Strings & bytes in Python 3

You are building an exploit and, not being a barbarian, have switched from Python 2 to 3. One part of your exploit involves leaking an important address by dumping a chunk of memory. This chunk of memory contains a lot of random data but somewhere in the middle you know that there is a string "Här: "[1] followed by the 4 bytes representing the little endian encoding on the address you are looking for. You copy some old Python 2 code that you have used for a similar situation:

```
def extract_leaked_pointer(leak):
    marker = 'Här: '
    start = leak.find(marker)
    leak_start = start + len(marker)
    leak_data = leak[leak_start:leak_start+4]
    return struct.unpack('<Q', leak_data)[0]
```

Sadly, when running this, you get the following error:

```
TypeError: argument should be integer
 or bytes-like object, not 'str'
```

To solve this, you try to decode the leaked bytes into a string by adding this line to the code:

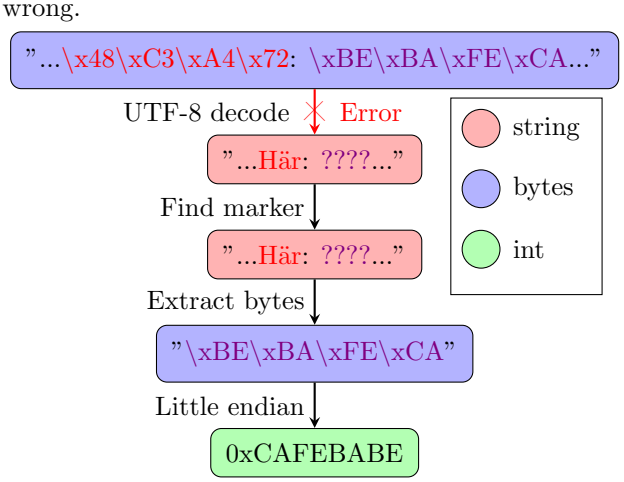
```
leak = leak.decode('utf-8')
```

Unfortunately, this doesn't work either and you are left staring at another error message:

```
UnicodeDecodeError: 'utf-8' codec can't
 decode bytes in position 0-1: invalid
 continuation byte
```

In ~~anger~~ your desire to develop as hacker, you turn to ~~Twitter and complain about how Python 3 sucks~~ this article to understand how to reason about Python 3, strings, character encodings and arbitrary bytes.

The problem is that you are trying to interpret an arbitrary sequence of bytes as UTF-8 encoded data. This is the equivalent of trying to push a square peg through a round hole. It won't work. The following diagram shows what you are trying to do and where it goes wrong.



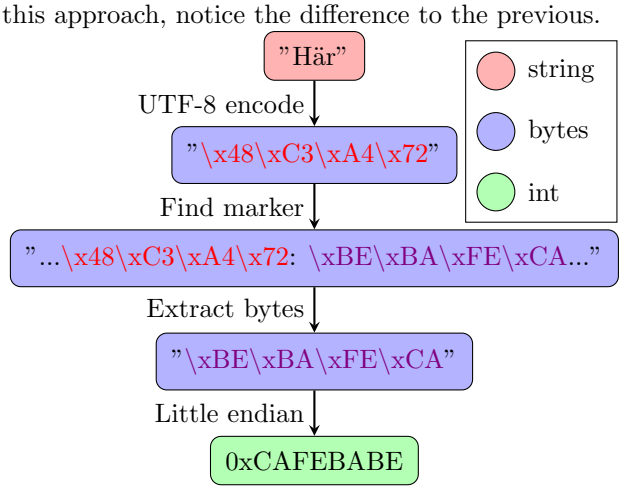
[1] Swedish for "here"

Let's remind ourselves on how character encodings work. The end goal is to represent a character such as "A". Computers work with numbers (more precisely bits) and not characters so we translate the character into a number. In the ASCII encoding, this translates to the number 65. We call this the codepoint. This codepoint is then encoded using a single byte 0x41. This is simple because there is a one to one to one mapping between characters, codepoints and bytes and can this be implicitly done without thinking about it.

Strings in python are not limited to ASCII but can represent the full Unicode range and thus if we take a character such as *ä* we instead get:

Character	Codepoint	Bytes
A	65	0x41
ä	228	0xC3 0xA4

The way to solve the initial problem is then instead of trying to convert the "haystack" bytes into a string and search for a sequence of character, to convert the "needle" marker into a sequence of UTF-8 bytes and search for that sequence of bytes in the haystack. When it is found we can extract bytes relative to that offset and convert those bytes into whatever we intended like a 32-bit number in this case. This diagram describes this approach, notice the difference to the previous.



Which, translated to Python 3 code looks like this:

```
def extract_leaked_pointer_python3(leak):
    marker = 'Här: '.encode('utf-8')
    start = leak.find(marker)
    leak_start = start + len(marker)
    leak_data = leak[leak_start:leak_start+4]
    return struct.unpack('<Q', leak_data)[0]
```

In conclusion, don't try to convert bytes that don't represent text, into text. Instead convert the text into bytes, use it to extract the relevant bytes and then process them accordingly. Now your exploit works in Python 3 and you can leave another legacy language behind.