express # guide

JWT Verification with Auth²

TCSS 460 — Client/Server Programming

In Sprint 2 your API minted its own tokens with `/auth/dev-login` and verified them with a shared `JWT_SECRET`. That worked because your API was both the auth server and the resource server. Sprint 3 splits those roles: **Auth²** issues tokens, your API verifies them. This guide walks through the wiring — `express-jwt` + `jwks-rsa`, audience and issuer pinning, the three role gates, and the local-user upsert pattern that maps an Auth² `sub` to a row in your own User table.

The companion theory lives in the Week 5 concept reading. This guide assumes you've read it and concentrates on the TypeScript/Express specifics.

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1 What This Guide Covers

By the end of this guide you'll have:

- A `requireAuth` middleware that verifies RS256 access tokens against Auth²'s JWKS endpoint
- A `resolveLocalUser` helper that maps an Auth² `sub` claim onto a row in your own `User` table, fetching from `/v2/oauth/userinfo` on first sight
- Three role gates — `requireRole`, `requireRoleAtLeast`, `hasRoleAtLeast` — for the 5-tier Auth² hierarchy
- A debugging mental model for the most common 401/403 failures

This guide is **opinionated** — it shows the exact pattern used by `TCSS460-backend-3`, the Sprint 3 reference implementation. When your group adapts backend-3 for your own group's API, the moving parts you'll actually rewrite are the env vars and (occasionally) the role thresholds. The middleware itself ships ready to use.

Prerequisite reading

Week 5: Authentication & Authorization Concepts — covers the *why* behind every choice in this guide. In particular, the asymmetric trust model (§4.4, §8), the audience/issuer claim discipline (§4.5), the IdP/application split (§5.4), and JWKS distribution (§9) are the conceptual scaffolding the code below assumes you understand.

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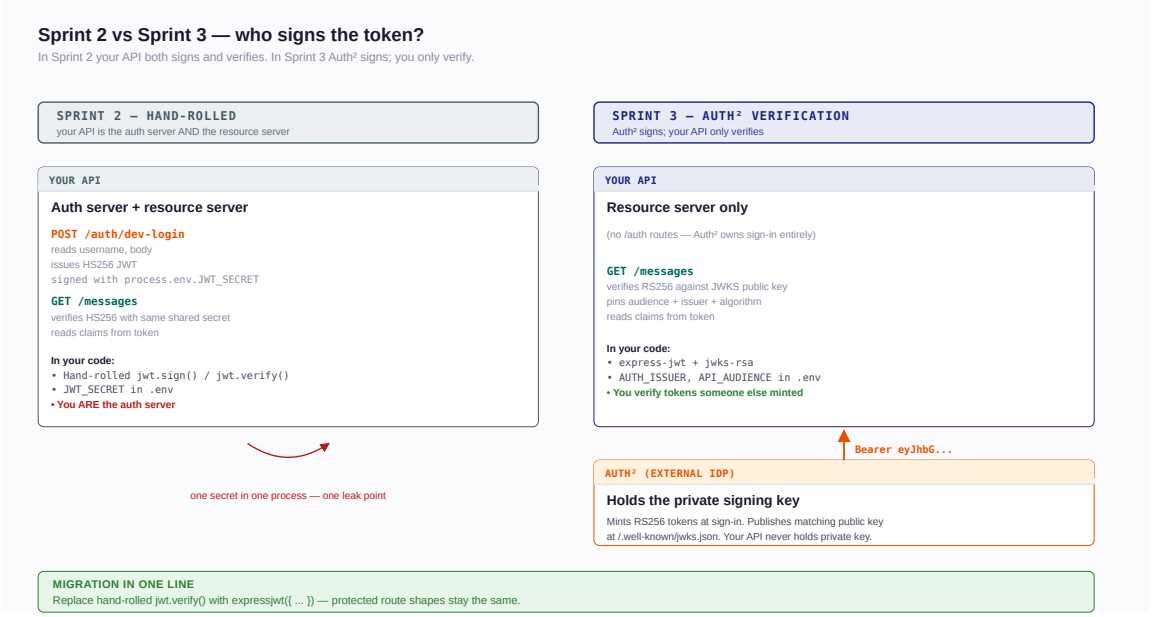
2 The Mental Model — Sprint 2 vs. Sprint 3

The single biggest shift between Sprint 2 and Sprint 3 is *who signs the token*. In Sprint 2 you signed it. In Sprint 3 someone else does, and you only verify.



Migration in one line: replace your hand-rolled `jwt.verify()` with `expressjwt({ ... })` from the `express-jwt` library, and replace your hand-rolled sign-in flow with "point users at Auth²." The shape of every protected route stays the same — only the middleware changes.

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3 Setting Up: Dependencies and Environment

3.1 Install the libraries

```
npm install express-jwt jwks-rsa
```

- **`express-jwt`** — Express middleware that verifies a Bearer JWT, decodes its claims, and attaches them to `request.auth`. It handles the cryptography and the standard claim checks (`exp`, `nbf`, `iss`, `aud`).
- **`jwks-rsa`** — A helper that fetches the IdP's JWKS, picks the right key for the token's `kid`, caches it, and hands `express-jwt` the public key on demand.

These two are designed to compose. `jwks-rsa` provides a `secret` function that `express-jwt` calls per-request to obtain the verification key.

3.2 Environment variables

Add two vars to your `.env`:

```
AUTH_ISSUER=https://tcss-460-iam.onrender.com
API_AUDIENCE=group-7-api
```

Replace `group-7-api` with **your group's** audience string — the one Auth² assigned to your tenant when your group's API client was registered. The default in backend-3's `.env.example` is `backend-3-messages`, which is backend-3's own audience as the lecture reference; your group's API has a different one.

> **Byte-exact strings**
>
> `AUTH_ISSUER` is compared byte-for-byte against the `iss` claim in incoming tokens. **No trailing slash.** The Auth² issuer URL is `https://tcss-460-iam.onrender.com` exactly. If you accidentally write `https://tcss-460-iam.onrender.com/`, every token your API receives will fail verification with "jwt issuer invalid."

You won't set a `JWKS_URI` env var — backend-3 derives it from `AUTH_ISSUER` in code (`${AUTH_ISSUER}/.well-known/jwks.json`). One less thing to misconfigure.

> **Try It Yourself**
>
> Open https://tcss-460-iam.onrender.com/.well-known/jwks.json in your browser. You'll see a JSON document with a `keys` array — those are the public keys Auth² uses to sign access tokens. Each key has a `kid` (key ID); the `kid` in your token's header tells the verifier which one to use. See concept reading §9 JWKS for the rotation story.

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4 The `requireAuth` Middleware

Backend-3's `src/middleware/requireAuth.ts` is short, and every line is doing real work. Here is the verification half — the role-gate helpers from the same file are covered in §6.

```
import { Request, Response, NextFunction, RequestHandler, ErrorRequestHandler
} from 'express';
import { expressjwt, type Request as JwtRequest } from 'express-jwt';
import jwksRsa from 'jwks-rsa';

export const ROLE_HIERARCHY = ['User', 'Moderator', 'Admin', 'SuperAdmin',
'Owner'] as const;
export type Role = (typeof ROLE_HIERARCHY)[number];

export interface AuthenticatedUser {
  sub: string;
  email?: string;
  role: Role;
  iat?: number;
  exp?: number;
  iss?: string;
  aud?: string | string[];
}

declare global {
  namespace Express {
    interface Request {
      user?: AuthenticatedUser;
    }
  }
}

const issuer = process.env.AUTH_ISSUER;
const audience = process.env.API_AUDIENCE;

if (!issuer || !audience) {
  throw new Error(
    'AUTH_ISSUER and API_AUDIENCE must be set. See .env.example for the Auth²
integration.'
  );
}

const verifyJwt = expressjwt({
  secret: jwksRsa.expressJwtSecret({
    jwksUri: `${issuer}/.well-known/jwks.json`,
    cache: true,
    cacheMaxAge: 10 * 60 * 1000,
    rateLimit: true,
    jwksRequestsPerMinute: 10,
  }),
  audience,
  issuer,
  algorithms: ['RS256'],
});
```

```
const attachUser = (request: JwtRequest, _response: Response, next:
NextFunction): void => {
  if (request.auth) {
    (request as Request).user = request.auth as AuthenticatedUser;
  }
  next();
};

const handleAuthError: ErrorRequestHandler = (error, _request, response, next)
=> {
  if (error && (error as { name?: string }).name === 'UnauthorizedError') {
    response.status(401).json({ error: 'Invalid or missing token' });
    return;
  }
  next(error);
};

export const requireAuth: Array<RequestHandler | ErrorRequestHandler> = [
  verifyJwt,
  attachUser,
  handleAuthError,
];
```

4.1 What each piece is doing

The role hierarchy is declared at the top as a `const tuple` so TypeScript can derive a literal-union `Role` type from it (`'User' | 'Moderator' | 'Admin' | 'SuperAdmin' | 'Owner'`). The order matters — index 0 is the lowest tier, index 4 is the highest. The role gates in §6 use that ordering directly.

The `AuthenticatedUser` interface describes the shape of the verified JWT claims. The `sub` claim is the only field guaranteed present; `email` is included by Auth² when available; `role` is the user's Auth² tenant role. The standard JWT claims (`iat` , `exp` , `iss` , `aud`) come along for the ride.

The `declare global` block augments Express's `Request` type so that downstream handlers can read `request.user` without a cast. This is the TypeScript convention for adding custom properties to library types — the augmentation merges with the library's own declarations at compile time.

The fail-fast block (`if (!issuer || !audience)`) runs at **module-load time** — Node executes it the first time the file is imported, before any request is served. If the env vars aren't set, the `throw` propagates out of the import and the process **fails to start** with a clear error in the boot logs. Without this guard, the misconfiguration would lurk silently until the first request hit a protected route, then surface as a confusing JWKS error inside the verifier. Failing loudly at startup is much cheaper to debug than failing per-request later.

The `verifyJwt` middleware is `express-jwt`'s engine. The `secret` field is unusual: instead of a static value, it's a *function* that `express-jwt` calls per-request to obtain the right verification key. `jwksRsa.expressJwtSecret(...)` returns that function and handles the JWKS fetch, the `kid` lookup, and the caching. The cache (10 minutes, 10 requests per minute max) keeps your API from hammering Auth² on every single request.

Why `algorithms: ['RS256']` is required. This is the algorithm-confusion defense. Without it, an attacker could craft a token whose header declares `alg: HS256`, sign it with the *public* key (which is, by design, public), and your verifier would happily use the same public key as an HMAC secret to recompute and accept it. See Week 5 reading §13.8. Pinning the algorithm lets the library reject any token whose header doesn't match.

`attachUser` copies `request.auth` (where `express-jwt` writes the verified claims) onto `request.user`. This isn't strictly necessary, but it gives downstream handlers a typed `request.user` instead of an `unknown`-ish `request.auth`. It's the line that makes the global type augmentation pay off.

`handleAuthError` turns `express-jwt`'s `UnauthorizedError` into a clean 401 JSON response. Without this, a bad token surfaces as Express's default HTML error page, which is unhelpful for an API.

The exported `requireAuth` is the array `[verifyJwt, attachUser, handleAuthError]`. Express handles arrays of middleware as if they were spread, so route definitions read as a single name: `router.get('/messages', requireAuth, handler)`.

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5 Subject-as-FK: The `resolveLocalUser` Pattern

`requireAuth` will tell you *who the bearer claims to be* (their `sub` and `role`), but it does not give you a row in your own database. For any route that needs a local User PK — to set `Message.authorId`, to look up app-specific preferences, to show "Hello, {displayName}" — you need to map the IdP's `sub` onto your local `User.id`. That's what `resolveLocalUser` does.

The conceptual frame is in Week 5 reading §5.4: the IdP owns identity, your app owns application data, and `sub` is the foreign key that joins them.

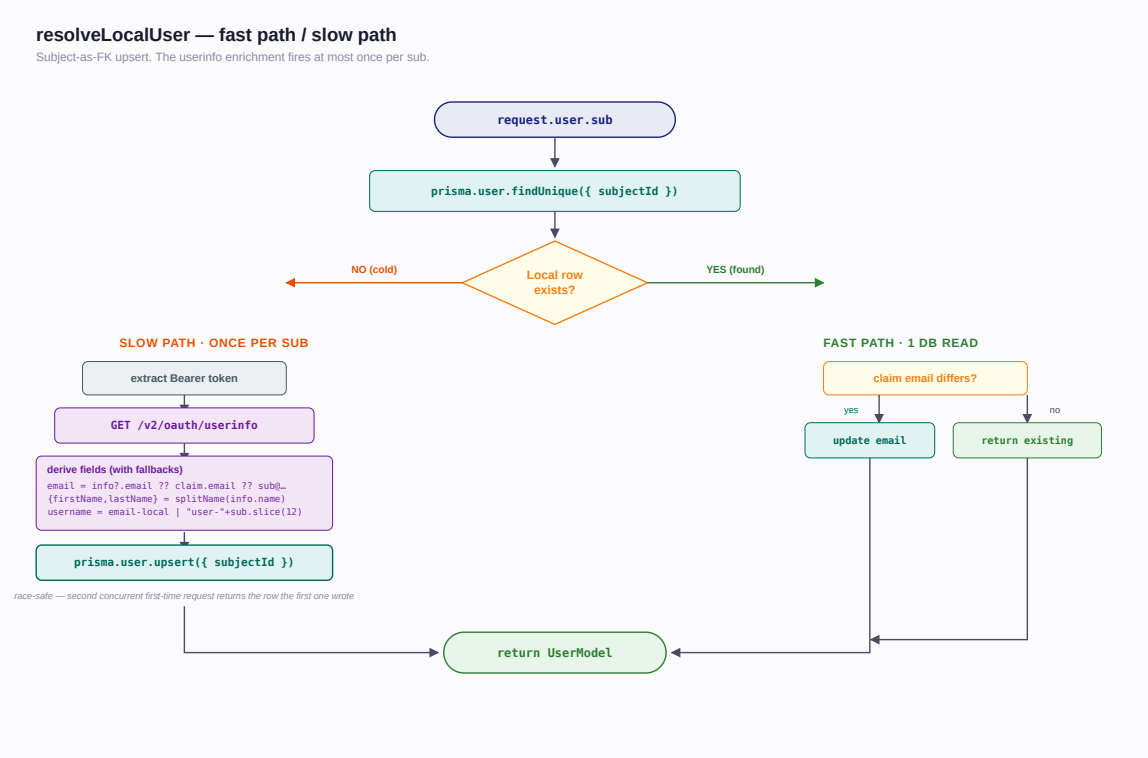
5.1 The helper

Backend-3's `src/auth/resolveLocalUser.ts`:

```ts
import type { Request } from 'express';
import { prisma } from '@/prisma';
import type { UserModel } from '@/generated/prisma/models';

/**
 * Upserts a local User row keyed by the Auth² `sub` claim, then returns it.
 * Call at the start of any handler that needs a local User PK — e.g. to set
 * as a foreign key on Message.authorId.
 *
 * A plain helper, not Express middleware — the DB write stays visible in the
 * handler body, and the auth middleware itself is side-effect-free.
 */
export const resolveLocalUser = async (request: Request): Promise<UserModel>
=> {
  const { sub, email: claimEmail } = request.user!;

  // Fast path: the local row caches the Auth² enrichment, so userinfo is
  // called at most once per sub — not per request.
  const existing = await prisma.user.findUnique({ where: { subjectId: sub }
});
  if (existing) {
    if (claimEmail && claimEmail !== existing.email) {
      return prisma.user.update({
        where: { subjectId: sub },
        data: { email: claimEmail },
      });
    }
    return existing;
  }

  const token = extractBearerToken(request);
  const info = token ? await fetchUserInfo(token) : undefined;

  const email = info?.email ?? claimEmail ?? `${sub}@placeholder.local`;
  const { firstName, lastName } = splitName(info?.name);
  const username =
    info?.username ?? (info?.email ? info.email.split('@')[0] :
`user-${sub.slice(0, 12)}`);

  // upsert (not create) to tolerate a race between two concurrent first-time
  // requests for the same sub.
  return prisma.user.upsert({
    where: { subjectId: sub },
    update: {},
    create: { subjectId: sub, username, email, firstName, lastName },
  });
};
```

5.2 How the code flows

`resolveLocalUser` has two paths — a fast path that hits the database once, and a slow path that runs the first time a particular `sub` is seen.



Fast path — the local row already exists. One database read, an optional email refresh if the JWT claim is newer than the local copy, and we return. The userinfo endpoint is *not* called. This is what every request after the first sees.

Slow path — no local row yet. We extract the same Bearer token the request arrived with, call Auth²'s `/v2/oauth/userinfo` to get a fuller profile (name, email, username if available), apply fallbacks for missing fields, and `upsert`. The `upsert` (rather than `create`) tolerates the race where two simultaneous first-time requests for the same `sub` both miss the cache and both try to insert; the second one finds the row the first one wrote and returns it.

The userinfo enrichment fires **at most once per `sub`**, not per request. After the first sign-in, the local row caches whatever Auth² gave us, and the fast path takes over.

5.3 Why it's a helper, not middleware

Two reasons.

First, **side effects belong in handlers**, not in middleware that runs on every protected request. Many routes don't need a local User row — a `GET /health` or a `GET /messages` that returns IDs only doesn't touch `User`. If `resolveLocalUser` were middleware, those routes would all do unnecessary database work on every request.

Second, **the DB write is part of the handler's contract**, not part of authentication. Reading the handler, you can see exactly when the upsert happens. If it fails — say, your DB is down —

the error surfaces on the route the user actually invoked, not as a confusing 500 from a middleware they didn't know existed.

Calling it from a handler looks like:

```
router.post('/messages', requireAuth, async (request, response) => {
  const user = await resolveLocalUser(request);
  const message = await prisma.message.create({
    data: { content: request.body.content, authorId: user.id },
  });
  response.status(201).json(message);
});
```

5.4 The userinfo response shape

When the user is new (no local row exists), `resolveLocalUser` calls Auth²'s `/v2/oauth/userinfo` endpoint with the same Bearer token the request arrived with. Auth² responds with:

```
{
  "sub": "12345",
  "email": "alice@example.com",
  "name": "Alice Anderson",
  "role": "User",
  "tenant": "tcss460-sp26"
}
```

Three things to notice. **`name` is concatenated** — Auth² stores firstName and lastName separately, but the userinfo endpoint returns them joined. Backend-3's `splitName()` re-splits on the first whitespace, falling back to `{ firstName: 'Unknown', lastName: 'User' }` when the name is empty.

There is no `username` field. Auth² doesn't expose username through userinfo today. Backend-3 derives a placeholder username from the email local-part (`alice@example.com` → `alice`) or from the `sub` itself (`user-abc123def456`) when neither email nor name is available.

The `role` here is the tenant role, not necessarily the same as the `role` claim in the access token — though they typically match. The token claim is what your API trusts for authorization decisions; the userinfo `role` is convenient for seeding your local row but should not be re-read on every request.

Try It Yourself

With a valid bearer token (see §8 for how to get one), curl the userinfo endpoint:

```
curl https://tcss-460-iam.onrender.com/v2/oauth/userinfo \
  -H "Authorization: Bearer <paste-your-token-here>"
```

You should see a JSON response with your `sub`, `email`, `name`, and `role`. This is the exact request `resolveLocalUser` makes on first sign-in.

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6 Role Gates — Three Helpers

Auth² emits a 5-tier role hierarchy in PascalCase, low to high:

```
User < Moderator < Admin < SuperAdmin < Owner
```

These are *Auth² tenant roles* — coarse-grained, IdP-issued, the same across every API in a tenant. App-specific permissions belong on your own User table, not in the JWT. (See Week 5 reading §5.4.)

Backend-3 ships three helpers in the same `requireAuth.ts` file, each suited to a different question:

6.1 `requireRole(role)` — exact match

```
export const requireRole = (role: Role): RequestHandler => {
  return (request, response, next) => {
    if (!request.user) {
      response.status(401).json({ error: 'Not authenticated' });
      return;
    }
    if (request.user.role !== role) {
      response.status(403).json({ error: 'Insufficient permissions' });
      return;
    }
    next();
  };
};
```

`requireRole('Admin')` admits **only** users with role `Admin`. A `SuperAdmin` or `Owner` will be rejected. This is rarely what you want for authorization, but it's useful for routes that target a

specific tier — say, a "manage admins" panel that should not be visible to Owners (who have a different panel).

6.2 `requireRoleAtLeast(minRole)` — minimum match

```
export const requireRoleAtLeast = (minRole: Role): RequestHandler => {
  const minIdx = ROLE_HIERARCHY.indexOf(minRole);
  return (request, response, next) => {
    if (!request.user) {
      response.status(401).json({ error: 'Not authenticated' });
      return;
    }
    const userIdx = ROLE_HIERARCHY.indexOf(request.user.role);
    if (userIdx < 0 || userIdx < minIdx) {
      response.status(403).json({ error: 'Insufficient permissions' });
      return;
    }
    next();
  };
};
```

`requireRoleAtLeast('Admin')` admits `Admin`, `SuperAdmin`, and `Owner`. **This is the gate you reach for first.** Most authorization rules read naturally as "this action requires at least an Admin," not "this action requires exactly an Admin."

The implementation closes over `minIdx` once at gate creation, so the per-request work is two array lookups and one comparison. No string comparison, no role list scan.

6.3 `hasRoleAtLeast(role, minRole)` — boolean predicate

```
export const hasRoleAtLeast = (role: Role | undefined, minRole: Role): boolean
=> {
  if (!role) return false;
  const userIdx = ROLE_HIERARCHY.indexOf(role);
  const minIdx = ROLE_HIERARCHY.indexOf(minRole);
  return userIdx >= 0 && userIdx >= minIdx;
};
```

This isn't middleware — it's a function that returns `true` or `false`. Use it inside a handler when the policy is "owner OR privileged," which can't be expressed as a single middleware gate.

```
router.delete('/messages/:id', requireAuth, async (request, response) => {
  const user = await resolveLocalUser(request);
  const message = await prisma.message.findUnique({ where: { id:
Number(request.params.id) } });

  if (!message) return response.status(404).json({ error: 'Not found' });
```

```
  // Anyone can delete their own; Moderators+ can delete anyone's.
  const isOwner = message.authorId === user.id;
  const isPrivileged = hasRoleAtLeast(request.user?.role, 'Moderator');

  if (!isOwner && !isPrivileged) {
    return response.status(403).json({ error: 'Forbidden' });
  }

  await prisma.message.delete({ where: { id: message.id } });
  response.status(204).end();
});
```

A middleware gate runs before the handler, so it can't see the resource being acted on. When the rule depends on the resource (ownership), the check has to happen *after* the resource is loaded. `hasRoleAtLeast` is the in-handler answer.

6.4 401 vs 403

The two helpers above return different status codes for different reasons. **401 Unauthorized** means *who are you?* — there's no `request.user` because authentication didn't run or didn't succeed. **403 Forbidden** means *I know who you are, but you can't do this* — authentication succeeded, but your role isn't sufficient. (Week 5 reading §5.2 covers the distinction.)

A common bug is returning 403 for both cases ("the user is *forbidden* from accessing without a token"). Don't — the codes are how clients distinguish "log in" from "ask for elevated access," and they signal different problems to operators reading server logs.

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7 Putting It Together — A Protected Route

Three example routes, in increasing order of authorization complexity.

7.1 Authenticated only

```
router.get('/messages', requireAuth, async (request, response) => {
  const messages = await prisma.message.findMany({
    orderBy: { createdAt: 'desc' },
  });
  response.json(messages);
});
```

Any signed-in user can list messages. No role check. No local-user resolution because the handler doesn't need a local User PK to read.

7.2 Authenticated + minimum role

```
router.delete(
  '/messages/:id',
  requireAuth,
  requireRoleAtLeast('Admin'),
  async (request, response) => {
    await prisma.message.delete({ where: { id: Number(request.params.id) } });
    response.status(204).end();
  }
);
```

`Admin`, `SuperAdmin`, or `Owner` can delete any message. `User` and `Moderator` are rejected with 403.

7.3 Authenticated + ownership-or-privilege

The example from §6.3 — a route where the role check depends on data loaded inside the handler:

```
router.delete('/messages/:id', requireAuth, async (request, response) => {
  const user = await resolveLocalUser(request);
  const message = await prisma.message.findUnique({ where: { id:
Number(request.params.id) } });
  if (!message) return response.status(404).json({ error: 'Not found' });

  const isOwner = message.authorId === user.id;
  const isPrivileged = hasRoleAtLeast(request.user?.role, 'Moderator');
  if (!isOwner && !isPrivileged) return response.status(403).json({ error:
'Forbidden' });

  await prisma.message.delete({ where: { id: message.id } });
  response.status(204).end();
});
```

7.4 The three responses to know

```
# Valid bearer token, sufficient role → 200
curl https://your-api.example.com/messages \
  -H "Authorization: Bearer <valid-token>"

# Missing or expired token → 401
curl https://your-api.example.com/messages
# { "error": "Invalid or missing token" }

# Valid token, insufficient role → 403
curl -X DELETE https://your-api.example.com/messages/1 \
```

```
  -H "Authorization: Bearer <user-tier-token>"
# { "error": "Insufficient permissions" }
```

Try It Yourself

Run backend-3 locally (or call your group's deployed API), grab a token from the Token Playground (§8), and exercise all three responses. The 403 is satisfying — you'll see your token validate cleanly and *still* get rejected because your role isn't high enough.

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8 Testing Without Re-Logging-In Constantly

Manually walking the OAuth2 redirect flow every time you want to test a curl command is a productivity disaster. The course ships a **Token Playground** that does the sign-in for you and hands you a copy-pastable access token.

Token Playground

https://tcss460-token-playground.onrender.com

Pick your group's audience from the dropdown, click **Sign In**, log in to Auth² in the popup, and the playground hands you back an access token + a Refresh button. Copy the token into Postman or your `Authorization: Bearer ...` header for curl. When the token expires (an hour after sign-in), click Refresh — no re-typing credentials.

First-time sign-in

The first time you use the Token Playground, you'll need to **create an Auth² account**. A few things worth knowing about this course's tenant:

- **Any email works.** There is no requirement to use your `@uw.edu` address — pick whatever you prefer.
- **Email verification is turned off.** Your account is usable immediately after signup; you won't get a "verify your email" link.
- **2FA is not enabled.** No authenticator app required for sign-in.

These relaxed settings are course-specific. A production Auth² tenant would normally require email verification (and often 2FA) before issuing tokens.

The playground is documented in detail in Sprint 3. For this guide, treat it as a black box: it's how you get a valid bearer token in your hands for testing your protected routes.

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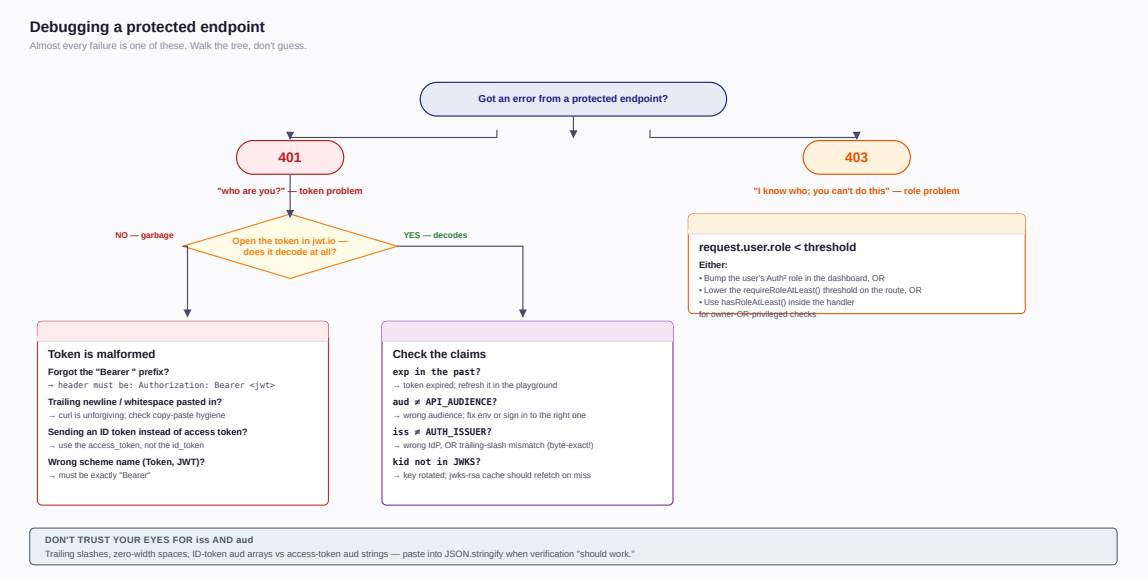
9 Debugging Failures

When a protected endpoint misbehaves, the answer is almost always one of a small handful of issues. The decision tree below covers them all.



9.1 Common errors and root causes

Symptom	Likely cause	Fix
`401 Invalid or missing token` on every request	Forgot `Authorization: Bearer ...` header, or wrong scheme name (`Token`, `JWT`)	Use exactly `Authorization: Bearer <jwt>`
`401`, token decodes fine on jwt.io	`aud` claim doesn't match `API_AUDIENCE` env var	Update `.env` to match the audience the token was issued for, or sign in against the correct audience

Symptom	Likely cause	Fix
`401`, token's `iss` looks right by eye	Trailing slash in `AUTH_ISSUER`	Remove the trailing slash. `iss` is byte-exact
`401`, started suddenly after no code change	Token expired (default 1 hour for Auth²)	Refresh the token in the playground, or sign in again
`500` on first request after deploy	`AUTH_ISSUER` or `API_AUDIENCE` not set in production env	Configure the env vars on your hosting platform; the boot-time `throw` will surface this loudly
`500` with "kid not found"	JWKS cache stale after an Auth² key rotation	The `jwks-rsa` cache (10 min) refetches automatically; if it doesn't, restart your server
`403 Insufficient permissions` for a user that should pass	Wrong gate — `requireRole('Admin')` instead of `requireRoleAtLeast('Admin')`	Use the "at least" gate unless you really mean exact-match

> **Don't trust your eyes for `iss` and `aud`**
>
> Strings that look identical sometimes aren't. A trailing slash, a zero-width space pasted from a doc, an `Aud` versus `aud`, an ID token's `aud` array versus an access token's `aud` string. When verification fails and you've eyeballed the values four times, paste them into `JSON.stringify` or compare byte lengths.

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10 What You Are NOT Doing (And Why)

A lot of the auth machinery you might *expect* to write is missing from this guide. That's intentional — Auth² owns those pieces, not you.

- **You are not implementing OAuth2 grant flows.** The authorization code flow with PKCE, the redirect dance, the consent screen — Auth² handles all of that. Your front-end (the Token Playground, your group's consumer app in later sprints) initiates it; your back-end never sees it. (Week 7 covers grant flows in depth — by then you'll already be using them.)

- **You are not storing passwords.** No bcrypt, no salt management, no password reset flow. Auth² owns user credentials globally; your app holds zero password material.
- **You are not minting tokens.** No `jwt.sign()`, no `JWT_SECRET` in your env, no `/auth/login` route. The authorization server has the private key. Your API only verifies.
- **You are not implementing refresh logic.** When an access token expires, the front-end exchanges its refresh token at Auth²'s `/token` endpoint to get a new access token. Your API just sees a stream of valid bearer tokens with sliding expiries. (Concept reading §4.6 for the why.)

What you *are* doing is verifying tokens and mapping `sub` to your own user records. That's it. The narrowness of the responsibility is the point — it's what makes auth-via-IdP scalable across many APIs in a tenant.

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11 Summary

Concept	Key Point
`requireAuth`	Verifies RS256 token via JWKS; pins `aud`, `iss`, `algorithms: ['RS256']`; attaches `request.user`
`AUTH_ISSUER`	Byte-exact issuer URL; **no trailing slash**; matches the `iss` claim
`API_AUDIENCE`	Your group's audience string; matches the `aud` claim; **note: `API_`, not `AUTH_`**
JWKS URL	Derived in code as `${AUTH_ISSUER}/.well-known/jwks.json`; no env var needed
`algorithms: ['RS256']`	Required — defends against `alg: none` and RS256→HS256 key confusion
`resolveLocalUser`	Helper, not middleware; upserts a local User row keyed by `sub`; called from handlers that need a User PK
Userinfo response	`{ sub, email, name, role, tenant? }`; `name` is concatenated; **no `username` field**

Concept	Key Point
Role hierarchy	`User < Moderator < Admin < SuperAdmin < Owner` (low → high)
`requireRole(role)`	Exact match; `Admin` does NOT admit `Owner`
`requireRoleAtLeast(minRole)`	Minimum-tier match; what you usually want
`hasRoleAtLeast(role, minRole)`	Boolean predicate for in-handler ownership-OR-privilege checks
401 vs 403	401 = no/bad token; 403 = valid token, insufficient role
Token Playground	`https://tcss460-token-playground.onrender.com` — get a bearer token without walking the OAuth flow

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12 References

Library Documentation:

- `express-jwt` — Express middleware that decodes Bearer JWTs and validates standard claims.
- `jwks-rsa` — JWKS client that pairs with `express-jwt` for asymmetric verification with caching.
- Express middleware guide — How Express composes middleware arrays.

Related Course Materials:

- Week 5 — Authentication & Authorization Concepts — Theory companion. The §4.5 audience/issuer story, §5.4 IdP/app split, §8 RS256 vs HS256 trust model, and §9 JWKS distribution are the conceptual base for this guide.
- Sprint 3 — Authentication & Authorization — Where students apply this guide to their own group's API.
- Auth Concepts — Common Mistakes — The §13.7 (audience/issuer) and §13.8 (algorithm confusion) entries map directly onto the verification options in this guide.

Standards & Specifications:

- RFC 7519 — JSON Web Token (JWT) — JWT structure and claim semantics.
- RFC 7517 — JSON Web Key (JWK) — The format published at `/.well-known/jwks.json`.
- OpenID Connect Core 1.0 — The userinfo endpoint contract.

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13 Further Reading

External Resources

- Auth0 — A look at the latest draft for JWT Best Current Practices — RFC 8725 distilled. The algorithm-pinning rationale lives here.
- `express-jwt` examples — More patterns (custom error handlers, conditional auth, token sources beyond the `Authorization` header).
- `jwks-rsa` configuration reference — Cache tuning, rate-limit knobs, key-rotation behavior.
- Aaron Parecki — OAuth 2 Simplified — Background on the grant flows you're *not* implementing here, useful for Week 7.

This guide is part of TCSS 460 — Client/Server Programming, School of Engineering and Technology, University of Washington Tacoma.