spelunking
- Unit Tests
  - Learn about the data endpoints expect to receive
  - Learn about expected behavior
  - Often can find the way to form/craft a request

Application Overview

https://github.com/keystonejs/keystone





Application Overview & Risk Assessment

uxTestSigninRedirect.js

```
module.exports = {
  before: function (browser) {
    browser.adminUIApp = browser.page.adminUIApp();
    browser.adminUISigninScreen = browser.page.adminUISignin();

    browser.url(browser.adminUIApp.url + 'users');
    browser.adminUIApp.waitForSigninScreen();
    browser.assert.urlEquals(browser.adminUIApp.url + 'signin?from=/keystone/users');
  },
  after: function (browser) {
    browser.
      end();
  },
  'AdminUI should allow users to login and redirect to custom url': function (browser) {
    browser.adminUISigninScreen.signin({wait: false});
    browser.adminUIApp.waitForListScreen();
    browser.assert.urlEquals(browser.adminUIApp.url + 'users');
  },
};

```

Risk Assessment

- Use the initial data about the app to perform a “mini” threat model
- Think about application concerns based on the application purpose, technology stack, and archeology.
- If possible, get someone else’s opinion of relevant risks.

Application Overview & Risk Assessment

Exercise Napoleon

1. Start a secure code review of ~/code/bhima
    a. Tech Stack
    b. Business Purpose
    c. Application Archeology
    d. Risk Assessment

Napoleon Exercise - Post-Mortem

At a minimum, these items were of note:

- Business Purpose
  - Basic Hospital Information Management Application
- Tech Stack
  - Node.js / Express
  - Angular
  - MySQL/Redis
- Documentation
  - https://github.com/IMA-WorldHealth/bhima/wiki
  - https://docs.bhi.ma/en/
- Risks
  - Patient Data
  - Employee Payroll Information

Napoleon Exercise - Post-Mortem

Other security important parts of the app:

- Express Configuration -
  - server/config/express.js
  - Uses default helmet.js
- User Authentication
  - server/controllers/auth.js
- Admin folder
  - Logic for admin logins - server/controllers/admin/users/index.js

Information Gathering

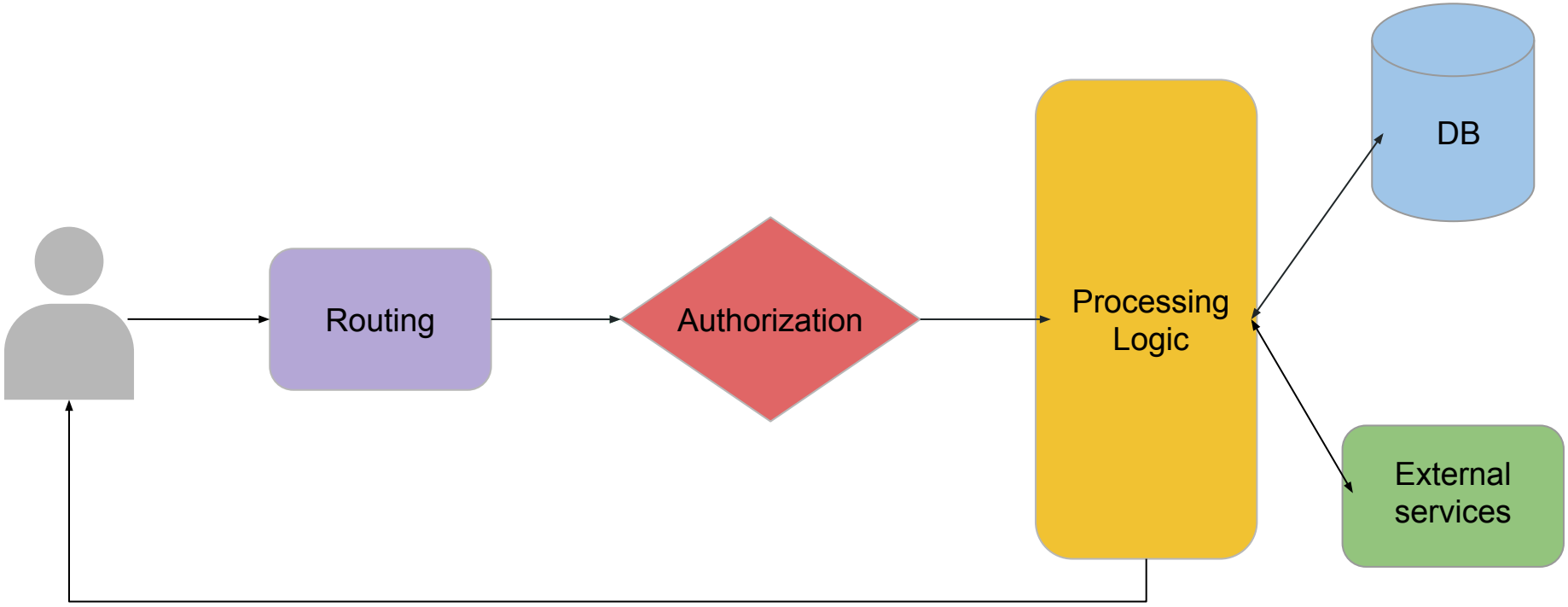
Information Gathering

1. Create Application Map
2. Identify Authorization Functions

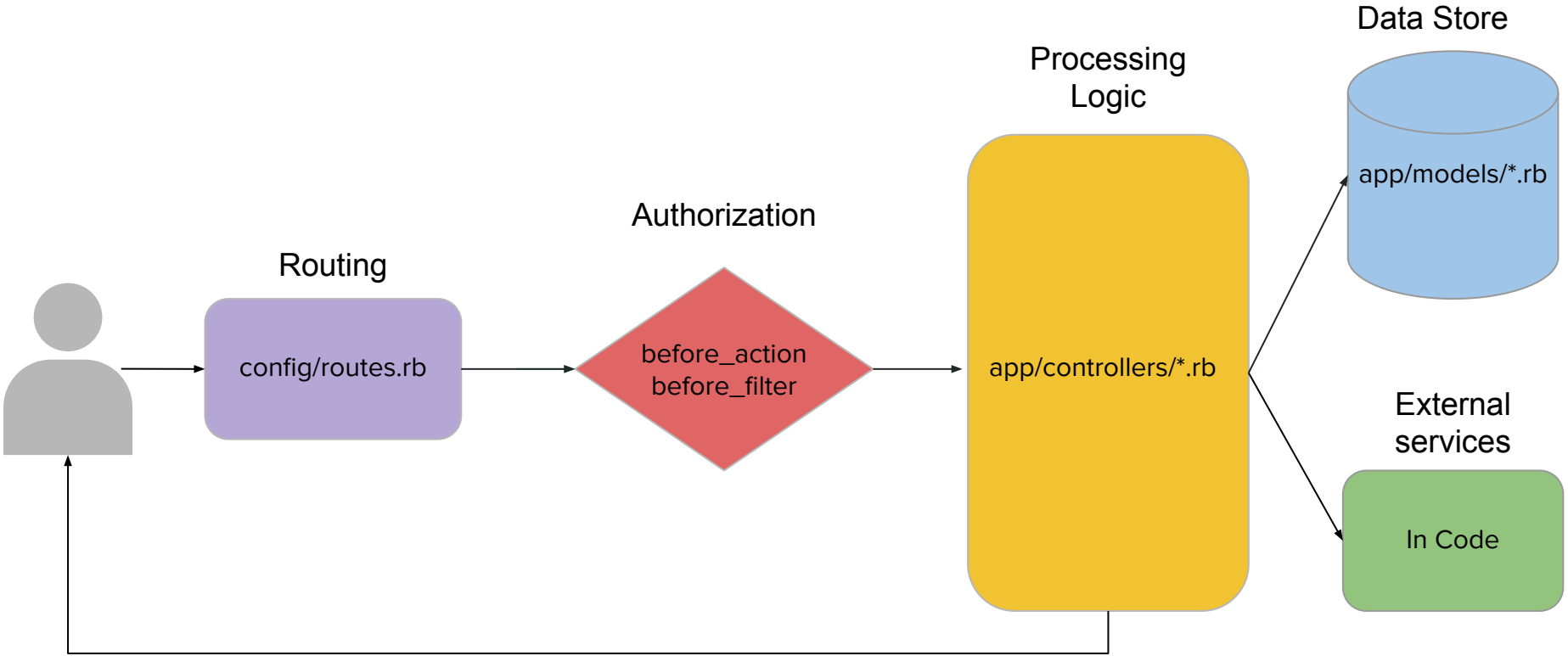
Mapping

Information Gathering - Application Map

- Identify endpoints, typical examples:
  - Rails = config/routes.rb - `rake routes`
  - Django= urls.py - `manage show_urls`
  - Node.js = index.js
  - Java Spring = *Controller.java
  - .Net Core = *Controller.cs
- Endpoints typically have at least three qualities
  - Authorization Filter
  - Logic processing
  - Datastore access



Typical Application Flow



Rails Application Flow

Rails - Map

- Run “rake routes” if you can!

1. cktricky@Kens-MacBook-Pro: ~/code/railsgoat (zsh)

```
cktricky@Kens-MacBook-Pro ~/code/railsgoat master rake routes
                  Prefix Verb   URI Pattern                                       Controller#Action
                   login GET    /login(.:format)                                  sessions#new
                  signup GET    /signup(.:format)                                 users#new
                  logout GET    /logout(.:format)                                 sessions#destroy
         forgot_password GET    /forgot_password(.:format)                        password_resets#forgot_password
                         POST   /forgot_password(.:format)                        password_resets#send_forgot_password
         password_resets GET    /password_resets(.:format)                        password_resets#confirm_token
                         POST   /password_resets(.:format)                        password_resets#reset_password
           dashboard_doc GET    /dashboard/doc(.:format)                          dashboard#doc
                sessions GET    /sessions(.:format)                               sessions#index
                         POST   /sessions(.:format)                               sessions#create
             new_session GET    /sessions/new(.:format)                           sessions#new
            edit_session GET    /sessions/:id/edit(.:format)                      sessions#edit
                 session GET    /sessions/:id(.:format)                           sessions#show
                         PATCH  /sessions/:id(.:format)                           sessions#update
                         PUT    /sessions/:id(.:format)                           sessions#update
                         DELETE /sessions/:id(.:format)                           sessions#destroy
user_account_settings GET    /users/:user_id/account_settings(.:format)        users#account_settings
user_retirement_index GET    /users/:user_id/retirement(.:format)              retirement#index
```

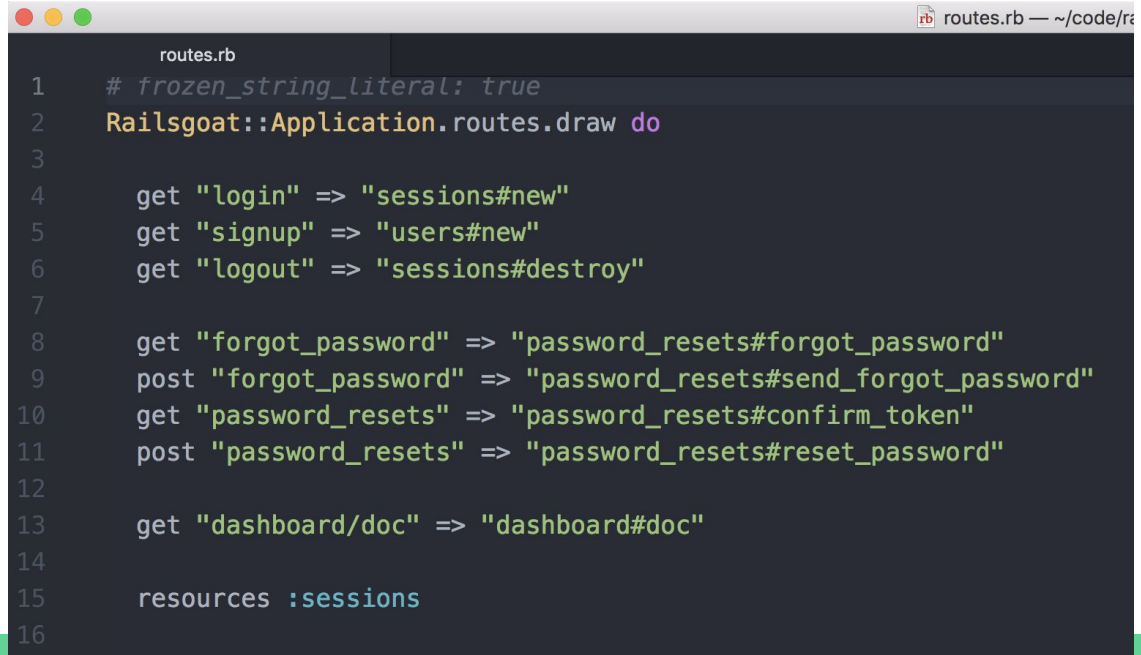
Rails - Map

```
forgot_password GET    /forgot_password(.:format)                password_resets#forgot_password
```

- Four parts
  - Path name (eg: forgot_password_path)
  - HTTP Verb (eg: GET)
  - HTTP Path (eg(s): forgot_password, forgot_password.json, forgot_password.xml)
  - Controller and Action (eg: Controller = password_resets, Action = forgot_password)

Rails - Map

- If you cannot run rake routes, you'll have to review the config/routes.rb file:

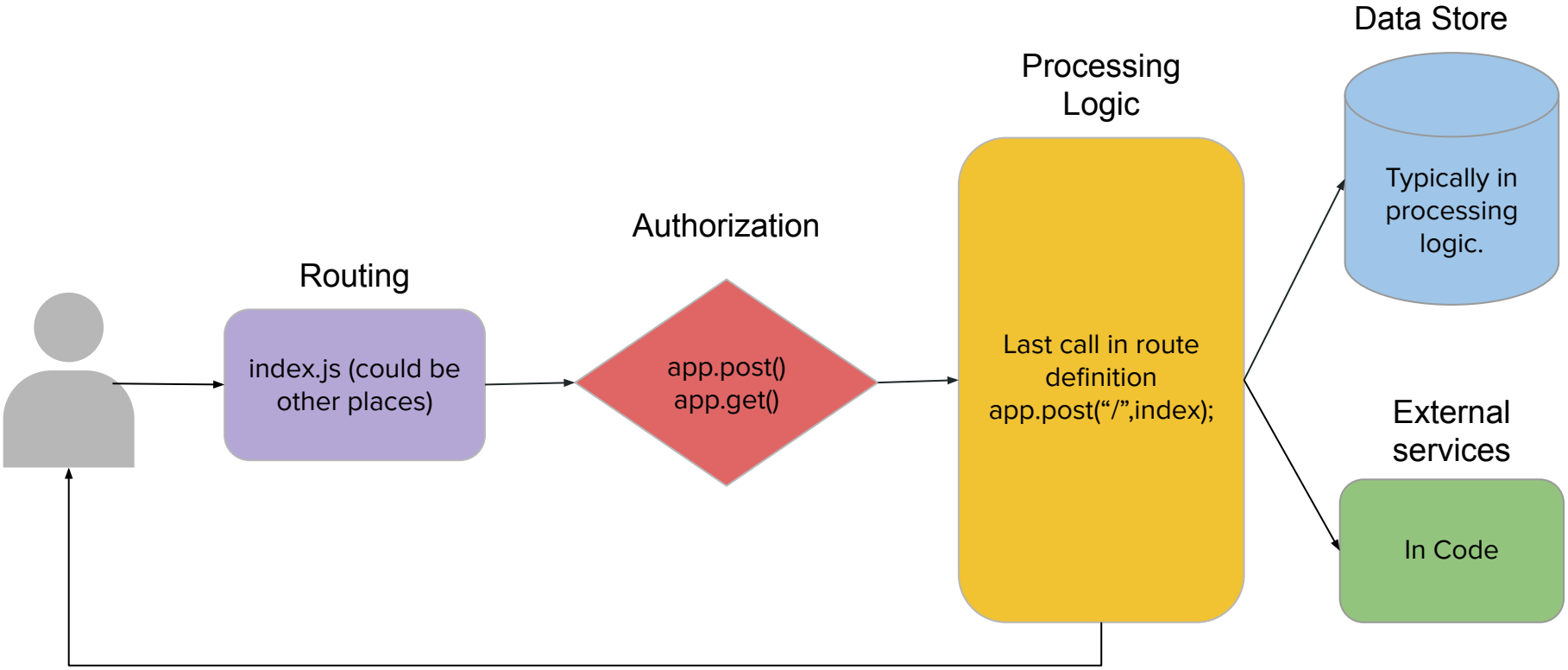


Rails - Routing Weirdness Alert

- What do PUT, PATCH, DELETE, and POST all have in common?
- That’s right, they are all POST requests
- Rails uses the _method parameter to determine what kind of request it is

Rails - Routing Weirdness Alert

```
POST /join HTTP/1.1
Host: github.com
User-Agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10.14; rv:66.0)
Gecko/20100101 Firefox/66.0
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Referer: https://github.com/join?source=header-home
Content-Type: application/x-www-form-urlencoded
Content-Length: 233
Connection: close
Cookie: logged_in=no
Upgrade-Insecure-Requests: 1

utf8=%E2%9C%93&authenticity_token=1YJBp5UZPnafW2qSy6GhEgg4ob05APDlMVUbmvLCCv
VqQS5JYA5cuVOcLWOS%2FDELy7z8J1AeH1TyxGCWojSxcw%3D%3D&user%5Blogin%5D=cktric
ky-example&user%5Bemail%5D=cktricky-example%40skea.com&user%5Bpassword%5D=d
olphin1&_method=patch
```



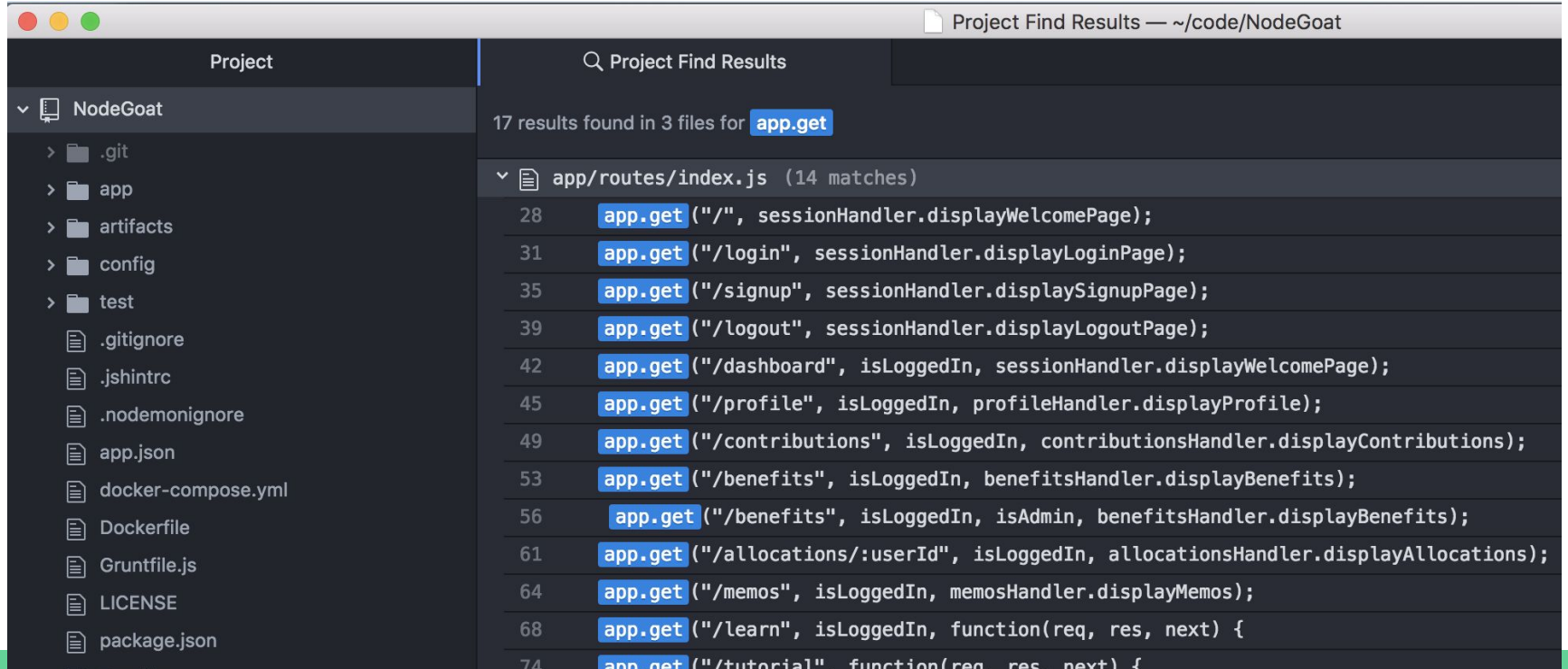
Node.js/Express Application Flow

Node.js/Express - Map

- Formula has been basic, searching for:
  - app.get
  - app.post
  - app.delete
- Annotate which of these is actually using authorization functions and middleware
- Create a checklist from the map for tracing

Node.js/Express - Map

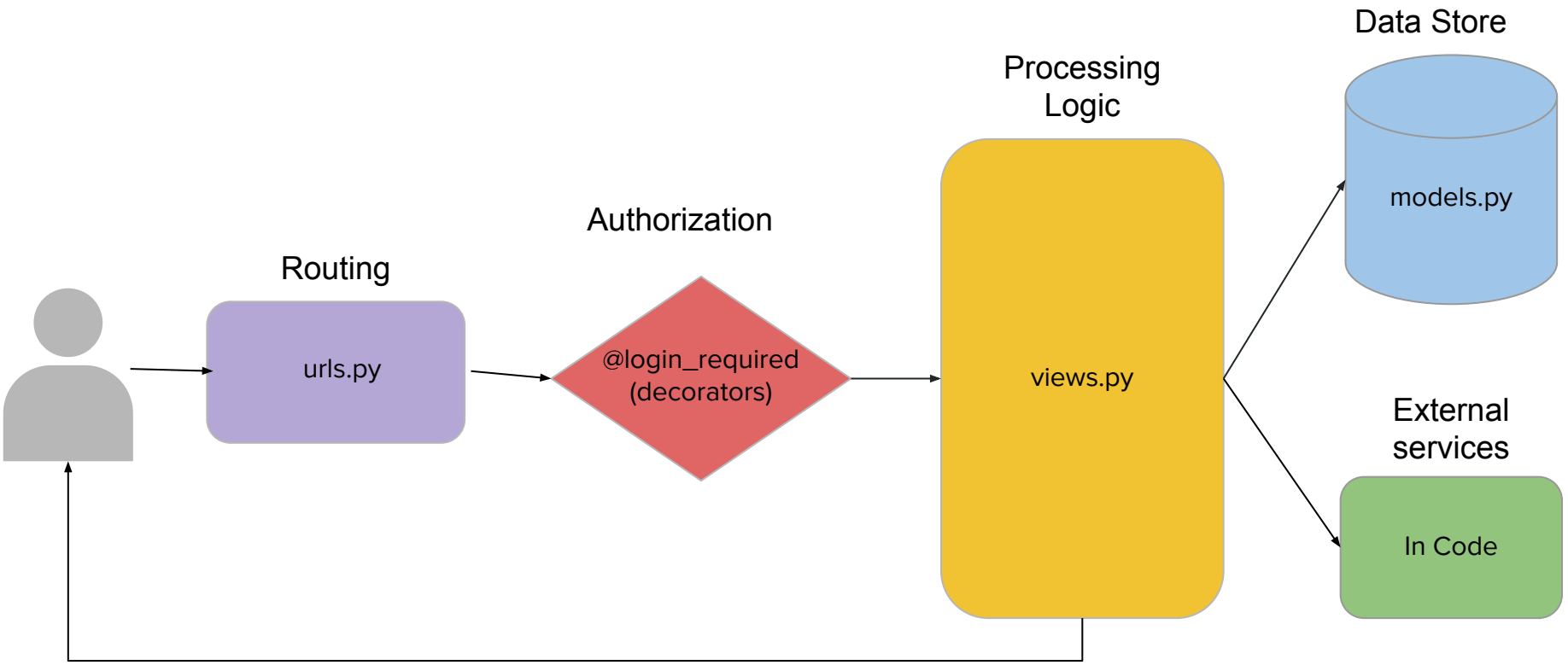
Here is an example from Nodegoat, I downloaded it, and searched for app.get



Node.js/Express - Map

Take a close looksie

```
app.get("/dashboard", isLoggedIn, sessionHandler.displayWelcomePage);
```



Django Application Flow

Django - Map

urls.py — ~/code/vtm

urls.py

```
1  # Vulnerable Task Manager
2
3  from django.conf.urls import include, url
4  from django.contrib import admin
5  from django.http import HttpResponseRedirect
6  from django.conf import settings
7  from django.views.defaults import page_not_found
8
9  from taskManager.views import index
10
11 urlpatterns = [
12     url(r'^$', index, name='index'),
13     url(r'^taskManager/', include(('taskManager.taskManager_urls','taskManager'), namespace="taskManager")),
14     url(r'^admin/', admin.site.urls ),
15    ]
16
```

Django - Map

taskManager_urls.py

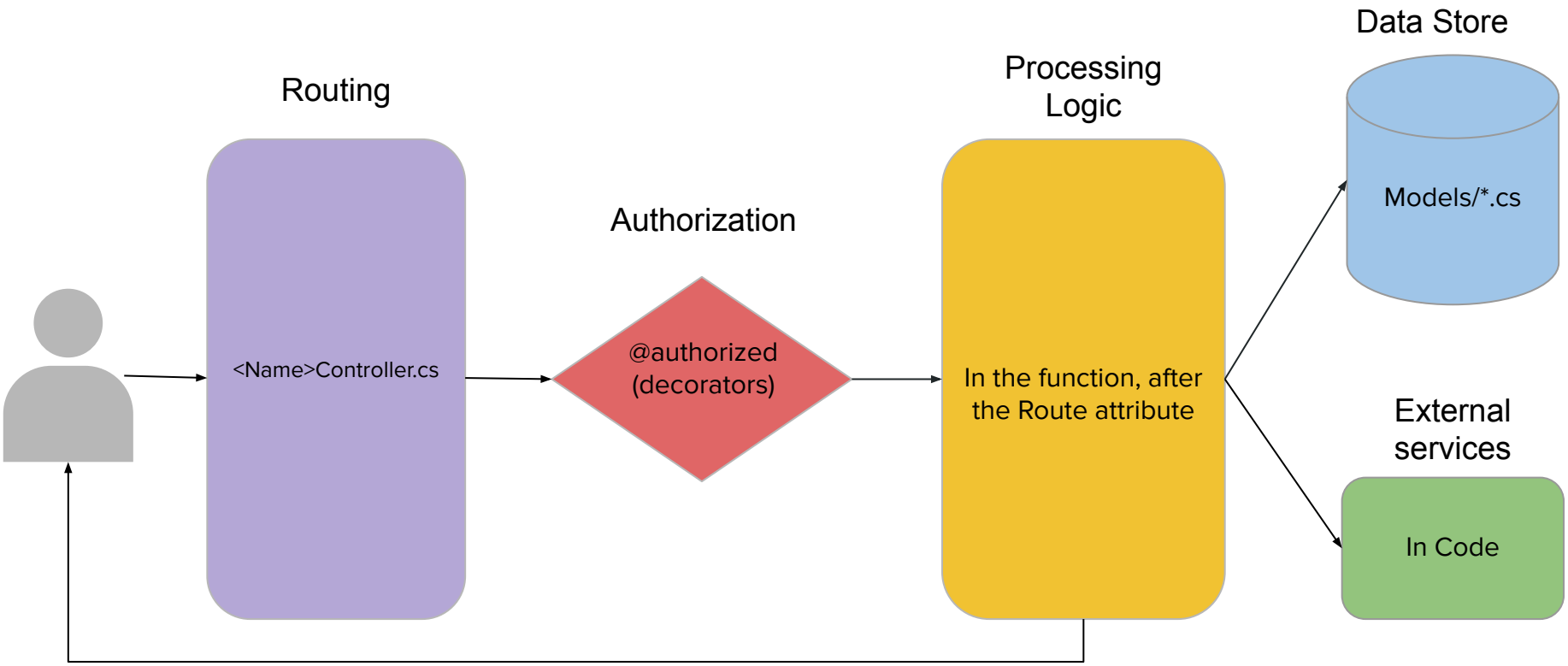
```
# Vulnerable Task Manager

from django.conf.urls import url

from taskManager import views

urlpatterns = [
                        url(r'^$', views.index, name='index'),

                        # User details
                        url(r'^view_all_users/$',
                            views.view_all_users, name='view_all_users'),

                        # File
                        url(r'^download/(?P<file_id>\d+)/$',
                            views.download, name='download'),
                        url(r'^(?P<project_id>\d+)/upload/$',
                            views.upload, name='upload'),
                        url(r'^downloadprofilepic/(?P<user_id>\d+)/$',
                            views.download_profile_pic, name='download_profile_pic'),
```

Django - Map

```
# User details
url(r'^view_all_users/$',
    views.view_all_users, name='view_all_users'),
```

Django - Map - `./manage.py show_urls`

```
/taskManager/<project_id>/task_edit/<task_id>   taskManager.views.task_edit     taskManager:task_edit
/taskManager/<project_id>/upload/       taskManager.views.upload        taskManager:upload
/taskManager/change_password/   taskManager.views.change_password      taskManager:change_password
/taskManager/dash.*     taskManager.views.dashboard     taskManager:dashboard
/taskManager/dashboard/ taskManager.views.dashboard     taskManager:dashboard
/taskManager/download/<file_id>/        taskManager.views.download      taskManager:download
/taskManager/downloadprofilepic/<user_id>/      taskManager.views.download_profile_pic  taskManager:do
wnload_profile_pic
/taskManager/forgot_password/   taskManager.views.forgot_password       taskManager:forgot_password
/taskManager/login/     taskManager.views.login taskManager:login
/taskManager/logout/    taskManager.views.logout_view   taskManager:logout
/taskManager/manage_groups/     taskManager.views.manage_groups taskManager:manage_groups
/taskManager/manage_projects/   taskManager.views.manage_projects       taskManager:manage_projects
/taskManager/ping/      taskManager.views.ping  taskManager:ping
/taskManager/profile/   taskManager.views.profile       taskManager:profile
/taskManager/profile/<user_id>  taskManager.views.profile_by_id taskManager:profile_by_id
/taskManager/profile_view/<user_id>     taskManager.views.profile_view  taskManager:profile_view
/taskManager/project_create/    taskManager.views.project_create        taskManager:project_create
/taskManager/project_list/      taskManager.views.project_list  taskManager:project_list
/taskManager/register/  taskManager.views.register      taskManager:register
/taskManager/reset_password/    taskManager.views.reset_password        taskManager:reset_password
/taskManager/search/    taskManager.views.search        taskManager:search
```



.Net Application Flow

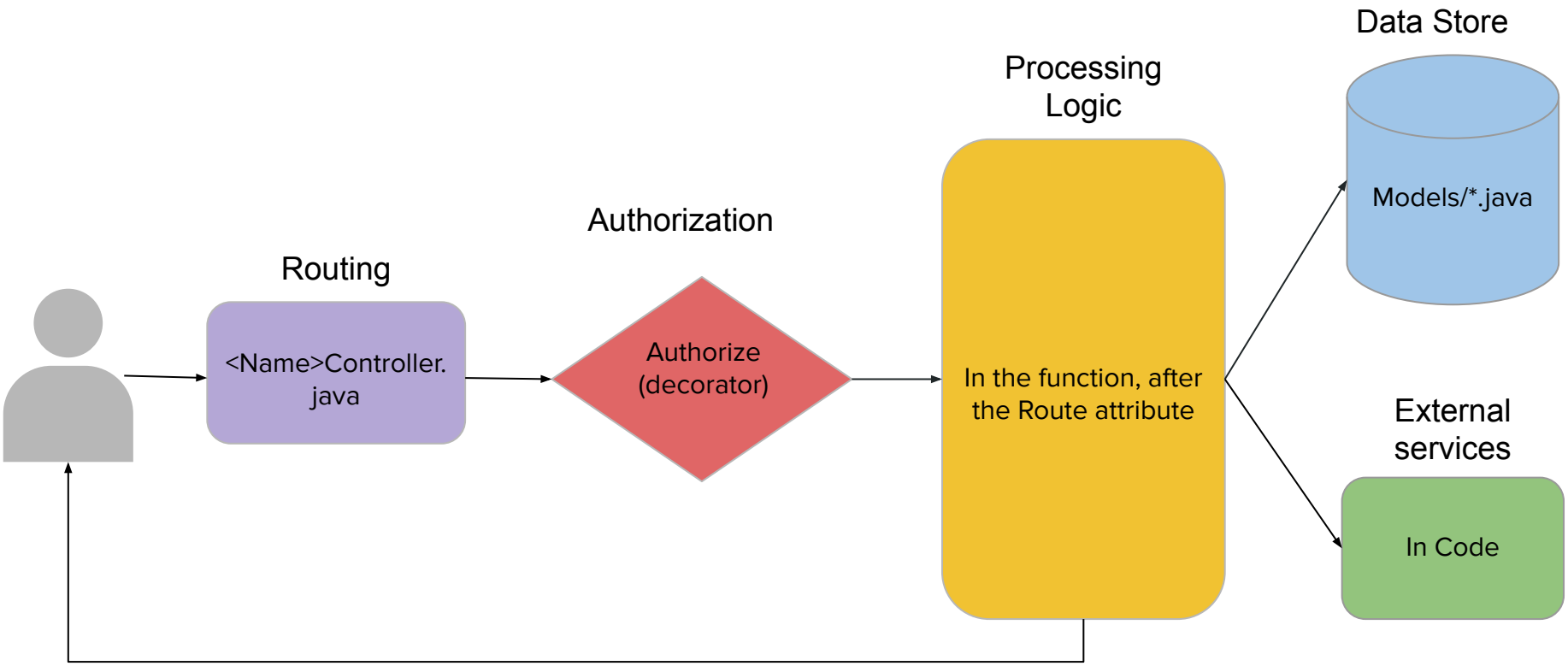
.NET Core - Map

AccountController.cs

```
1   using Microsoft.AspNetCore.Authentication;
2   using Microsoft.AspNetCore.Authentication.Cookies;
3   using Microsoft.AspNetCore.Authorization;
4   using Microsoft.AspNetCore.Mvc;
5   using Miniblog.Core.Models;
6   using System.Security.Claims;
7   using System.Threading.Tasks;
8   using Miniblog.Core.Services;
9
10  namespace Miniblog.Core.Controllers
11  {
12      [Authorize]
13      public class AccountController : Controller
14      {
```

.NET Core - Map

```
[Route("/login")]
[AllowAnonymous]
[HttpGet]
public IActionResult Login(string returnUrl = null)
{
    ViewData["ReturnUrl"] = returnUrl;
    return View();
}

[Route("/login")]
[HttpPost, AllowAnonymous, ValidateAntiForgeryToken]
public async Task<IActionResult> LoginAsync(string returnUrl, LoginViewModel
```

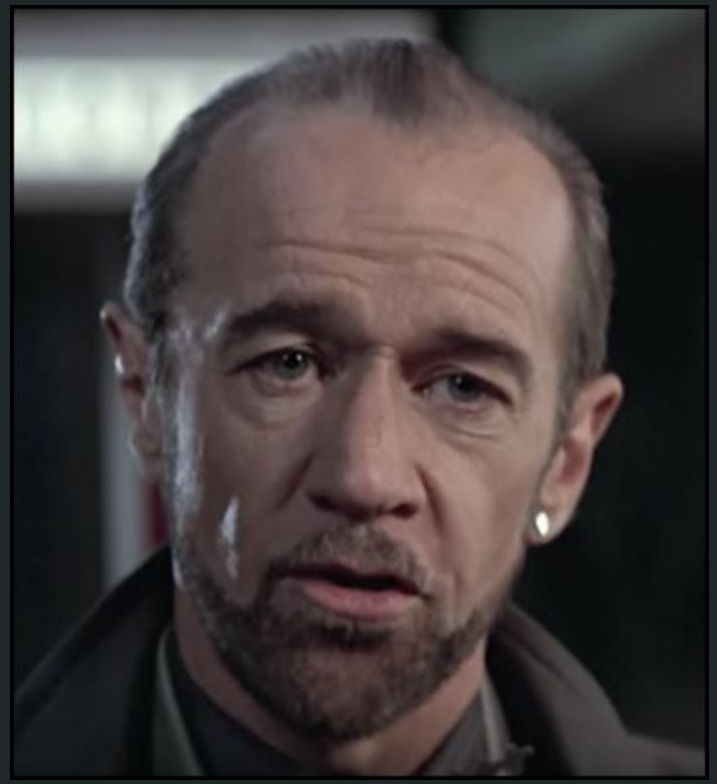


Java Application Flow

Mapping

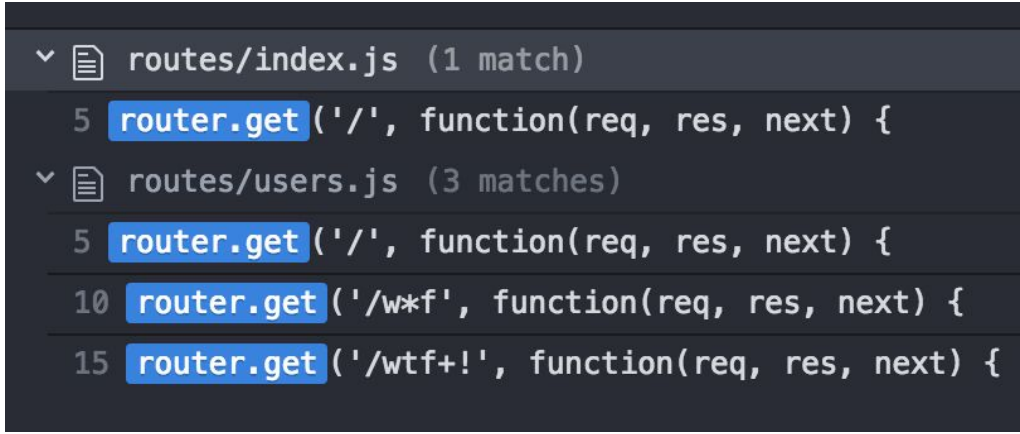
Exercise Rufus

1. Start secure code review of ~/code/skea_node
    a. Perform Info Gathering
        i. (Biz Purpose/Tech Stack/App Arch/Risk Assessment)
    b. Map Routes
2. Continue secure code review of ~/code/bhima
    a. Identify routes



Rufus Exercise - Post-Mortem

- Notes for skea_node
  - A commit #
  - The endpoints as shown
  - Interesting items you may have found:
    - The fact the auth function doesn't do anything
    - The fact we have a Debug statement in our app and its printing env variables



Information Gathering - Authorization Functions

- A later step is dedicated to creating authorization checks
- This is about getting to know the application better
- Identify pattern used for access control on the application endpoints

Information Gathering - Authorization Functions

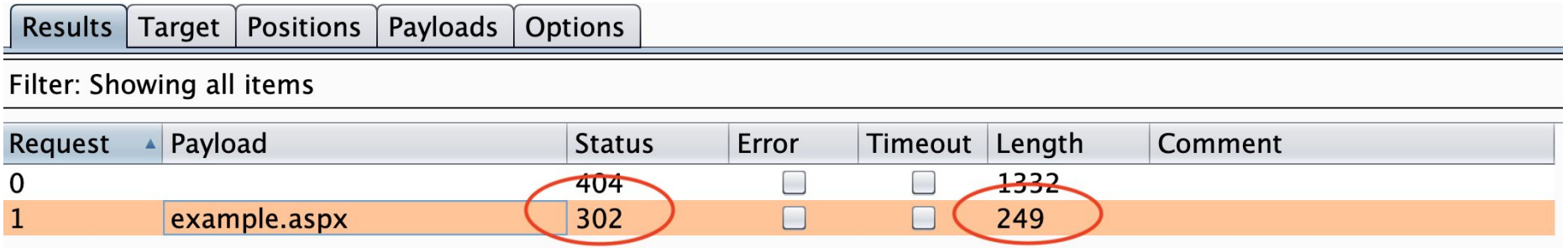
- Patterns & Anti-patterns
  - How is user identified? eg: Session, Token, Basic Auth
  - What is the purpose? Authenticated users, Role check, CSRF?
- What could go wrong? (add to the risks checklist)
  - User-supplied parameters (IDOR)
  - CSRF
  - Client-side cookies, JWTs etc. (just general wonkiness in persistence)

Story:

Redirection & Authorization Issue in .NET

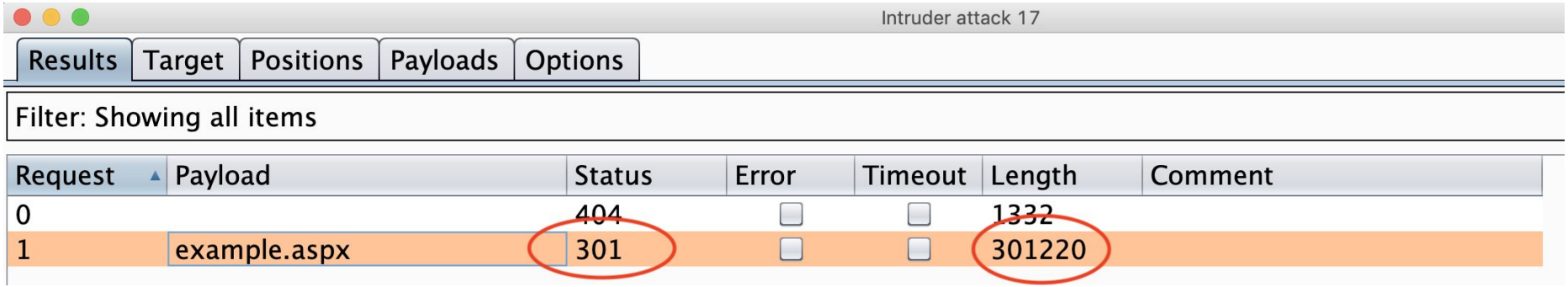
Redirection & Authorization Issue in .NET

Normal



Redirection & Authorization Issue in .NET

Definitely **NOT** Normal



Redirection & Authorization Issue in .NET

Redirect(String, Boolean)

Redirects a client to a new URL. Specifies the new URL and whether execution of the current page should terminate.

C# Copy

```
public void Redirect (string url, bool endResponse);
```

Parameters

`url` String

The location of the target.

`endResponse` Boolean

Indicates whether execution of the current page should terminate.

Authz Functions - Incorrectly Configured Example

application_controller.rb

```
1  # frozen_string_literal: true
2  class ApplicationController < ActionController::Base
3    before_action :authenticated, :has_info, :create_analytic, :mailer_optic
4    helper_method :current_user, :is_admin?, :sanitize_font
5
6    # Our security guy keep talking about sea-surfing, cool story bro.
7    # Prevent CSRF attacks by raising an exception.
8    # For APIs, you may want to use :null_session instead.
9    protect_from_forgery #with: :exception
10
```

Authorization Functions Checklist

- ❏ How are users identified
  - Session
  - Token
  - Basic Authentication
  - Something else?

Authz functions checklist

- ❏ Identify its purpose
  - Is it just checking that we’re authenticated? - AuthN
  - Is it looking for a specific role? - RBAC
  - Is it doing some sort of HMAC verification for events?

Authz functions checklist

- ❏ What could go wrong?
  - Insecure timing comparisons
  - Framework nuances
  - IDOR
  - Lack of rate limiting (see this often with basic auth or tokens)
  - Think about if it was *not* applied, what would happen
  - **Get creative, you’re trying to decide what the risk, if any, is here**

Authz Functions

Exercise Sigmund Freud

1. Start secure code review of ~/code/skea_rails
    a. Perform Info Gathering
        i. (Tech Stack/Biz Purpose/Risk Assessment)
    b. Map Routes
    c. Map AuthZ Functions
2. How are users authorized in ~/code/skea_rails?
    a. Could take some time

Sigmund Freud Exercise - Post-Mortem

- Yeah, you probably have questions re: **“authenticate_user!”**
  a. Which is why its part of the exercise :=D. THIS HAPPENS A LOT!

- How to decipher where this action is defined will be defined by:
  a. Access to an interactive runtime env?
  b. Experience with the framework/libs?
  c. No previous experience with it, only access to source?

Sigmund Freud Exercise - Post-Mortem

- Did you catch the CSRF? - “Framework Nuance”

```
post    "/articles", to: "articles#create"
get     "/articles/new", to: "articles#new", as: :new_article
get     "/articles/:id/:action", to: "articles#edit", as: :edit_article
get     "/articles/:id", to: "articles#show", as: :article
post    "/articles/:id/vote/:type", to: "articles#vote", as: :vote
```

Sigmund Freud Exercise - Post-Mortem

- Anyone know what the request attack string would look like?


```
get     "/articles/:id/:action", to: "articles#edit", as: :edit_article
```

Sigmund Freud Exercise - Post-Mortem

- So what's the point with this whole thing?
  - You need to do your homework on framework nuances
  - Good example of why I often double-back and check one last time... (story time)

Checklists & Reviews

Authorization

Authorization Review

- Analyze source for role enforcement, appropriate user boundaries, privileges required for access, and business-logic flaws
- Roles and associated enforcement routines must be identified during information gathering
- Pay attention to any endpoints that include sensitive data or functionality
  - Vertical authorization weaknesses - escalated privileges
    - Authenticated and unauthenticated access
  - Horizontal authorization weaknesses - access another user’s data

Authorization Review Vulnerabilities

- Broken Access Control - OWASP Top 10 A5:2017
  - Privilege Escalation
  - Missing Function Level Access Control
  - Insecure Direct Object Reference
- Sensitive Data Exposure - OWASP Top 10 A3:2017
- Mass Assignment
- Business Logic Flaws

Authorization Review Checklist

- What are the different authorization functions?
  - Token/User/Role validation?
  - Is this handled by custom framework functionality?
  - Decorators vs. static source code
- Can non-privileged users view, add, or alter accounts?
- Is there functionality to add accounts with higher access levels than their own access?
- How is separation of duties handled?
- Are disabled accounts prevented from accessing content?
- Can password-protected pages be directly accessed without authentication?

Mass-Assignment

- Goes by a few names
  - Insecure Binder Vulnerability
  - Insecure Object Mapping
  - Mass-Assignment
- Typically happens when a database entry is created or modified and we do so by throwing in *all* user-supplied parameters
- For example...

Mass-Assignment - Node

```
var user = new User(req.body);
user.save();
```

Mass-Assignment - Rails

Rails 2/3

```ruby
def create
  user = User.new(params[:user])
  if user.save
    session[:user_id] = user.id
    redirect_to home_dashboard_index_path
  else
    @user = user
    flash[:error] = user.errors.full_messages.to
    redirect_to :signup
  end
end
```

Rails 4+

```ruby
def create
  user = User.new(user_params)
  if user.save
    session[:user_id] = user.id
    redirect_to home_dashboard_inde
```

```ruby
def user_params
  params.require(:user).permit!
end
```

Authorization Review Checklist

- Is it possible to bypass authorization restrictions by accessing content directly (e.g. can a non-privileged user access the administration pages of an application)?
- Can a user escalate privileges through cookie modification, altering form input values and HTTP headers, or by fuzzing URL-based parameters?
- Are there horizontal escalation/Insecure Direct Object References in the source code?
- Are authentication and authorization flows the first logic executed for each request?
- Are authorization checks granular (page and directory level) or per-application?

Authorization Review Checklist

- Are access to sensitive pages and data denied by default?
- Are users forced to re-assert their credentials for requests that have critical side-effect (account changes, password reset, etc)?
- Do authorization checks have clearly defined roles?
- Can authorization be circumvented by parameter or cookie/token manipulation?
- Are CSRF protections in place and appropriate?

Authorization

Exercise Genghis Khan

1. Start secure code review of ~/code/skea_django
    a. Info Gathering
        i. (Tech Stack/Biz Purpose/App Arch/Risk Assessment)
    b. Map Routes
    c. AuthZ Functions
2. Build an authorization checklist
3. Test checklist items

Genghis Khan Exercise - Post-Mortem

- First of all look into views.py

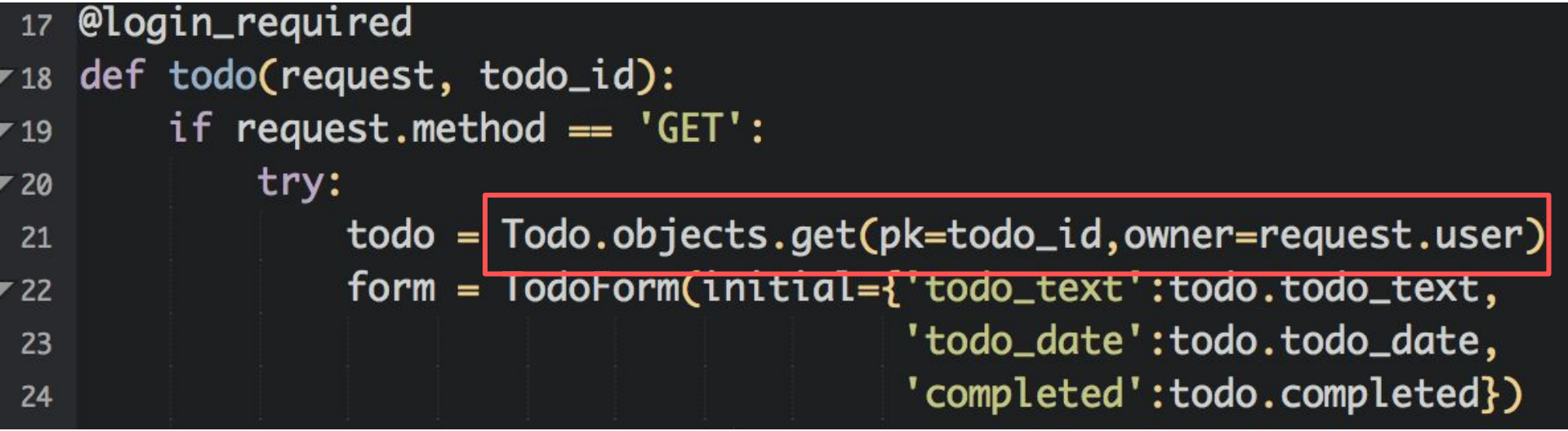
settings.py × views.py ×

... RPS > Training > SKEA > skea_django > intro > views.py > create_todo

```
12
13 # Create your views here.
14 def index(request):
15     return HttpResponse("Welcome to Seth & Ken's Excellent Adventures
16
17 @login_required
18 def todo(request, todo_id):
19     if request.method == 'GET':
20         try:
```

Genghis Khan Exercise - Post-Mortem

- What about objects? Does it protect against IDOR? How?



Authentication

Authentication Review

- Authentication establishes user identity
- Examine the user identification process of the application.
- Available application resources include both unidentified and identified users
- Use enumeration of the application endpoints to trace the authentication flow and functions.
- Sensitive application and business functionality should redirect as appropriate to the authentication flow to properly identify a user
- Include an application functionality that identifies a user in this review

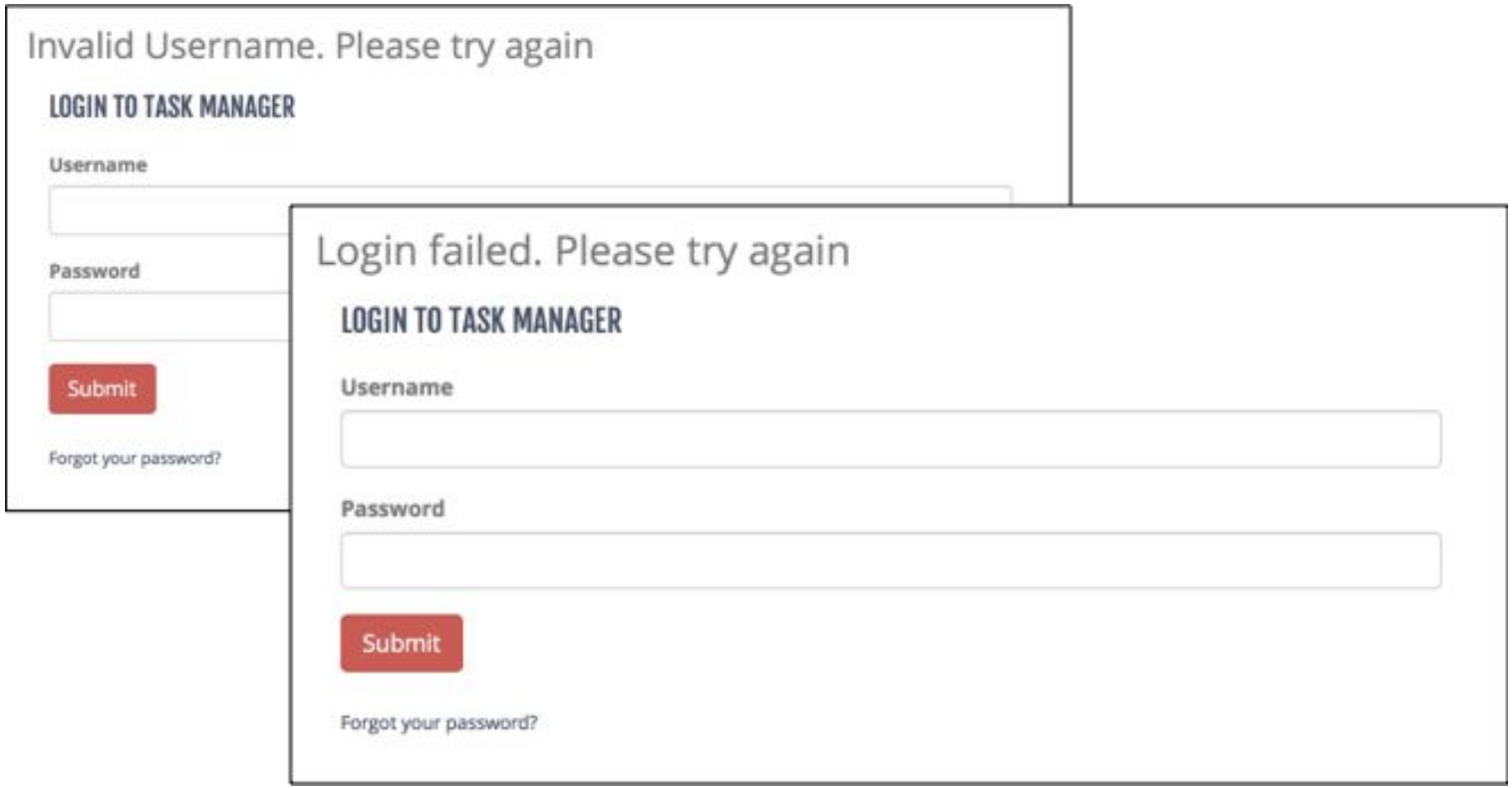
Authentication Review

How does an application confirm identity?

Authentication Review Vulnerabilities

- Broken Authentication - OWASP Top 10 A2:2017
- User Enumeration
- Session Management Issues
- Authentication Bypass
- Brute-Force Attacks

User Enumeration - Login Page



Broken Authentication - Node

```
exports.update = function(req, res) {

    if (req.body.new_password = req.body.new_password_confirmation){
        username = req.body.username
        current_password = req.body.current_password
        isMatch = true

        db.User.find({where: {username: username}}).success(function (user){
            hash = user ? user.password : ''
            isMatch = db.User.validPassword(current_password, hash, function () { console.lo
        });
        if (isMatch) {
            req.user.username = username
            req.user.password = req.body.new_password
            req.user.save()
        } else {
            console.log('Bad Password')
        }
    }

    res.redirect('/account')
};
```

Authentication Review Checklist

- What are the different authentication flows?
  - User Login
  - User Registration
  - Forgot Password
- How are users identified? What information do they have to provide?
  - Username, email, password, 2fa token, etc.
- How is authentication handled on each application endpoint?
  - Sensitive endpoints should require authentication
- Are there any hard-coded accounts?
- Does application allow for easily-guessed, default, or common passwords?

Authentication Review Checklist

- How are usernames determined, what naming conventions?
  - Does registration allow for easy enumeration?
- Does the application allow for account enumeration through server responses or information disclosure?
  - login/registration/forgot password flows
- Are user credentials protected in the data store using modern password hashing algorithms?
- Are security policies configurable via environment variables and not hard-coded?
- What standard security frameworks are used?
  - Is there code specific to the application, especially when dealing with password storage?

Authentication Review Checklist

- How are user management events such as authentication failures, password resets, password changes, account lockout and disabled accounts handled?
- Are suspicious event handling such as multiple failed login attempts, session replay and attempted access to restricted resources handled properly?
- Does the application implement strong password policies?
- Are authentication credentials being passed using technologies that could be cached (HTTP GET, lack of proper cache-control settings)?
- If applicable, are encryption mechanisms in place during authentication for secure communications (TLS, etc)?

Authentication Review Checklist (Registration)

- Are limits on application access, such as geographical boundaries, enforced properly?
- Is there a manual approval process or is access granted automatically?
  - Can the automated process be abused or bypassed using scripting or brute-forcing?
- In cases where a validation email and link are required, how are the tokens generated?
- Can users elevate their initial access via mass assignment or business-logic bypasses?
- Are files and objects owned by a user removed or archived?

Authentication Review Checklist (Sessions)

- Are encryption and hashing used properly?
- Do encryption protocols use strong algorithms and industry-standard key lengths?
- Are authentication tokens set with time limits?
- Are cookies security parameters set properly (e.g. Secure, HTTPOnly, path)?
- Are session IDs sent over a secure channel?
- Are session IDs invalidated before a new login is made?
- Are CSRF tokens set for all authentication requests?

User Enumeration - Node

```
31      User.findOne({
32              username: req.body.username
33      }, function(err, user) {
34              if (err){
35                      res.send(err);
36              }
37              else{
38                      if (!user) {
39                              res.send("User not found");
40                      }
41                      else {
42                              if (user.password == req.body.password) {
43                                      var token = jwt.sign(user, config.secret, {expi
44
45                                      res.redirect('/homepage?token='+token);
46
47                              } else {
48                                      res.send("Incorrect Password");
49                              }
```

User Enumeration - Django

```
387         if User.objects.filter(username=username).exists():
388             user = authenticate(username=username, password=password)
389             if user is not None:
390                 if user.is_active:
391                     auth_login(request, user)
392                     # Redirect to a success page.
393                     return redirect(request.GET.get('next', '/taskManager/'))
394                 else:
395                     # Return a 'disabled account' error message
396                     return redirect('/taskManager/', {'disabled_user': True})
397             else:
398                 # Return an 'invalid login' error message.
399                 return render(request,
400                               'taskManager/login.html',
401                               {'failed_login': False})
402         else:
403             return render(request,
404                           'taskManager/login.html',
405                           {'invalid_username': False})
```

Authentication

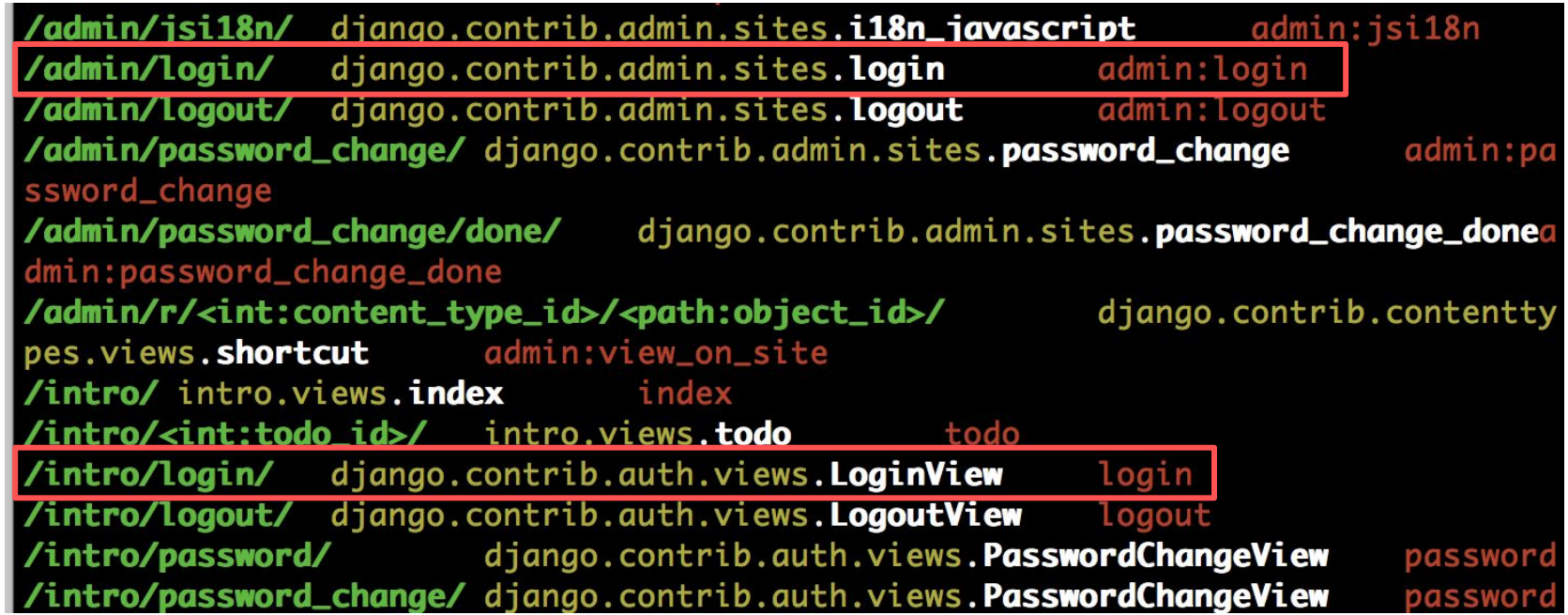
Exercise Socrates

1. Continue review of ~/code/skea_django
   a. Build/Review AuthN Checklist

2. Continue review of ~/code/bhima
   b. Build/Review AuthN Checklist

So-crates Exercise - Post-Mortem

- So what exactly are we looking for?
  a. ./manage.py show_urls (django extensions have to be enabled).



So-crates Exercise - Post-Mortem

- Where do they go?
  a. *intro/urls.py* has no references to login????

urls.py

```
from django.urls import path
from django.contrib.auth import views as auth_views
from . import views

urlpatterns = [
    path('', views.index, name='index'),
    path('signup/', views.SignUp.as_view(), name='signup'),
    path('password/', auth_views.PasswordChangeView.as_view(template_name='change_password.html'), name='password'),
    path('<int:todo_id>/',views.todo, name='todo'),
    path('todo/',views.create_todo, name='create todo'),
    path('todos/',views.todos, name='todos'),
    path('todos/completed/',views.todos_completed, name='completed todos')
]
```

So-crates Exercise - Post-Mortem

- Either does *skea_django/urls.py* - but there is a reference to django.contrib.auth.urls

urls.py — intro | urls.py — skea_django

```
1  from django.contrib import admin
2  from django.urls import include, path
3  from django.views.generic.base import TemplateView
4
5  urlpatterns = [
6      path('', TemplateView.as_view(template_name='home.html'), name='home'),
7      path('admin/', admin.site.urls),
8      path('intro/', include('intro.urls')),
9      path('intro/',include('django.contrib.auth.urls')),
10 ]
11
```

So-crates Exercise - Post-Mortem

- Configuration documentation for django.contrib.auth leads us to *skea_django/settings.py*

```
103
104   AUTH_USER_MODEL = 'intro.TodoUser'
105
106   LOGIN_REDIRECT_URL = 'home'
107   LOGOUT_REDIRECT_URL = 'home'
108   LOGIN_URL = '/intro/login/'
109
```

So-crates Exercise - Post-Mortem

- Searching for django.contrib.auth leads us to *intro/models.py*

login.html | *models.py* | views.py

```
1  from django.db import models
2  from django.contrib.auth.models import AbstractUser
3
4  # Create your models here.
5
6  class TodoUser(AbstractUser):
7
8      def __str__(self):
9          return self.email
10
11 class Todo(models.Model):
12     todo_text = models.TextField()
```

So-crates Exercise - Post-Mortem

- If we go back to the django.contrib.auth documentation, it uses the templates in the registration directory.

Auditing

Auditing Review

- Validate that appropriate logging and exception handling are handled within application source
- One path in the trace of sensitive data from source to sink
- Logging functions and error messages are considered a data sink
- Logging should happen in any endpoint that performs a state-changing operation or has security implications
- This data is used for immediate analysis and future forensics needs.
- Check that sensitive data is appropriately handled (no credit card numbers, etc) and the correct details are logged
- Administrators must trust that logs may not be manipulated by unauthorized parties

Auditing Review Vulnerabilities

- Sensitive Data Exposure - OWASP Top 10 A3:2017
- Insufficient Logging & Monitoring - OWASP Top 10 A10:2017
- Debug Messages
- Error Handling
- Information Leakage

Auditing Review Checklist

- If an exception occurs, does the application fail securely?
- Do error messages reveal sensitive application or unnecessary execution details?
- Are Component, framework, and system errors displayed to end user?
- Does exception handling that occurs during security sensitive processes release resources safely and roll back any transactions?
- Are relevant user details and system actions logged?
- Is sensitive user input flagged, identified, protected, and not written to the logs?
    - Credit Card #s, Social Security Numbers, Passwords, PII, keys

Auditing Review Checklist

- Are unexpected errors and inputs logged?
  - Multiple login attempts, invalid logins, unauthorized access attempts
- Are log details specific enough to reconstruct events for audit purposes?
- Are logging configuration settings configurable through settings or environment variables and not hard-coded into the source?
- Is User-controlled data validated and/or sanitized before logging to prevent log injection?

Logging - Java

```
2
3   import java.util.Date;
4
5   import org.apache.log4j.Level;
6   import org.apache.log4j.Logger;
7
```

```
20      public void createContactData(String[] sendBioData, Date
21          try{
22              bioDAO.createContactData(sendBioData, dateCreate
23          }catch (Exception e) {
24              logger.log(Level.ERROR, e.getMessage(), e);
25          }
26      }
```

Auditing

Exercise Abraham Lincoln

1. Continue review of ~/code/skea_django
   a. Build/Review Auditing Checklist

2. Continue review of ~/code/bhima
   b. Build/Review Auditing Checklist

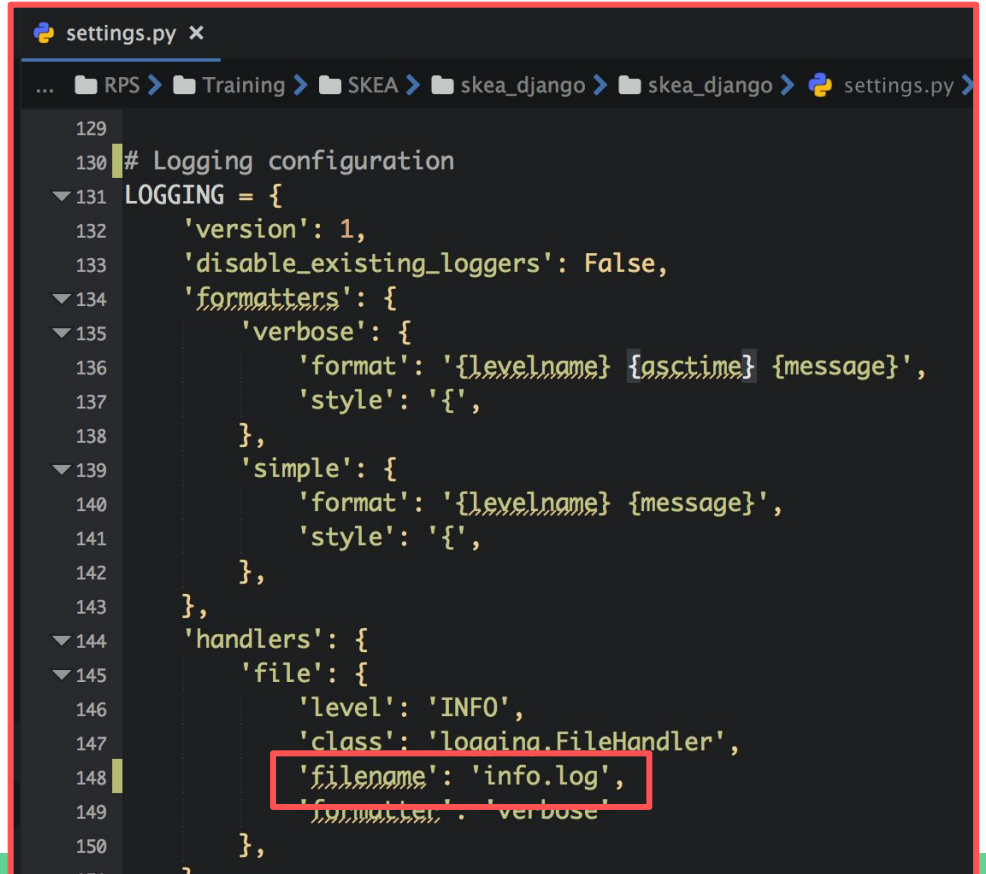
Abraham Lincoln Exercise - Post-Mortem

- So where should we look? Sensitive functions.

```
47 @login_required
48 def create_todo(request):
49     if request.method == 'POST':
50         form = TodoForm(request.POST)
51         if form.is_valid():
52             t = Todo( todo_text=form.cleaned_data['todo_text'],
53                       todo_date = form.cleaned_data['todo_date'],
54                       completed = form.cleaned_data['completed'])
55             t.owner = request.user
56             t.save()
57             logger.info("Created todo %s by %s" % (todo_id,request.user.username))
58             return HttpResponseRedirect('/intro/todos/')
59
60     else:
61         form = TodoForm()
```

Abraham Lincoln Exercise - Post-Mortem

- It's django, so everything is setup in settings.py.
- The intro application goes right along with this.



Injection

Injection

- Causes:
  - Input Validation
  - Output Encoding
- Types
  - SQL Injection
  - HTML Injection (XSS)
  - LDAP, XML, Command ...

Injection Vulnerabilities

- Injection - OWASP Top 10 A1:2017
- XML External Entities (XXE) - OWASP Top 10 A4:2017
- Cross-Site Scripting (XSS) - OWASP Top 10 A7:2017
- Redirects
- SSRF

Input Validation

- Analyze code that handles user input for type, format, and content validation before being used or stored by the application.
- Compile list of data sources to work through.
- Start with the routes identified in the information gathering phase, but also include:
  - Configuration files
  - Environment variables
  - External services
  - Database calls to external and internal databases.
  - ...

Input Validation - Checklist

- Is all the input validated without exception?
- Do the validation routines check for known good characters and cast to the proper data type (integer, date, etc.)?
- Is the user data validated on the client or server or both (security should not rely solely on client-side validations that may be bypassed)?
- If both client-side and server-side data validation is taking place, are these validations consistent and synchronized?
- Do string input validation use regular expressions?
- Do these regular expressions use blacklists or whitelists?
- What bypasses exist within the regular expressions?

Input Validation - Checklist

- Does the application validate numeric input by type and reject unexpected input?
- How does the application evaluate and process input length?
- Is a strong separation enforced between data and commands (filtering out injection attacks)?
- Is there separation between data and client-side scripts?
- Is provided data checked for special characters before being passed to SQL, LDAP, XML, OS and third party services?
- For web applications, are often forgotten HTTP request components, including HTTP headers (e.g. referrer) validated?

SQL Injection - Django

```
@csrf_exempt
def forgot_password(request):

    if request.method == 'POST':
        t_email = request.POST.get('email')

        try:
            result = User.objects.raw("SELECT * FROM auth_user where email = '%s'" % t_email)

            if len(list(result)) > 0:
                result_user = result[0]
                # Generate secure random 6 digit number
                res = ""
                nums = [x for x in os.urandom(6)]
```

SQL Injection - Node.js

```
10
11 exports.search = function(req,res) {
12     q = "";
13     users = [];
14     if (req.query.q) {
15         q = req.query.q;
16         db.User.findAll({attributes: ['id', 'username'], where: {username: { like: '%'
           +req.query.q+'%' } }}).success(function(users){
17             //console.log('Users:', users)
18             res.render("search.ejs", { q: q, username: req.user.username, users: users
                });
19         });
20     } else {
21         db.User.findAll().then(function(users){
22             //console.log('Users:', users)
23             res.render("search.ejs", { q: q, username: req.user.username, users: users
                });
24         });
```

Output Encoding

- Analyze code that sends user data to client for context, type, and format before sending to uncontrolled data sinks.
- Start with a list of data sinks where data is being stored, sent, processed.
  - Source code libraries
  - 3rd-party services
  - Storage components (database in any of its possible forms)
  - File system interactions
  - Log files
- XSS, SSRF

Output Encoding - Checklist

- Do databases interactions use parameterized queries?
- Do input validation functions properly encode or sanitize data for the output context?
- How do framework-provided database ORM functions used?
- Does the source code use potentially-dangerous ORM functions? (.raw, etc)
- What output encoding libraries are used?
- Are output encoding libraries up-to-date and patched?
- Is proper output encoding used for the context of each output location?
- Are output encoding routines dependent on regular expressions? Are there any weaknesses or blind-spots in these expressions?

XSS - Node.js (ejs templates)

```
106     <tbody>
107
108       <% for(var i=0; i < listings.length; i++) { %>
109       <tr>
110         <td><%- listings[i].created %></td>
111         <td><%- listings[i].name %></td>
112         <td><%- listings[i].description %></td>
113         <td><%- listings[i].deadline %>
114
115         </td>
116         <td><a class="icon-ok" href="javascript:alert('Apply for Position')"></a><a c
117       </tr>
118       <% } %>
119     </tbody>
120   </table>
121   </div>
```

XSS - Django

```
<!-- user login dropdown start-->
<li class="dropdown">
    <a data-toggle="dropdown" class="dropdown-toggle" href="#">
        <!--User Identity -->
        <span class="username"><i class="fa fa-user fa-fw"></i> {{ user.username|safe }}</span>
        <b class="caret"></b>
    </a>
    <ul class="dropdown-menu extended logout">
        {% if user.id %}
```

Injection

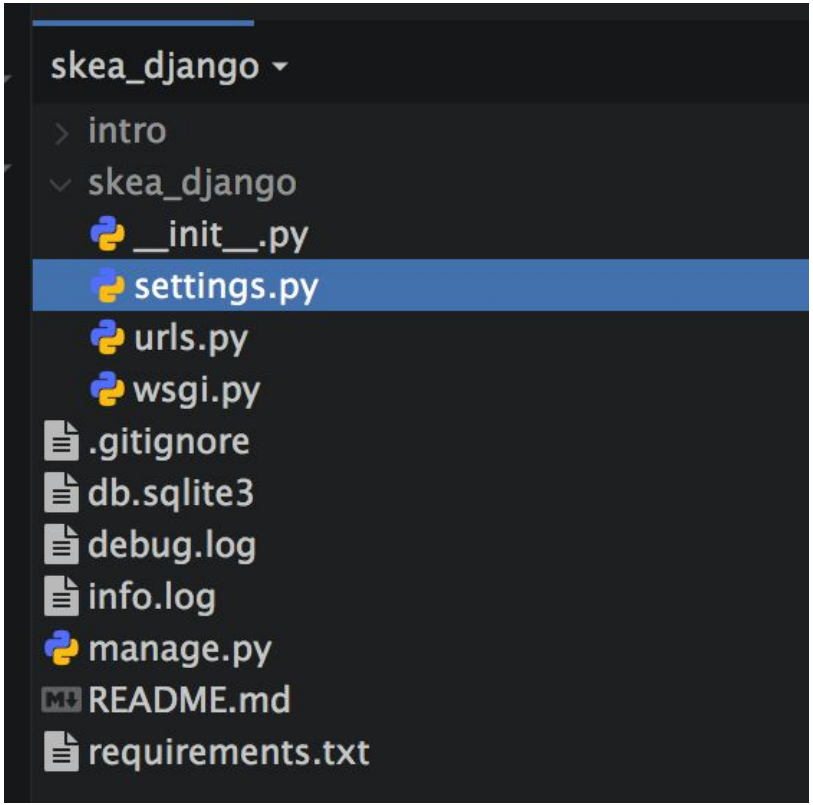
Exercise Billy the Kid

1. ~/code/skea_django
   a. Build Injection Checklist
   b. Trace all sources To sinks

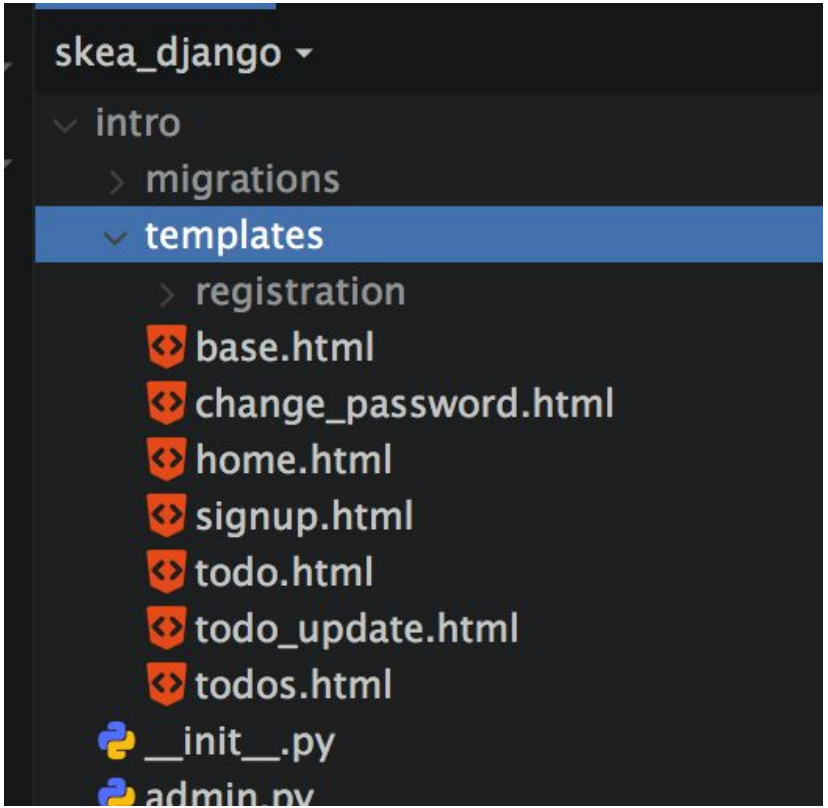
1. ~/code/bhima
   b. Build Injection Checklist
   c. Trace at least 3 different sources to sinks

Exercise Billy the Kid - Post-Mortem

- Some sources have already been identified. Are there others?
- Configuration files, additional services, even databases.
- Settings.py is somewhat trusted, but other people could manipulate data in the database before it gets to us.



Exercise Billy the Kid - Post-Mortem



- Now for sinks, we know that the database file is one, but what else?
- Anywhere data is /sent/ somewhere, file system, user, etc.

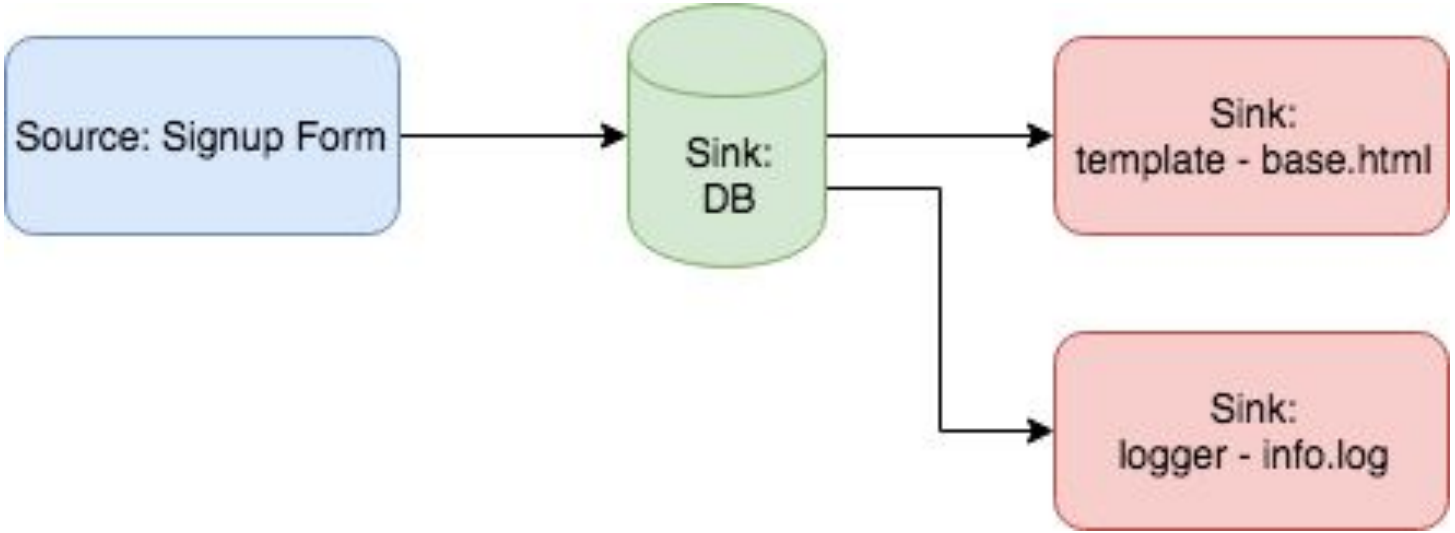
Exercise Billy the Kid - Post-Mortem

- Search for user.username shows multiple references.

File	Line	Content
<skea_django>/intro/admin.py	12	list_display = ['email', 'username',]
<skea_django>/intro/forms.py	12	fields = ('username', 'first_name', 'last_name', 'email')
<skea_django>/intro/forms.py	18	fields = ('username', 'first_name', 'last_name', 'email')
<skea_django>/intro/views.py	28	logger.info("GET todo %s by %s" % (todo_id,request.user.username))
<skea_django>/intro/views.py	43	logger.info("Updated todo %s by %s" % (todo_id,request.user.username))
<skea_django>/intro/views.py	57	logger.info("Created todo %s by %s" % (todo_id,request.user.username))
<skea_django>/intro/views.py	68	logger.info("GET todos by %s" % (request.user.username))
<skea_django>/intro/views.py	74	logger.info("GET completed todos by %s" % (request.user.username))
<skea_django>/intro/migrations/0001_initial.py	27	('username', models.CharField(error_messages={'unique': 'A us
<skea_django>/intro/migrations/0001_initial.py	27	('username', models.CharField(error_messages={'unique': 'A us
<skea_django>/intro/migrations/0001_initial.py	27	('username', models.CharField(error_messages={'unique': 'A us
<skea_django>/intro/migrations/0001_initial.py	27	('username', models.CharField(error_messages={'unique': 'A us
<skea_django>/intro/templates/base.html	30	{{user.username}} |

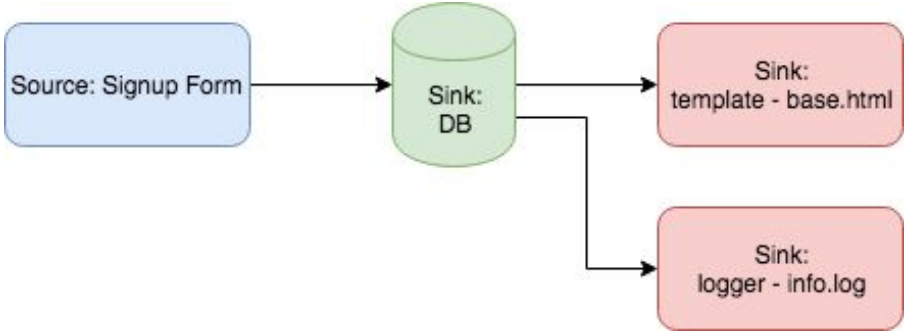
Exercise Billy the Kid - Post-Mortem

- Diagram for user.username ends up looking like this.



Exercise Billy the Kid - Post-Mortem

- This means we will be looking for the following injection flaws:
  a. SQL Injection (database storage)
  b. XSS (Stored/Reflected)
  c. Log Forging/Injection



Cryptographic Analysis

Cryptographic Analysis

- Analyze code for encryption flaws, outdated protocols, custom-developed algorithms, weak encryption, and misuse
- Automated tools will uncover some of this, including
  - Use of older hashing algorithms (MD5, SHA-1, etc)
- Code and routes that handles sensitive information specifically should be reviewed
  - API Tokens
  - Credit Card Numbers
  - Social Security Numbers
  - Customer Data
- IDE Search for the following terms:
  - md5, sha1, base64, encrypt, decrypt, secure

Cryptographic Analysis Vulnerabilities

- Lack of Encryption
- Improper Encryption
- Insecure Token Generation/Randomness

Cryptographic Analysis - Checklist

- What are the standard encryption libraries are used for?
  - Hashing functions - password hashing, cryptographic signing, etc
  - Encryption functions - data storage, communications
- Do the strength of implemented ciphers meet industry standards?
  - Less than 256-bit encryption
  - MD5/SHA1 for password hashing
  - Any RC4 stream ciphers
  - Certificates with less than 1024-bit length keys
  - All SSL protocol versions
- Are cryptographic private keys, passwords, and secrets properly protected?

Cryptographic Analysis

Exercise Beeth-oven

1. ~/code/skea_django
   a. Build Crypto Checklist
   b. How are passwords stored/tokens generated
2. ~/code/bhima
   a. Build Crypto Checklist
   b. What hashing/crypto is being used?

Exercise Beethoven - Post-Mortem

- Sessions - Only indication we have of activity is settings.py

```
INSTALLED_APPS = [
    'intro.apps.IntroConfig',
    'django.contrib.admin',
    'django.contrib.auth',
    'django.contrib.contenttypes',
    'django.contrib.sessions',
    'django.contrib.messages',
    'django.contrib.staticfiles',
    'django_extensions',
]

MIDDLEWARE = [
    'django.middleware.security.SecurityMiddleware',
    'django.contrib.sessions.middleware.SessionMiddleware',
    'django.middleware.common.CommonMiddleware',
    'django.middleware.csrf.CsrfViewMiddleware',
```

Exercise Beethoven - Post-Mortem

- Sessions - Django documentation helps us out a little.

Configuring the session engine

By default, Django stores sessions in your database (using the model **`django.contrib.sessions.models.Session`**). Though this is convenient, in some setups it's faster to store session data elsewhere, so Django can be configured to store session data on your filesystem or in your cache.

Exercise Beethoven - Post-Mortem

- Sessions - but also gives us a warning...

Warning

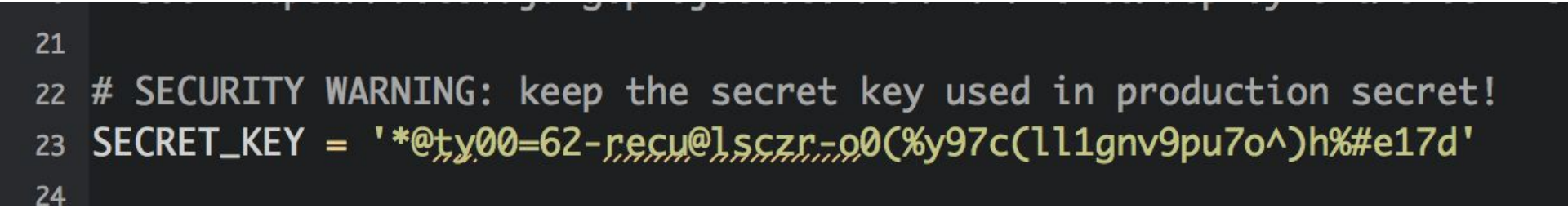
If the SECRET_KEY is not kept secret and you are using the `PickleSerializer`, this can lead to arbitrary remote code execution.

An attacker in possession of the **SECRET_KEY** can not only generate falsified session data, which your site will trust, but also remotely execute arbitrary code, as the data is serialized using pickle.

If you use cookie-based sessions, pay extra care that your secret key is always kept completely secret, for any system which might be remotely accessible.

Exercise Beethoven - Post-Mortem

- Alright, so we should check the randomness of the SECRET_KEY



- Looks random and secure, right? What are the concerns you have with this? Bueller?

Exercise Beethoven - Post-Mortem

- Possible issues (outside of encryption routines):
  a. Hardcoded values stored in source
  b. Same key used for dev/staging/production

Exercise Beethoven - Post-Mortem

- Password Storage? Nothing in settings.py?

How Django stores passwords

Django provides a flexible password storage system and uses PBKDF2 by default.

The **password** attribute of a **User** object is a string in this format:

```
<algorithm>$<iterations>$<salt>$<hash>
```

Exercise Beethoven - Post-Mortem

- PASSWORD_HASHERS in settings.py

```
[
    'django.contrib.auth.hashers.PBKDF2PasswordHasher',
    'django.contrib.auth.hashers.PBKDF2SHA1PasswordHasher',
    'django.contrib.auth.hashers.Argon2PasswordHasher',
    'django.contrib.auth.hashers.BCryptSHA256PasswordHasher',
    'django.contrib.auth.hashers.BCryptPasswordHasher',
    'django.contrib.auth.hashers.SHA1PasswordHasher',
    'django.contrib.auth.hashers.MD5PasswordHasher',
    'django.contrib.auth.hashers.UnsaltedSHA1PasswordHasher',
    'django.contrib.auth.hashers.UnsaltedMD5PasswordHasher',
    'django.contrib.auth.hashers.CryptPasswordHasher',
]
```

Exercise Beethoven - Post-Mortem

- Did you run the app?

```
sqlite> select * from intro_todouser;
1|pbkdf2_sha256$120000$GJ1WIimqmSAl$6+WnzERREqiR44/FFLy8JjaEx160ysYFJW60MpdGizo=
|2018-10-05 21:14:37.054197|1|admin|||admin@test.com|1|1|2018-10-05 20:20:38.818
426
2|pbkdf2_sha256$120000$a2sGvDgOaIXT$Qa1LbL4hWolywacEqdEatLsH2Vcv0NlKopjq14oTC/E=
|2018-10-08 02:05:50.669012|0|test|Firsc|Last|test@test.com|0|1|2018-10-05 20:21
:00.520448
```

Configuration Review

Configuration Review

- Analyze any configurations included for security flaws
  - Includes language, framework, and server configurations
- Highly specific to the targeted language/framework
- Consult the server/framework documentation for guides on security flags and settings.
- Examples:
  - Administrative Functionality enabled through configuration files
  - CSRF settings
  - Cookie parameters

Configuration Review Vulnerabilities

- Security Misconfiguration - OWASP Top 10 A6:2017
  - Insecure defaults
  - Incomplete configurations
  - Open cloud storage
- Using Components with Known Vulnerabilities - OWASP Top 10 A9:2017
  - Any dependencies, libraries, services

Configuration Review - Checklist

- Are any endpoints enabled through configurations properly protected with authentication and authorization?
- Are security protections implemented in framework properly configured?
- Does the target language and framework version have any known security issues?
- Are configuration-controlled security headers implemented according to recommended best practices?

Configuration Analysis

Exercise Joan of Arc

1. ~/code/skea_**node** and bhima
   a. Build Config Checklist
   b. Run/review npm audit and nodejsscan
2. ~/code/skea_**rails** and railsgoat
   a. Build Config Checklist
   b. Run/review brakeman

Security Misconfiguration - Java Spring

```
# Database Configuration
spring.datasource.url=jdbc:h2:mem:AZ;DB_CLOSE_DELAY=-1;DB_CLOSE_ON_EXIT=FALSE
spring.datasource.driverClassName=org.h2.Driver
spring.datasource.username=sa
spring.datasource.password=
spring.jpa.database-platform=org.hibernate.dialect.H2Dialect
hibernate.hbm2ddl.import_files_sql_extractor=org.hibernate.tool.hbm2ddl.MultipleLinesSqlCommandExtractor
hibernate.hbm2ddl.auto=create

# H2 Options
security.basic.enabled=true
security.basic.authorize-mode=none
spring.h2.console.enabled=true
spring.h2.console.settings.web-allow-others=true
spring.h2.console.path=/console
```

Additional Resources

Additional Resources

- OWASP Code Review Guide - Includes some language-specific best practices for Java, .Net, C, C++.
- Simplicable Secure Code Review Checklist
- Infosec Institute - Secure Code Review: A Practical Approach
- OWASP Input Validation Cheatsheet
- OWASP XSS Prevention Cheatsheet
- Recommended headers for internal and external Web User Interfaces
- Wikipedia - Principle of Layered Security
- Wikipedia - Principle of Least Privilege
- OWASP ASVS (Application Security Verification Standard)

Reporting and Retesting

Reporting and Retesting

- This phase of the methodology is critical.
- Document findings in a manner that can be understood by a developer.
- Review the source after remediation using the same techniques (rinse & repeat).
- THIS IS THE WHOLE POINT.

Report Writing (or ticket creation)

- Detailed findings include:
  - Description
  - Applicable File, Function, Variables, Line Numbers
  - Risk Severity
  - Likelihood of Exploitation
  - Ease of Exploitation
  - Remediation Approach
  - References

Walkthrough:
Vulnerable Task Manager
https://github.com/sethlaw/vtm

Open Source Projects


BE EXCELLENT TO EACH OTHER AND
PARTY ON DUDES
made on imgur

Seth - seth@redpointsecurity.com

Justin - jl@redpointsecurity.com