Shaking the MCP Tree: A Security Deep Dive

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Content

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All posts

In this post, I'll show you what happens when that tradeoff goes wrong. We'll look at how MCP servers handle authentication, why a feature called Dynamic Client Registration is often left wide open, and how attackers can exploit it. Then I'll walk you through real vulnerabilities I found along the way, from XSS to full-read SSRF. Let's dive in.

Understanding MCP Servers

Before we jump into the fun part (breaking things), let's take a moment to understand what we're actually dealing with. Trust me, once you get this, the attack will feel so much more satisfying!

What Even Is an MCP Server?

MCP stands for Model Context Protocol. Think of it like a middleman between AI and other apps.

Imagine you only speak English, and you need to talk to someone who only speaks Japanese. You'd need a translator, right? That's what MCP does, it translates between AI and apps like Slack, Google Drive, or Salesforce so they can understand each other.

Without MCP, AI assistants are stuck in a bubble. They can read what you type and write back, but they can't reach outside that bubble. They can't check your email, look at your files, or update your to-do list.

With MCP, the bubble pops. Now the AI can actually go out and do things for you.

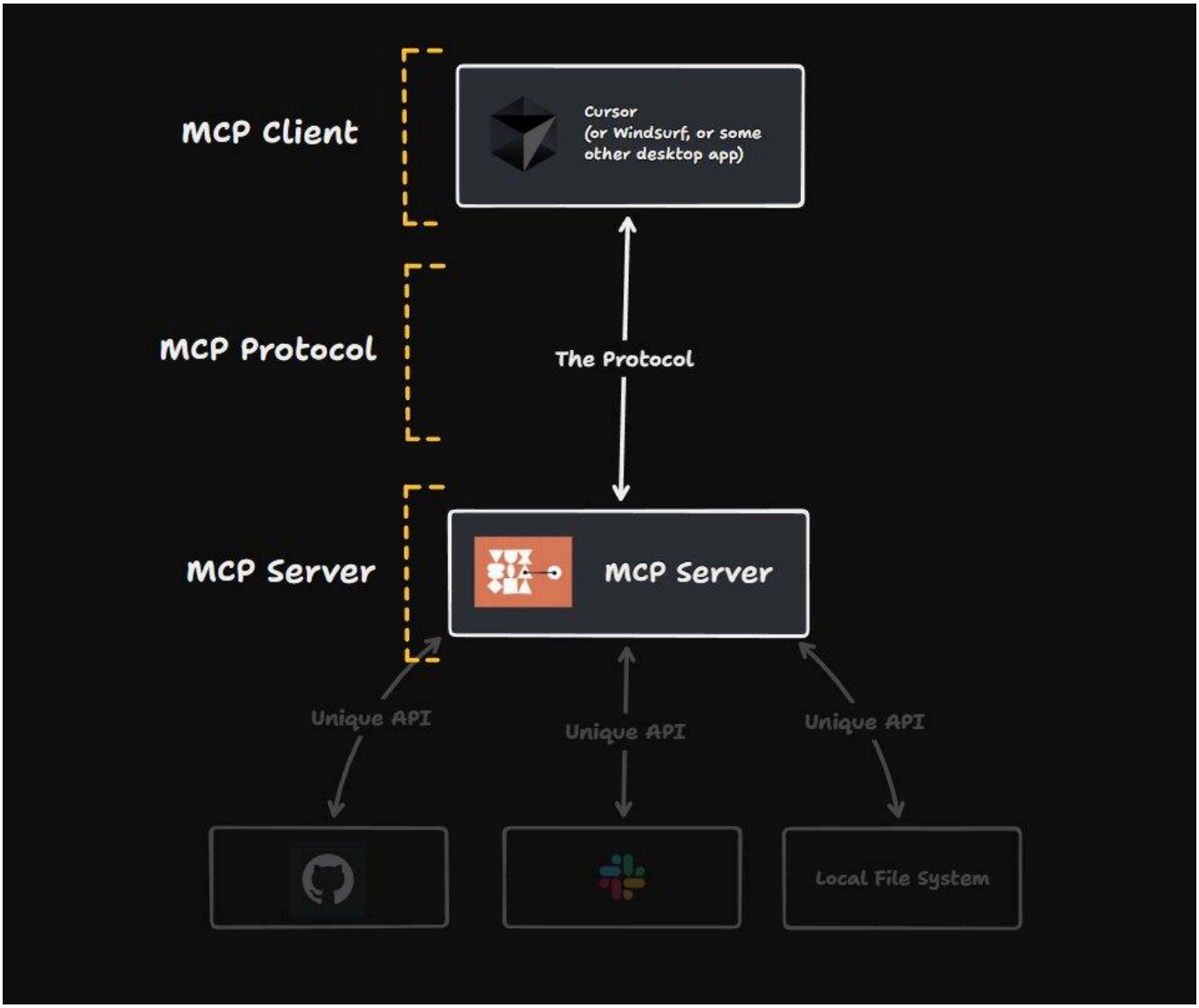
How Does It Work?

Let's say you ask Claude: "What meetings do I have tomorrow?"

- Claude realizes it needs your calendar data, which it doesn't have

- Claude calls the Google Calendar MCP server
- The MCP server logs into your calendar, grabs tomorrow's meetings, and organizes the info
- It sends everything back to Claude in a format Claude understands
- Claude shows you your schedule

You just see the answer. All the behind-the-scenes work happens automatically.



How Do MCP Servers Handle Authentication?

Okay, here's where things start to get spicy. Most MCP servers use OAuth 2.0 for authentication. That's totally normal and expected. But here's the fun part: a lot of them leave **Dynamic Client Registration wide open**.

What does that mean? Anyone can register as an OAuth client. No approval process. No verification. Just automatic access. Why would they do this? Flexibility. They want any AI tool to connect quickly and easily, without jumping through hoops.

But as we all know, when convenience beats security... hackers get happy!

Dynamic Client Registration: The Unlocked Door

This is important, so let's break it down. Understanding this will make the attacks later make way more sense.

The Old-School Way

Traditionally, if you wanted to become an OAuth client, you had to go through a manual process. You'd fill out forms, maybe wait for someone to review your application, and eventually get your `client_id` and `client_secret`.

The service provider knows exactly who you are. They control which redirect URIs you can use. They can kick you out anytime they want.

Is it annoying? Yes. Is it slow? Absolutely. But is it secure? You bet.

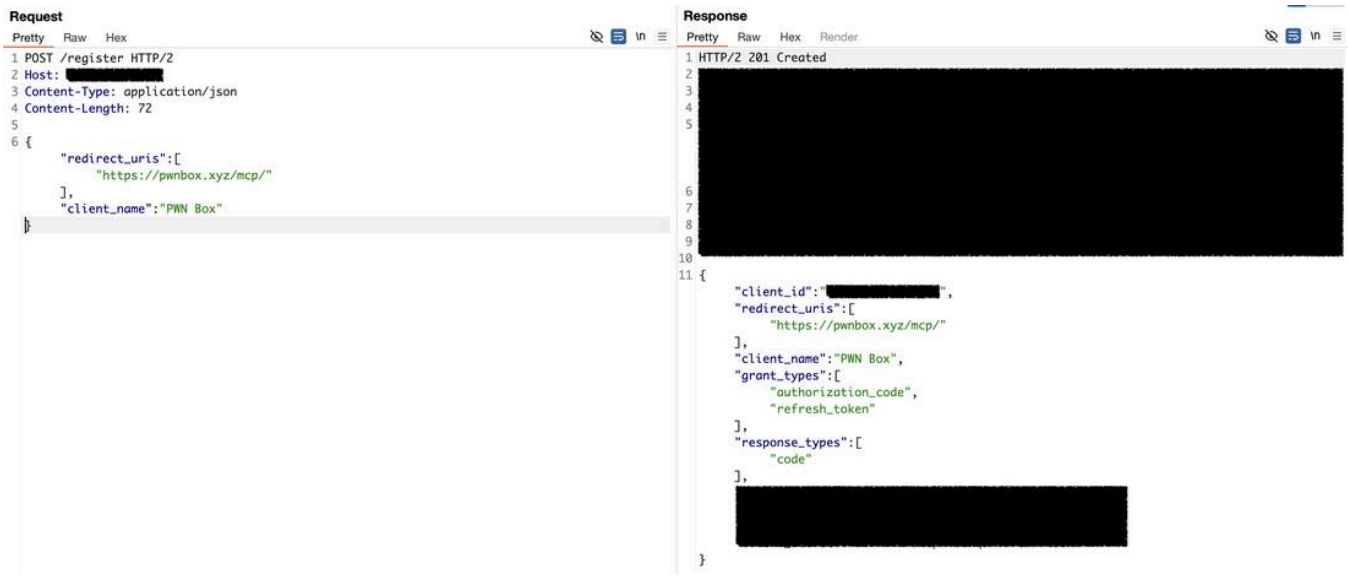
Then Came RFC 7591

Dynamic Client Registration (DCR) threw all that out the window.

Instead of begging for approval, clients can now register themselves automatically. Just hit the registration endpoint (`/register`) with a POST request containing your client details:

```
{
  "redirect_uris": ["https://legit-app.com/callback"],
  "client_name": "Totally Legit App",
  "token_endpoint_auth_method": "none",
  "grant_types": ["authorization_code", "refresh_token"],
  "response_types": ["code"]
}
```

And just like that, you get a shiny new `client_id` (and sometimes a `client_secret` too). No questions asked. No humans involved. Fully automatic.



So, let's move to detection phase.

Detecting Open DCR at Scale

Alright, we know what DCR is. But how many MCP servers actually leave it wide open? Time to find out.

Manual testing doesn't scale, so I wrote a Nuclei template to automate the whole discovery process. The idea is simple: send client data to the registration endpoint and report back if it works.

But first – where do we even find these registration endpoints?

OAuth and OIDC servers expose their configuration through well-known URIs. RFC 8414 defines `/.well-known/oauth-authorization-server` for OAuth 2.0 servers, while OpenID Connect uses `/.well-known/openid-configuration`. Both return a JSON document containing all the server's endpoints, and if DCR is supported, you'll find a `registration_endpoint` field sitting right there.

So the template first hits these well-known paths, extracts the `registration_endpoint` from the response, then fires a POST request with minimal client metadata, just a name, redirect URI, and grant type.

```yaml
id: open-dcr-detection

info:
  name: Open Dynamic Client Registration Detection
  author: amirmsafari
  severity: info

requests:
  - method: GET
    path:
      - "{{BaseURL}}/.well-known/openid-configuration"
      - "{{BaseURL}}/.well-known/oauth-authorization-server"

    stop-at-first-match: true
    extractors:
      - type: json
        name: registration_endpoint
        internal: true
        json:
          - ".registration_endpoint"

  - method: POST
    path:
      - "{{registration_endpoint}}"

    headers:
      Content-Type: application/json

    body: |
      {
        "client_name": "Example App",
        "redirect_uris": ["https://example.com/callback"],
        "grant_types": ["authorization_code"],
        "response_types": ["code"]
      }

    matchers:
      - type: status
        status:
          - 200
          - 201

      - type: word
        part: header
```

```
    words:
      - "application/json"

  - type: word
    part: body
    words:
      - "client_id"
```

```
amir@home:~/mcp$ nuclei -t oidc-dcr.yaml -l subdomains.txt

                     __     _
   ____  __  _______/ /__  (_)
  / __ \/ / / / ___/ / _ \/ /
 / / / / /_/ / /__/ /  __/ /
/_/ /_/\__,_/\___/_/\___/_/   v3.4.1

                projectdiscovery.io

[INF] Supplied input was automatically deduplicated (1 removed).
[WRN] Found 1 templates loaded with deprecated protocol syntax, update before v3 for continued support.
[INF] Current nuclei version: v3.4.1 (outdated)
[INF] Current nuclei-templates version: v10.3.8 (latest)
[WRN] Scan results upload to cloud is disabled.
[INF] New templates added in latest release: 457
[INF] Templates loaded for current scan: 1
[WRN] Loading 1 unsigned templates for scan. Use with caution.
[INF] Targets loaded for current scan: 154
[INF] Running httpx on input host
[INF] Found 153 URL from httpx
[oidc-dcr] [http] [info] https://                    auth/register
[oidc-dcr] [http] [info] https://                    ister
[oidc-dcr] [http] [info] https://                    ter
[oidc-dcr] [http] [info] https://                    register
[oidc-dcr] [http] [info] https://                              /register
[oidc-dcr] [http] [info] https://                    oauth/register
[oidc-dcr] [http] [info] https://                    idc/register
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[oidc-dcr] [http] [info] https://                                  /register
```

Now it's time to manually exploit each of findings.

Hunting for Bugs in Open DCR Endpoints

Now let's get into the good stuff, finding vulnerabilities!

Quick note: the attack techniques I'm about to show you aren't brand new. People have been poking at Open DCR and authorization servers for years. PortSwigger wrote a great article about th is back in 2021 if you want some background reading.

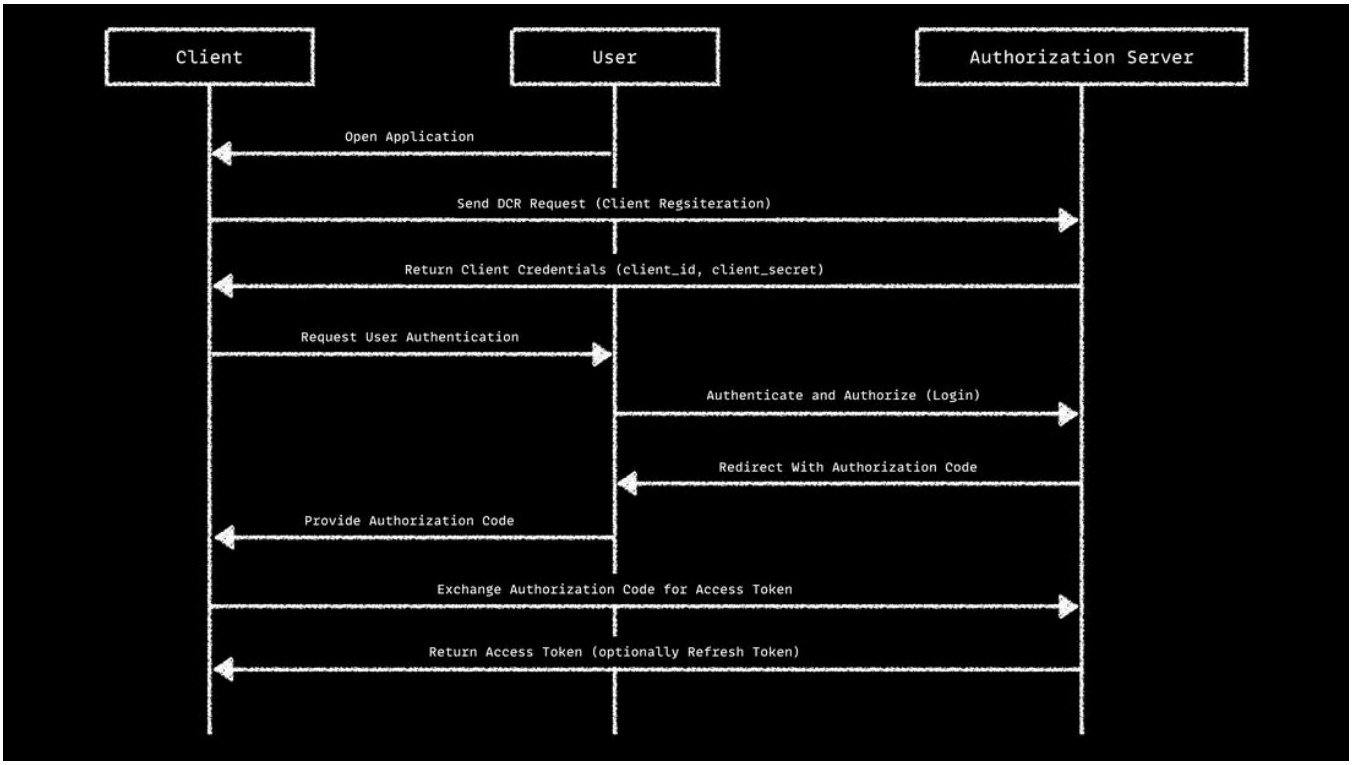
So what's different now? MCP servers. They've made these DCR endpoints way more common, which means more targets and better chances of finding something juicy. Here are some vulnerabilities I discovered during my hunt.

Client-Side Redirect Gadget, DOM-Based XSS

Once your client is registered with the authorization server, you now have your `client_id` and `client_secret`. The next step is the **authorization endpoint**, which handles three key responsibilities:

- **Authenticates the user**: verifies their identity, typically through a login form
- **Shows a consent screen**: prompts the user to approve the requested permissions (if required)
- **Redirects back to your application**: sends the user to your registered `redirect_uri` with an authorization code

The diagram below illustrates this complete flow:



Here's the key question: *How does that final redirect from user to client happens?*

If the server handles the redirect on the client side (using JavaScript), we might have a problem. Why? Because maybe we can register a client with a `javascript:` scheme as the redirect URI!

The Attack

- Register a client with `javascript:alert(location.origin);//` as the redirect URI
- Send a victim to the authorization URL:

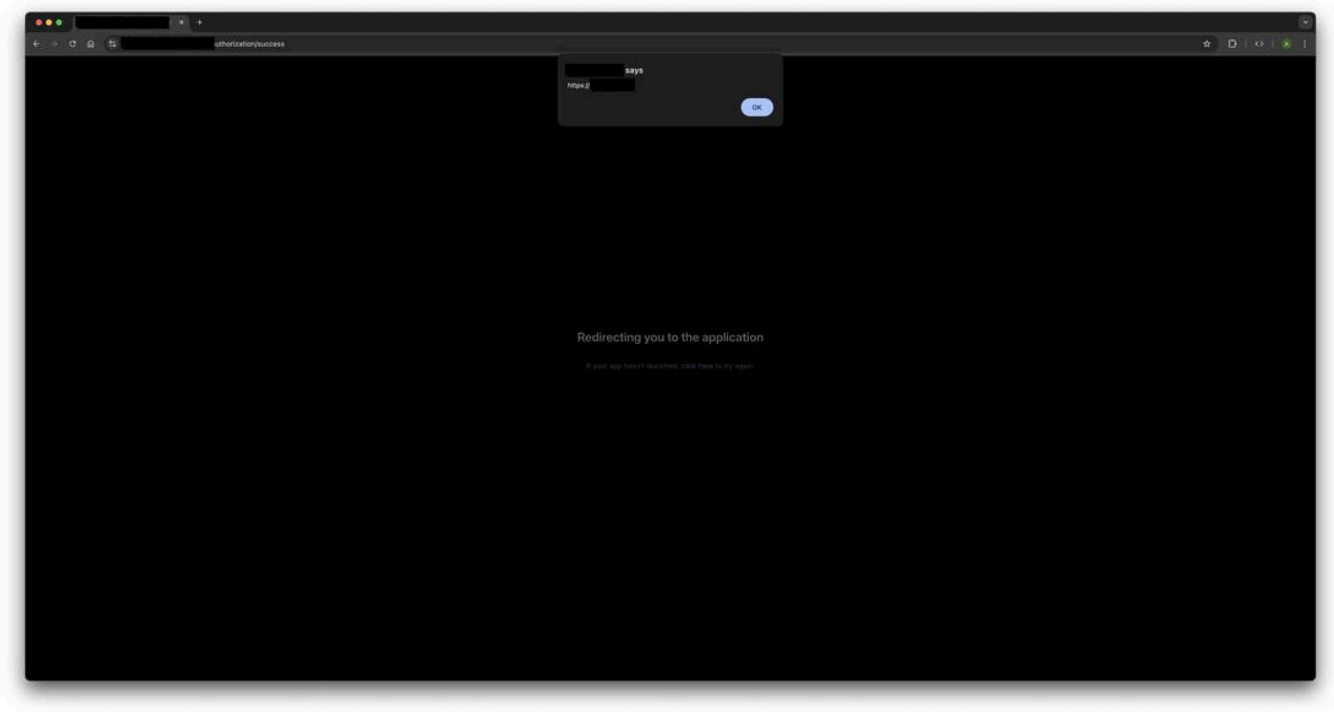
```
https://mcp.company.tld/authorize
  ?response_type=code
  &client_id=<client_id>
  &redirect_uri=javascript:alert(location.origin);//
  &scope=read+write
  &state=random
  &code_challenge=<code_challenge>
  &code_challenge_method=S256
```

- Once the user completes authorization, the app tries to redirect them back to the client. But instead of a normal URL, it triggers our JavaScript payload

Some applications try to be smart about this. They extract the hostname from the URL and validate it. But I use this payload to bypass them:

```
javascript://pwnbox.xyz/%0aalert(location.origin);//
```

This tricks the validator into thinking `pwnbox.xyz` is the hostname, but the browser still executes our JavaScript.

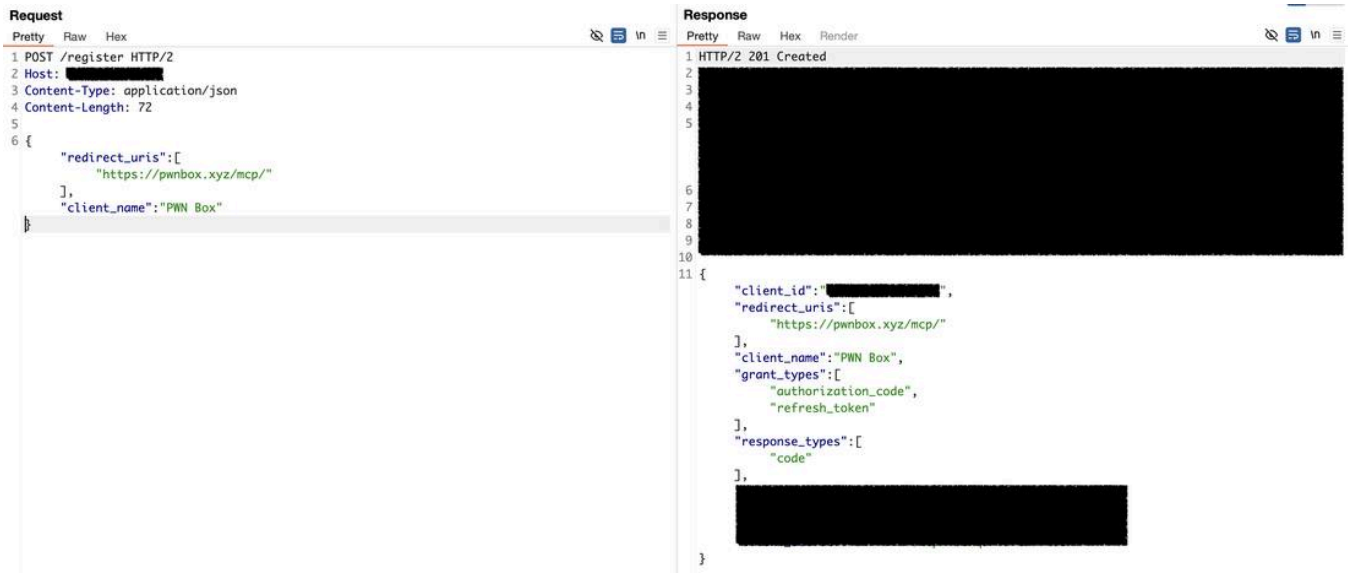


OAuth Consent Screen Gadget, Stored XSS

You know that screen that pops up asking "Do you want to allow this app to access your account?" That's the OAuth consent screen, and it's a goldmine for XSS hunters.

The consent screen usually displays information about the client requesting access: the app name, logo, description, and sometimes the redirect URI. All of this data comes from the client registration we control!

While exploring different authorization servers, I stumbled upon one that reflected the `redirect_uri` directly inside a `<script>` tag on the consent page.



My eyes lit up. If I can inject into a script tag, I can break out of it! I registered a client with this redirect URI:

```
https://pwnbox.xyz/mcp/</script><script>alert(location.origin)</script>
```

The `</script>` closes the existing script tag, and then my payload executes.

Missing or Confusing Consent Screen, OAuth Misuse

The consent screen we mentioned earlier? Some authorization servers just skip it entirely or don't mention the client information.

During my research, I found *a* lot of authorization servers that don't show any consent screen at all. Here's what happens:

- User clicks a authorize link
- They authenticate with their credentials
- The server immediately redirects them to the `redirect_uri`, no questions asked

See the issue? The user never gets a chance to see *which* application is requesting access. They just log in and their authorization code gets sent straight to wherever we specified.

If an attacker registers a malicious client with their own `redirect_uri`, they can trick users into giving up account access with just one click. The victim thinks they're logging into something legitimate, but their auth code ends up in the attacker's hands.

Even when consent screens *do* exist, some of them are so vague or confusing that users have no idea what they're actually approving. If the screen doesn't clearly show which client is requesting access, it's almost as bad as having no screen at all.

(If you want to dive deeper into this type of attack, this blog post covers it really well!)

Other Attack Vectors Worth Trying

Like I mentioned earlier, open DCR in authorization servers is a well-known attack surface. Security researchers have been poking at this stuff for years, and there's a ton of great content out there if you want to go deeper.

Here are some other attack types you might want to try on your targets:

- **CSRF on the consent page** – Can you trick users into approving authorization requests without realizing it?
- **SSRF via the `logo_uri` field** – When you register a client, you can specify a logo URL. What if the server fetches that image from an internal network?
- **Session poisoning to steal authorization codes** – Messing with session handling to hijack code from legitimate client

Unfortunately, I didn't have any luck finding these vulnerabilities on the authorization servers I tested. But hey that doesn't mean they're not out there! So go ahead, read up on these techniques, and try them on your targets. You might have better luck than me ;)

Going Beyond Authentication Attacks

So far, we've focused on hijacking tokens and stealing user sessions. But open DCR in MCP servers opens up another interesting avenue worth exploring.

Direct Access to the MCP Server

If we can register our own OAuth client, we can complete the full authentication flow ourselves:

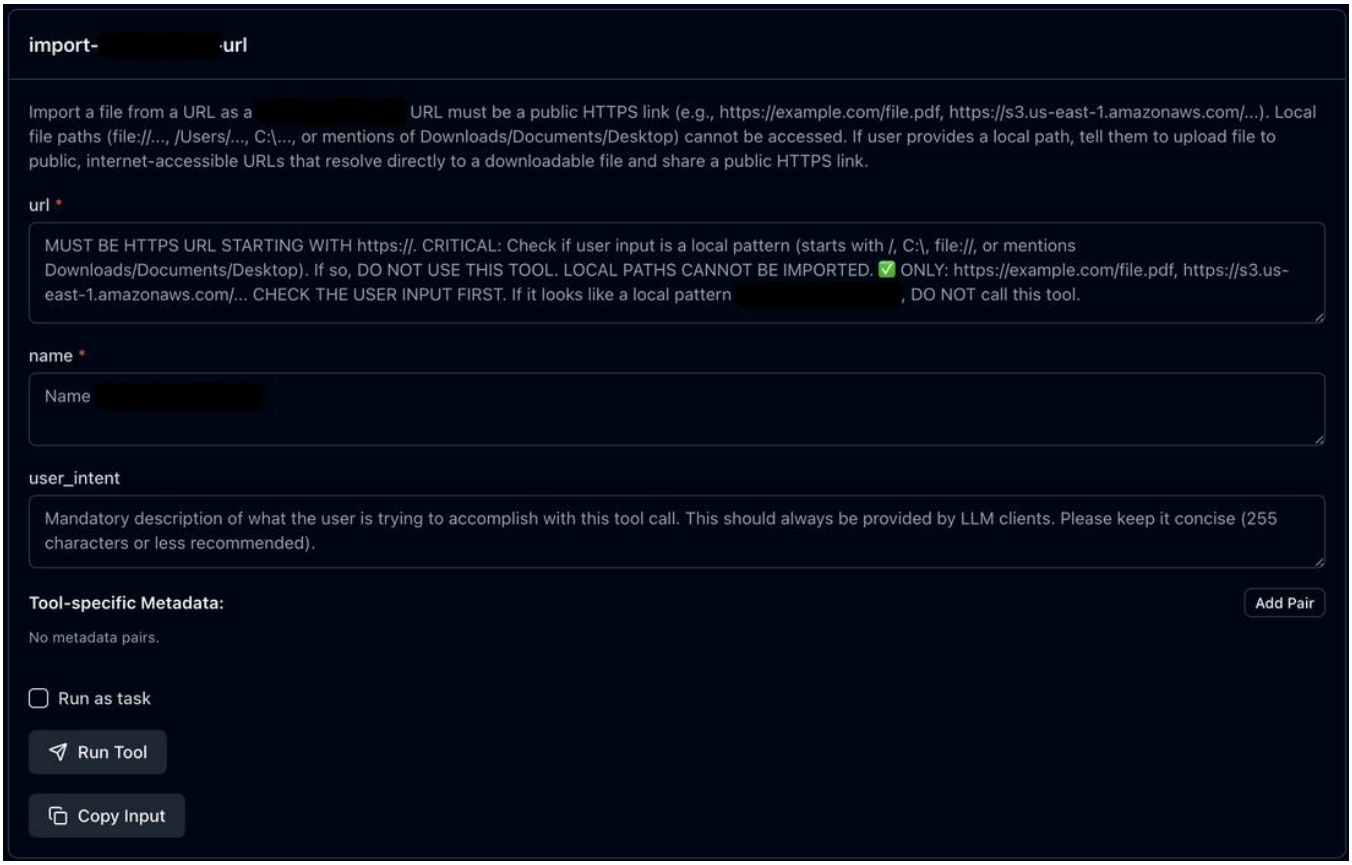
- Register a client with our `redirect_uri`
- Get the authorization code
- Exchange that code for an access token
- Connect directly to the MCP server as a legitimate client

So why does this matter?

MCP Servers Weren't Built to Handle Attackers

MCP servers are designed to interact with AI assistants, not humans probing them manually. Developers often assume that AI clients will behave predictably and follow the intended usage patterns.

For example, look at this tool from an MCP server that imports projects from a URL. Notice how it instructs the AI not to use local links:



These instructions work fine for AI assistants that follow rules. But as direct users of the MCP server, we're not bound by these guidelines. We can call any tool and provide whatever input we choose, including inputs the developers never anticipated.

Even when token hijacking fails due to the server restricting redirect URIs to specific domains, this technique remains useful. During my research, I found an authorization server for an MCP integration that only allowed `chatgpt.com` as a redirect URI. I couldn't register my own redirect_uri. However, I could still register a client with the allowed `chatgpt.com` URI, initiate the auth flow, capture the authorization code from the redirect, and exchange it for an access token myself.

The result? Direct access to the MCP server which is designed only for ChatGPT. From there, I could interact with all the available tools and methods without any AI-imposed restrictions.

Connect To A MCP Server

Once authentication is complete and you're redirected back to the client, you'll have an authorization code. The next step is exchanging that code for an access token.

Step 1: Exchange the Code for an Access Token

Send the following request to the token endpoint, filling in your registered client details:

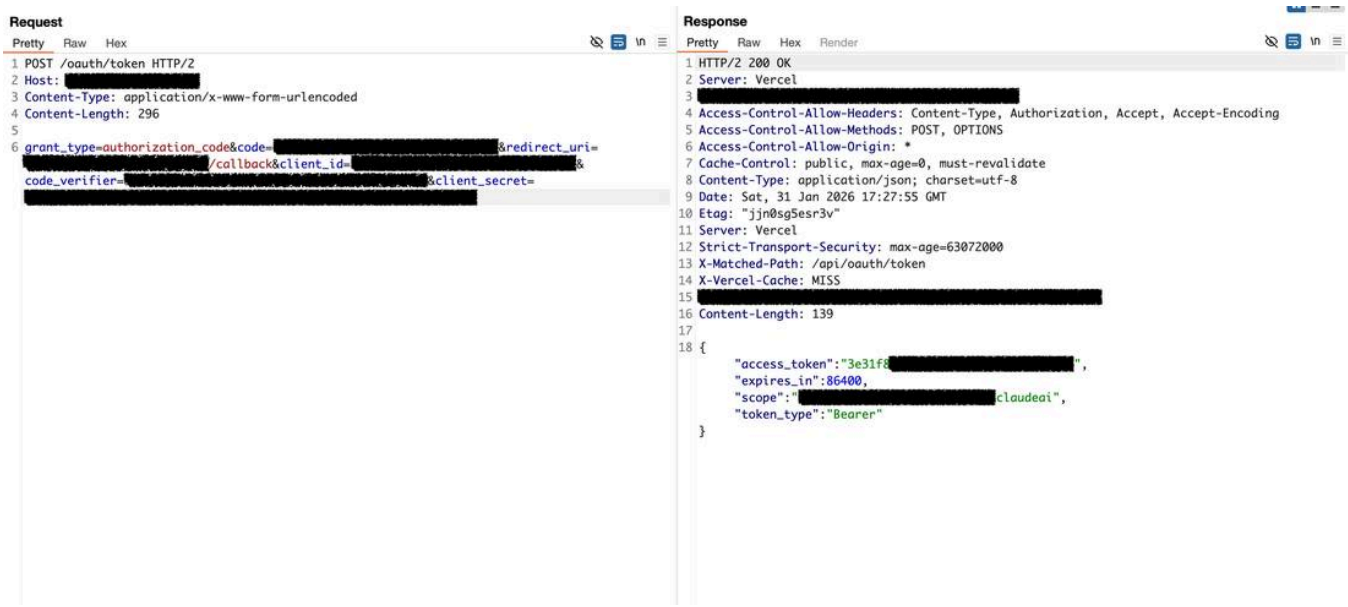
```
POST /oauth/token HTTP/2
Host: mcp.company.tld
Content-Type: application/x-www-form-urlencoded
Content-Length: 296

grant_type=authorization_code
&code=<code>
&redirect_uri=<redirect_uri>
&client_id=<client_id>
&code_verifier=random
&client_secret=<client_secret>
```

A few notes on these parameters:

- `code`: The authorization code you received in the redirect
- `code_verifier`: The original random string you generated before creating the `code_challenge` (this is part of PKCE)
- `client_secret`: Include this only if you received one during client registration, some servers don't require it
- `redirect_uri`: The client `redirect_uri`

If everything is correct, you'll receive an access token in the response.



Step 2: Install MCP Inspector

Now that you have an access token, you can connect to the MCP server using a tool called MCP Inspector. This tool provides a user-friendly interface for interacting with MCP servers directly.

Install and run it with the following command:

```
npx -y @modelcontextprotocol/inspector npx @playwright/mcp@latest
```

This will start a local web interface, typically available at `http://localhost:6274`

Step 3: Configure the Connection

In the MCP Inspector panel, you'll need to configure the following settings:

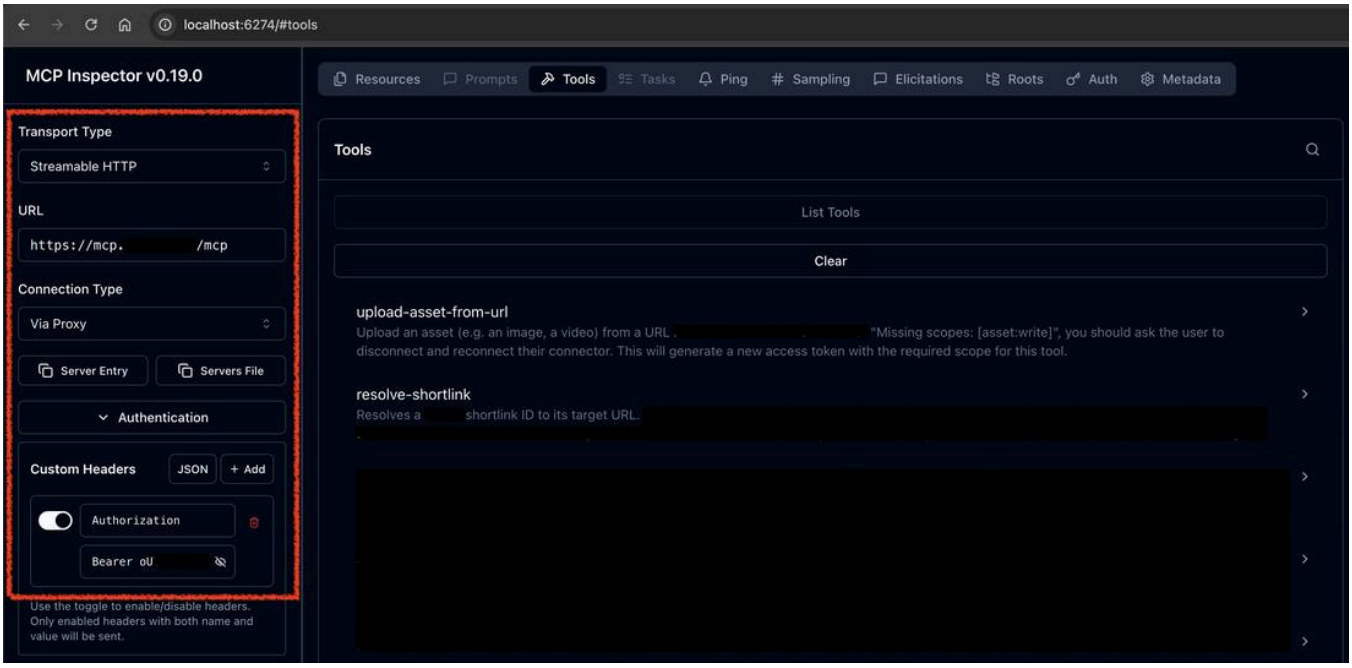
- **MCP Server URL**: Enter the full URL of the MCP endpoint. Common paths include:
- `/mcp` – for Streamable HTTP transport
- `/sse` – for Server-Sent Events transport
- **Transport Type**: Select the appropriate transport based on the endpoint:
- Choose **Streamable HTTP** if the endpoint uses `/mcp`
- Choose **SSE** if the endpoint uses `/sse`
- **Authentication**: MCP servers typically use Bearer token authentication. In the authentication header field, enter:

```
Bearer <your_access_token>
```

- Click **Connect** to establish the connection.

Step 4: Explore the Tools

Once connected, navigate to **Tools** **List Tools** to see all available tools and their expected inputs. You can browse through them and test each one directly.

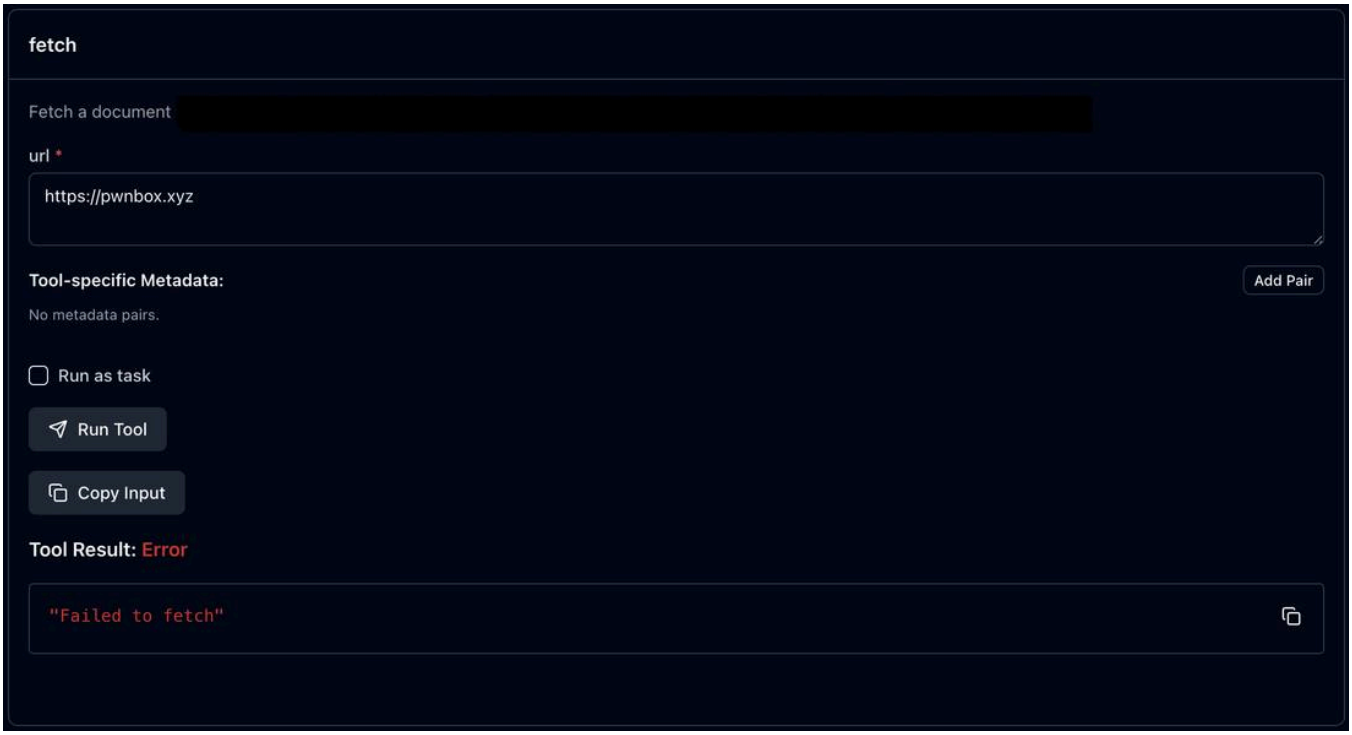


Discovering a Full-Read SSRF Vulnerability

So there I was, poking around an MCP server and loading up its tools, when one particular tool caught my eye. This little guy takes a document URL, fetches it, converts the response to Markdown, and hands it back to you. Neat, right? Naturally, my first thought was: *"Can I make it fetch my site?"* Classic SSRF vibes.

First Attempt: The Easy Way

I tried pointing it at my own domain to see what would happen. No luck, it spat back this error:



Okay, fair enough. The server was being picky about which URLs it would accept.

Finding the Rules

Next, I tried a legitimate document URL from the target website, something like:

```
https://company.tld/documents/{document-id}
```

This worked! So I started figuring out the rules. Turns out, the server had a strict whitelist that only allowed URLs matching `https://company.tld/documents/.*`. I tried a bunch of tricks to bypass the domain check, but nothing worked. This thing was locked down tight.

The Path Normalization Trick

At this point, the only thing on my mind was: *"I need to find an open redirect somewhere on this website."* If I could find one, I could chain it with the SSRF to redirect requests to any host I wanted.

But here's the problem, I was stuck inside the `/documents` path. Finding an open redirect in the documentation section is so hard or even impossible. So What if I could escape the `/documents` folder first?

I tested whether the server handles path normalization differently than it validates URLs. I crafted this payload:

```
https://company.tld/documents/..%2Fdocuments%2F{document-id}%23
```

And it worked! The server loaded the same content as before. This confirmed I could use `../` to climb out of the `/documents` folder and access other parts of the website. Now the whole site was my playground, and finding an open redirect became way easier.

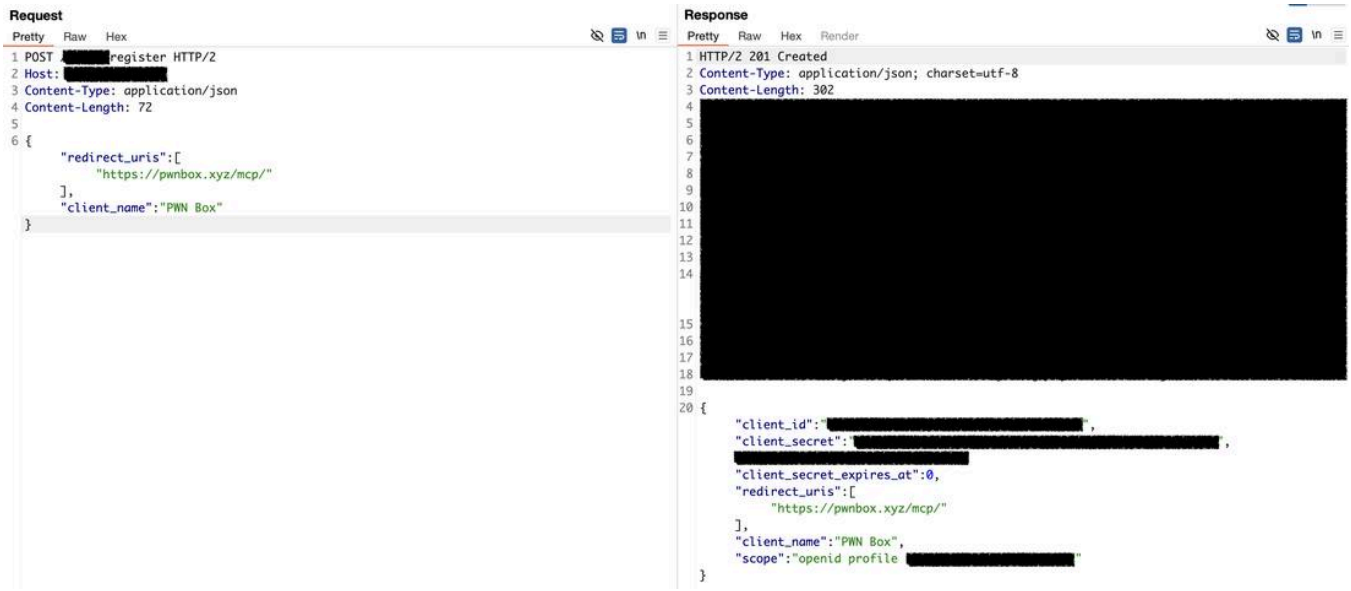
Dynamic Client Registration: My Secret Weapon

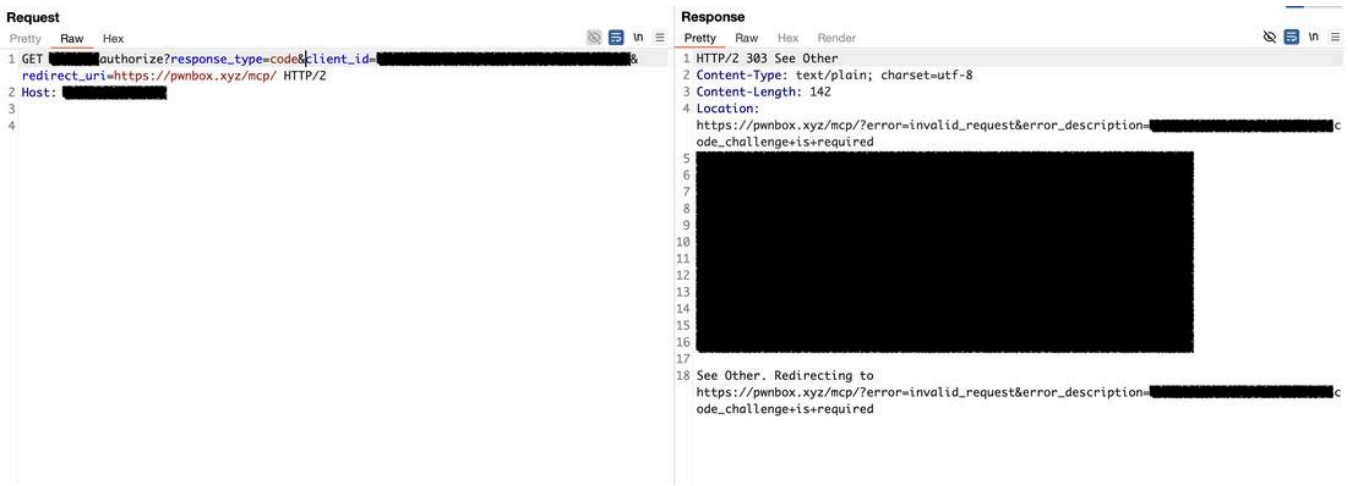
Here's where things get fun. I needed an open redirect, and OAuth's dynamic client registration feature gave me exactly that.

According to RFC 6749 (Section 4.1.2.1), when an OAuth request fails, the authorization server redirects the user back to the client's `redirect_uri` with an error message. Something like:

```
HTTP/1.1 302 Found
Location: https://client.example.com/cb?error=access_denied&state=xyz
```

The key insight? I could register a new OAuth client with *any* `redirect_uri` I wanted, including my own server. Then, by triggering an error, I'd get a open redirect!





Putting It All Together

Now I had all the pieces. I combined the path normalization bypass with my open redirect gadget to create this payload:

```
https://company.tld/documents/..%2Fredacted%2Fauthorize%3Fresponse_type=code%26client_id=<CLIENT_ID>%26redirect_
```

This made the server:

- Accept the URL (because it starts with the whitelisted path)
- Normalize the path and hit the OAuth endpoint
- Follow the redirect to my server

Full SSRF achieved! After that I redirect server to the localhost and did some port scanning and discovered an application running on port 8080. Even better, it had a Swagger API endpoint, and I could read all the client data through it!

Conclusion

MCP servers sit at a critical point between AI and the real world. They handle authentication, manage permissions, and give AI assistants the power to take real actions. That responsibility comes with risk.

Open Dynamic Client Registration was designed for flexibility, but as we've seen, it opens the door to XSS, token theft, SSRF, and direct access to tools that were never meant for manual interaction. The vulnerabilities are there – waiting to be found.

If you're building these integrations, think carefully about who can register as a client and what they can access. And if you're a security researcher, MCP servers are fresh ground worth exploring. Start shaking those trees.

Happy hacking!
