Introduction to
Cybersecurity

David J. Malan
malan@harvard.edu

Securing Software

Phishing

```
<!DOCTYPE html>

<html>
  …
  <body>
     …
  </body>
</html>
```

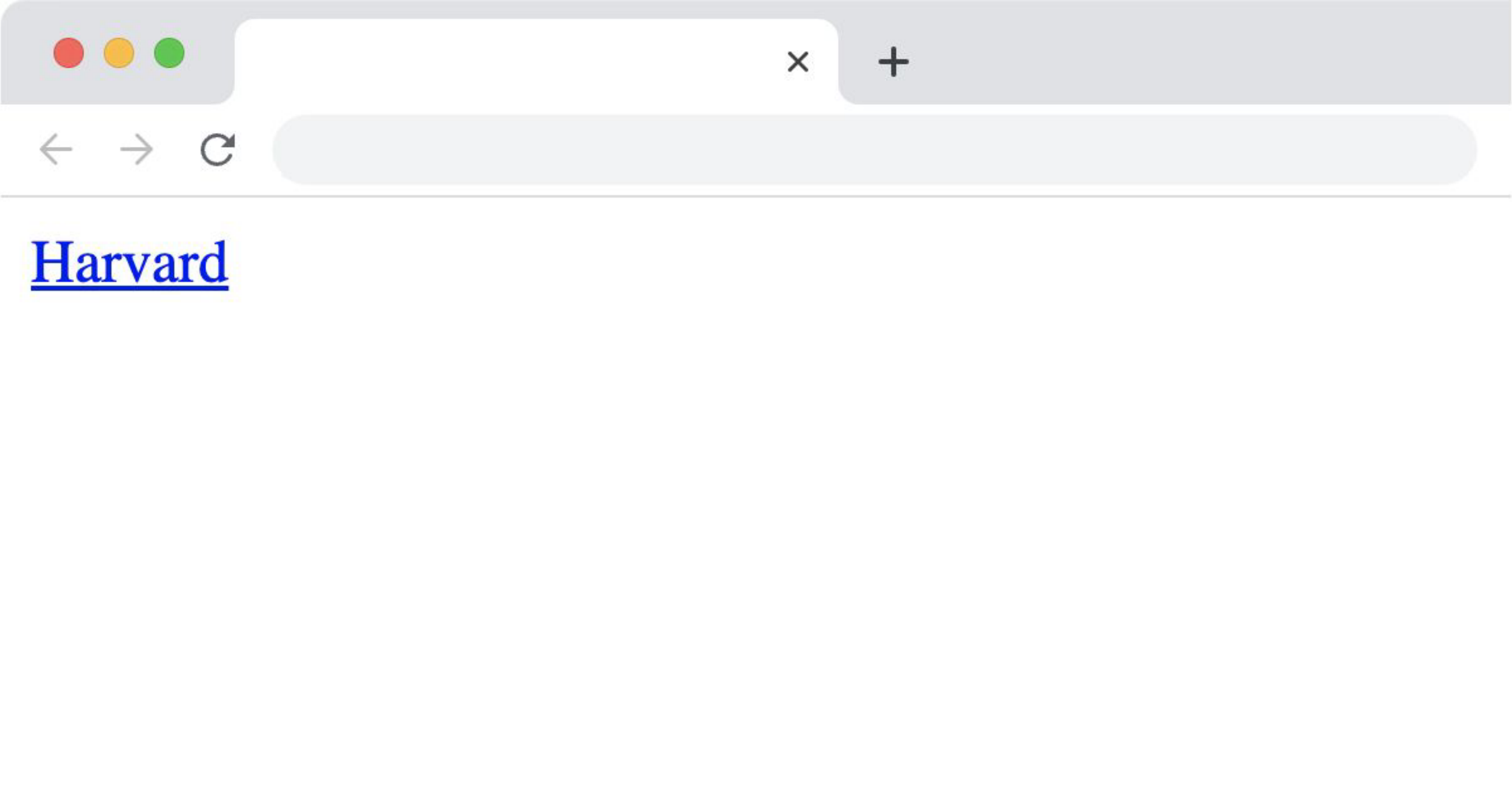
```
<p>...</p>
```

```
<script>...</script>
```

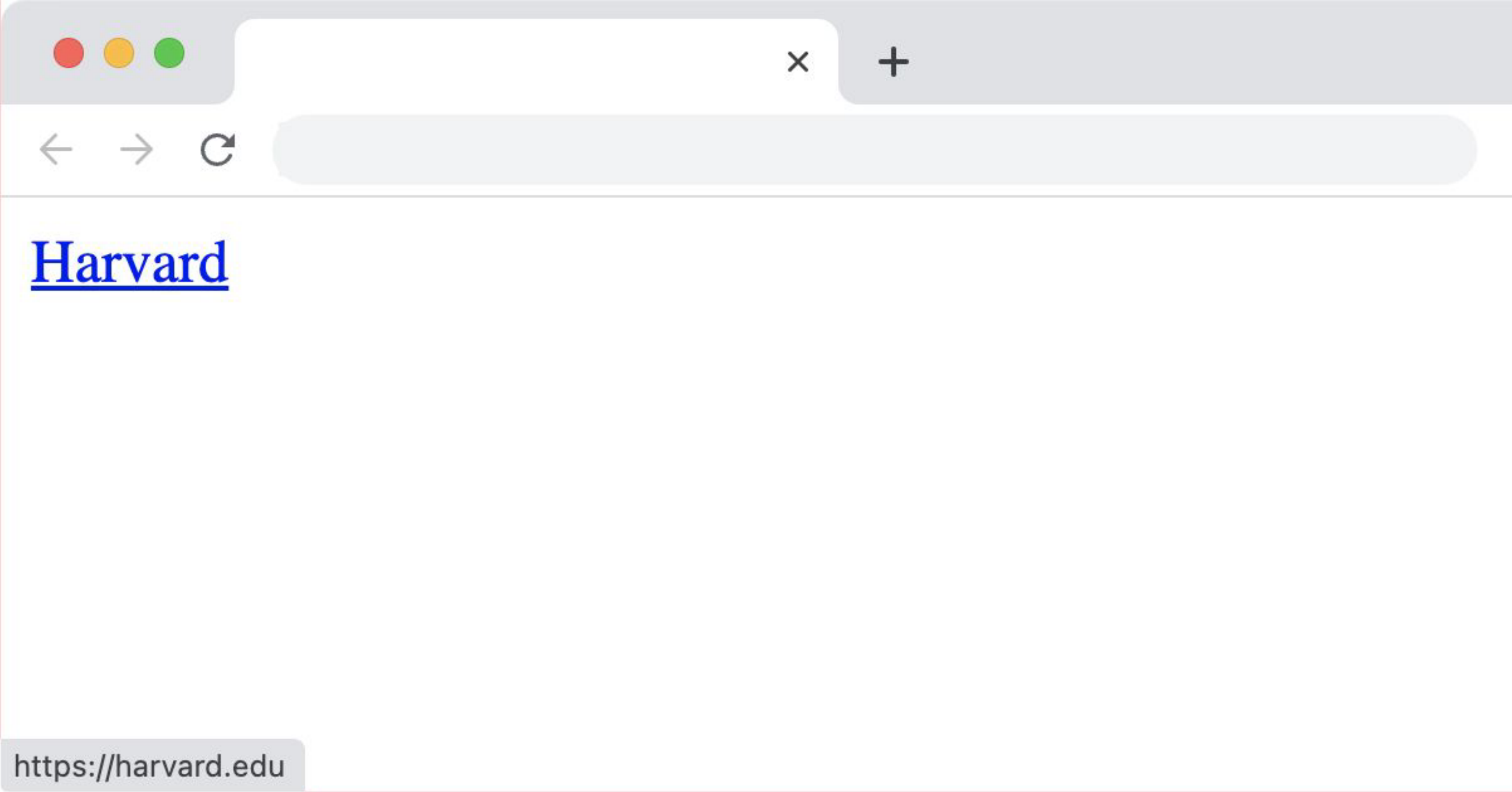
```
<a>Harvard</a>
```

```
<a href="...">Harvard</a>
```

```
<a href="https://harvard.edu">Harvard</a>
```



Harvard

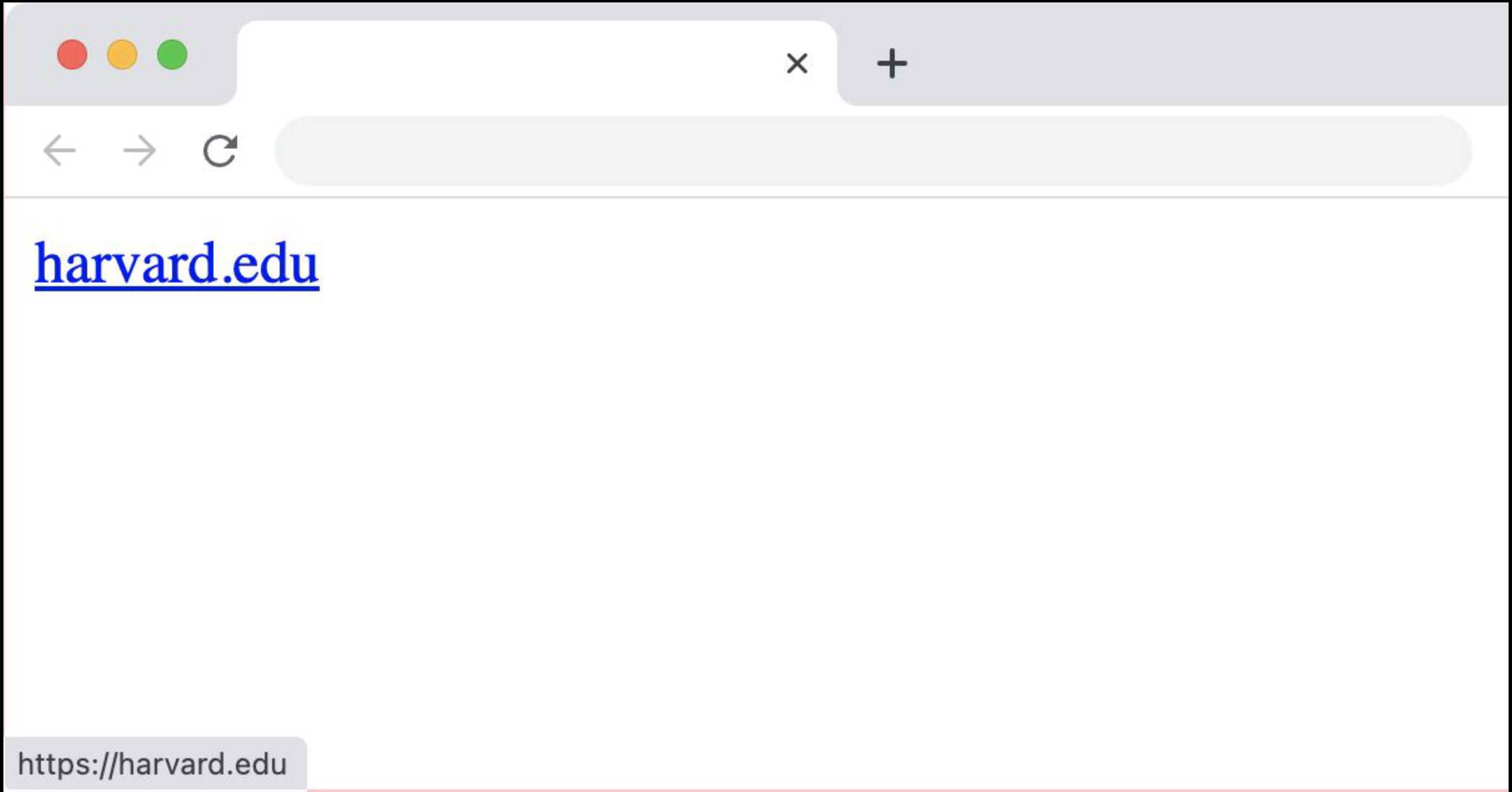


Harvard

https://harvard.edu

```html
<a href="https://harvard.edu">Harvard</a>
```

```html
<a href="https://harvard.edu">harvard.edu</a>
```

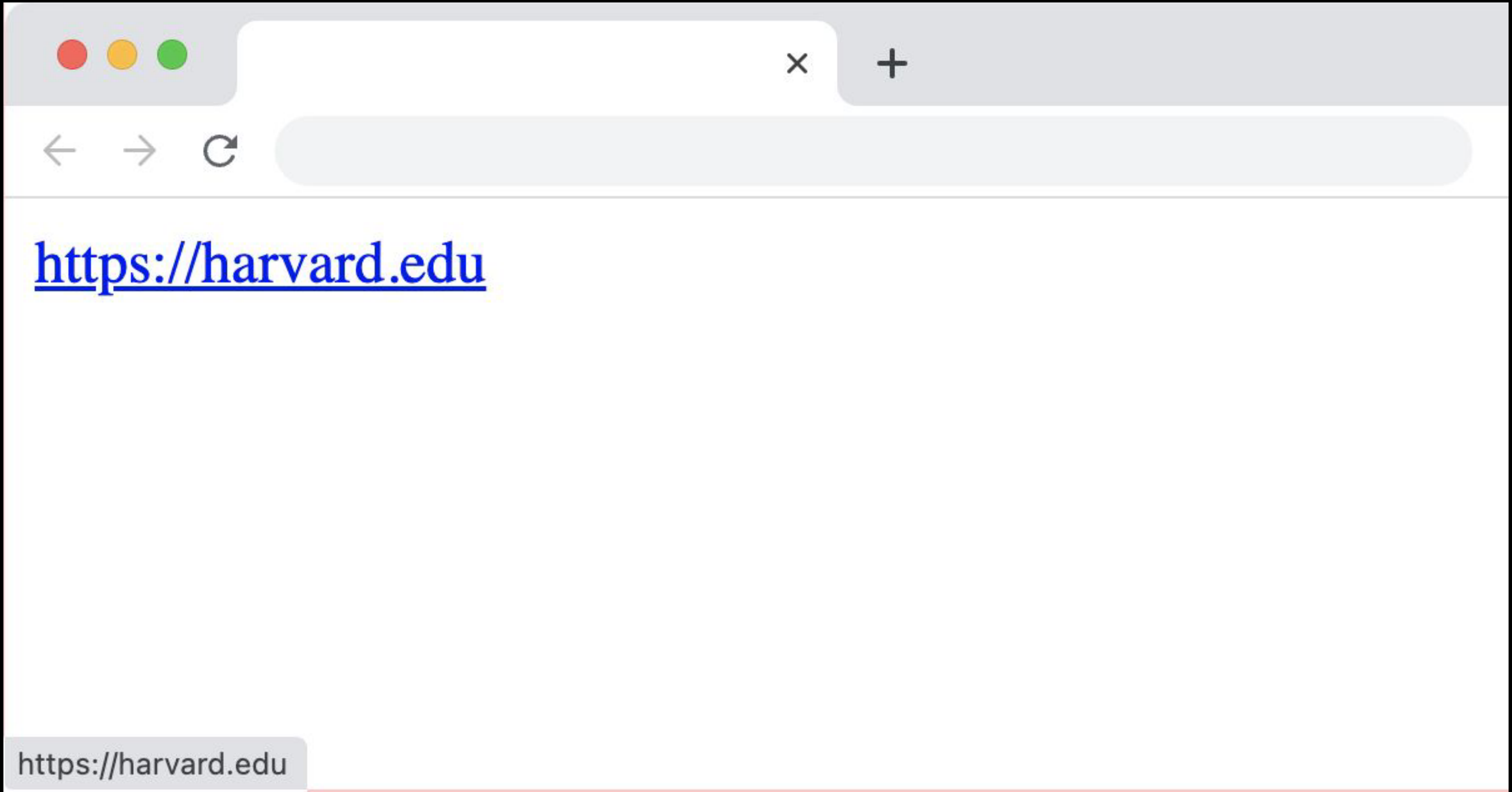


harvard.edu

https://harvard.edu

```
<a href="https://harvard.edu">harvard.edu</a>
```

```
<a href="https://harvard.edu">https://harvard.edu</a>
```

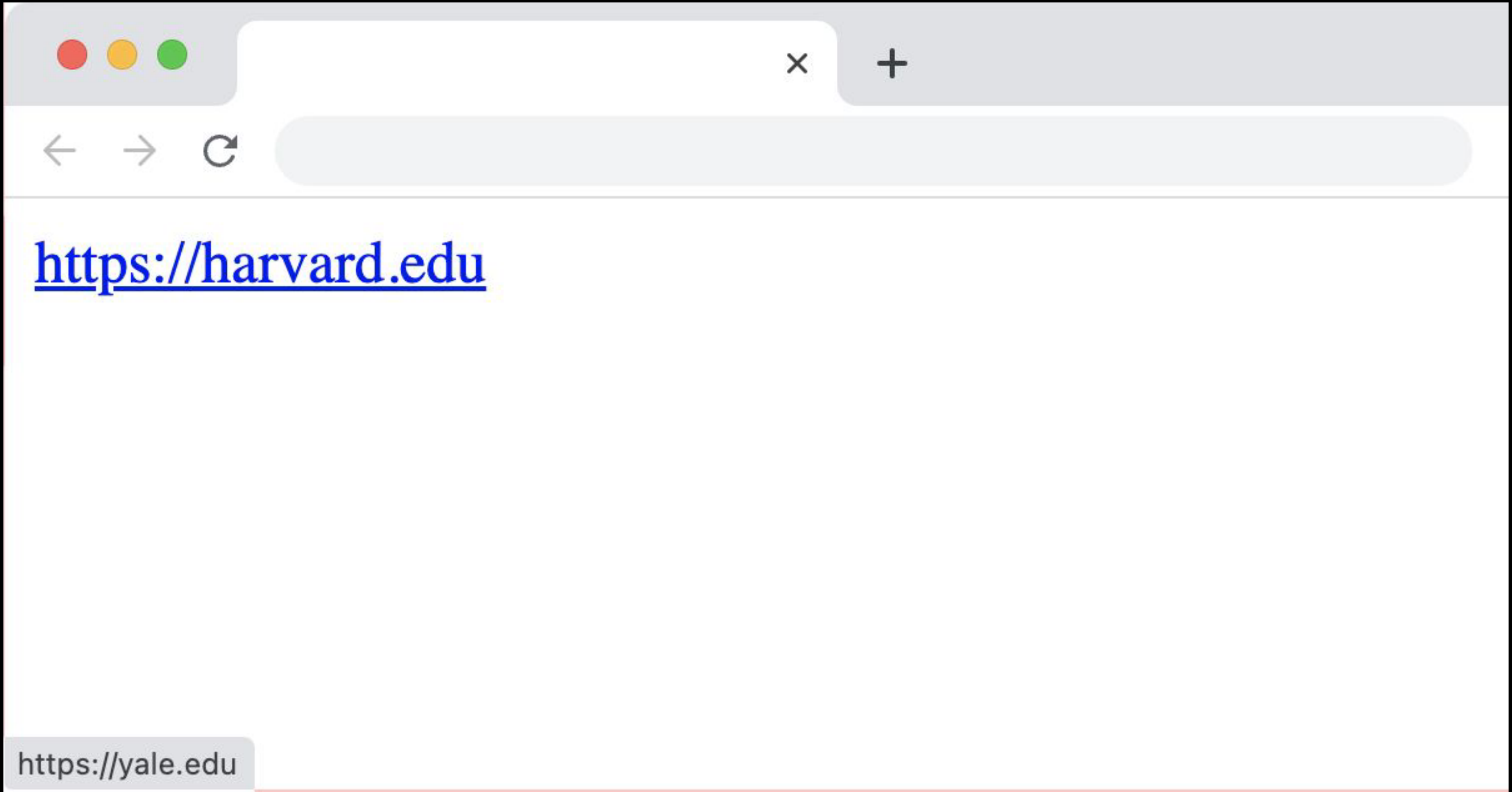


https://harvard.edu

https://harvard.edu

```
<a href="https://harvard.edu">https://harvard.edu</a>
```

```html
<a href="https://yale.edu">https://harvard.edu</a>
```

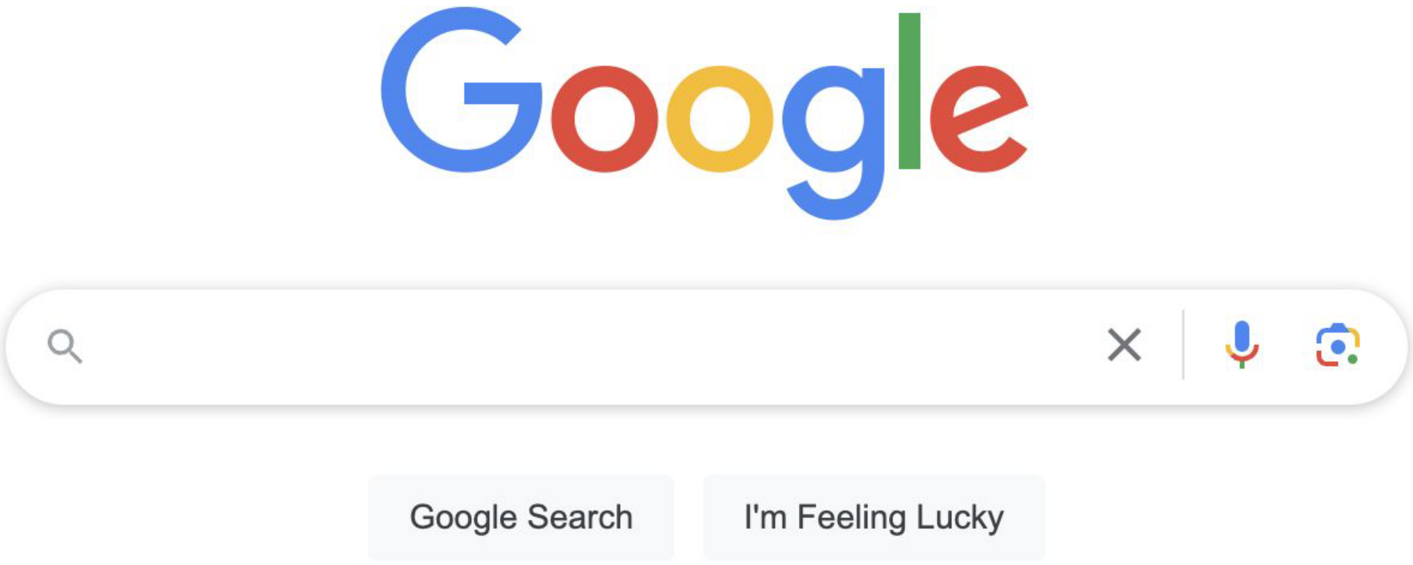


[https://harvard.edu](https://yale.edu)

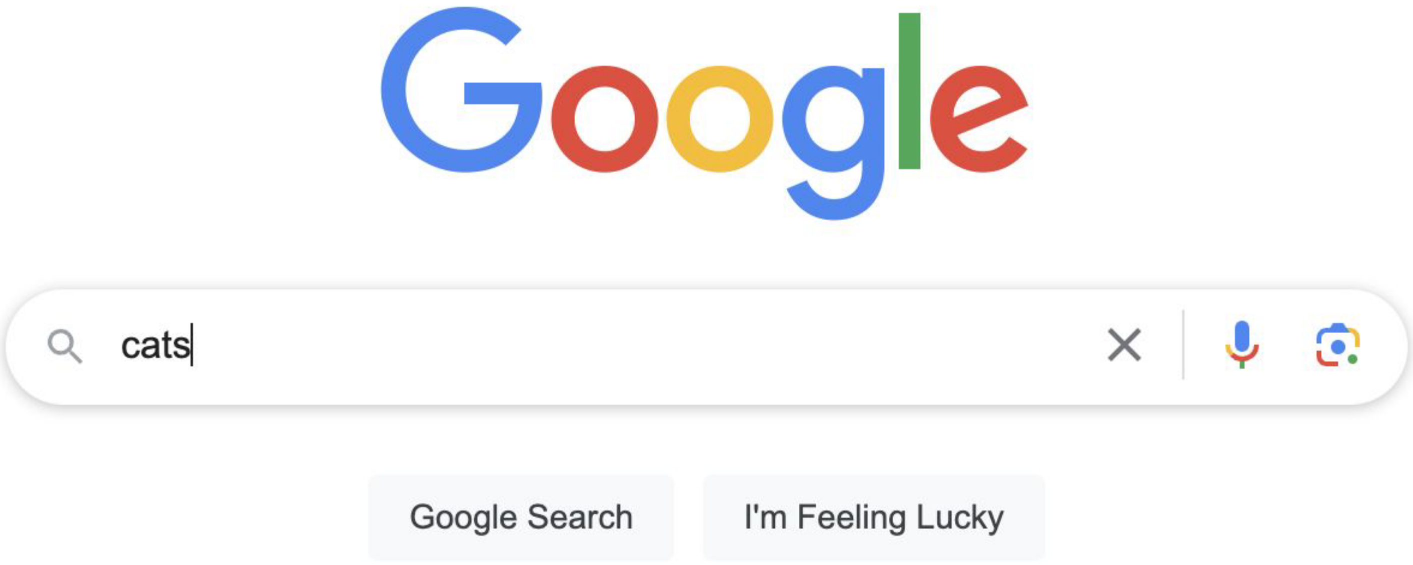
https://yale.edu

Code Injection

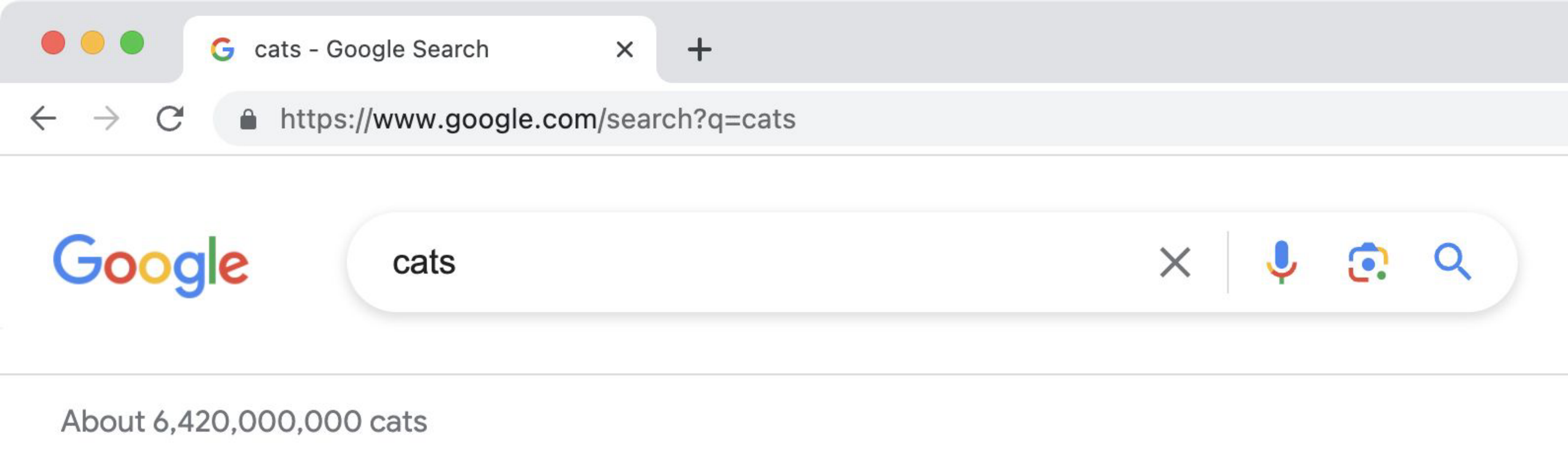
Cross-Site Scripting (XSS)



Google
Google Search
I'm Feeling Lucky

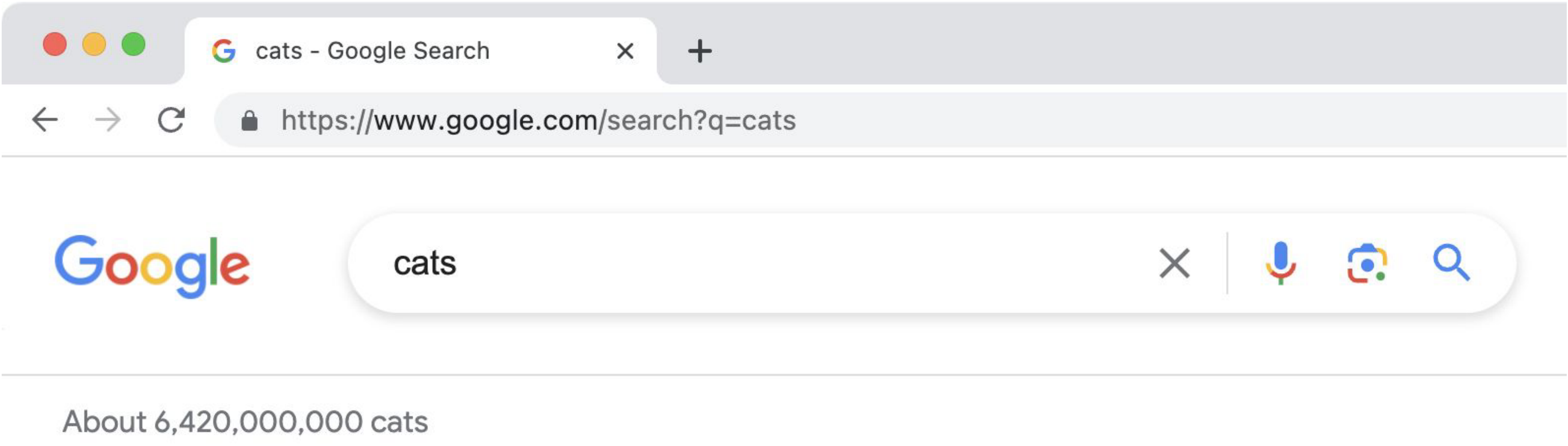


cats



About 6,420,000,000 cats

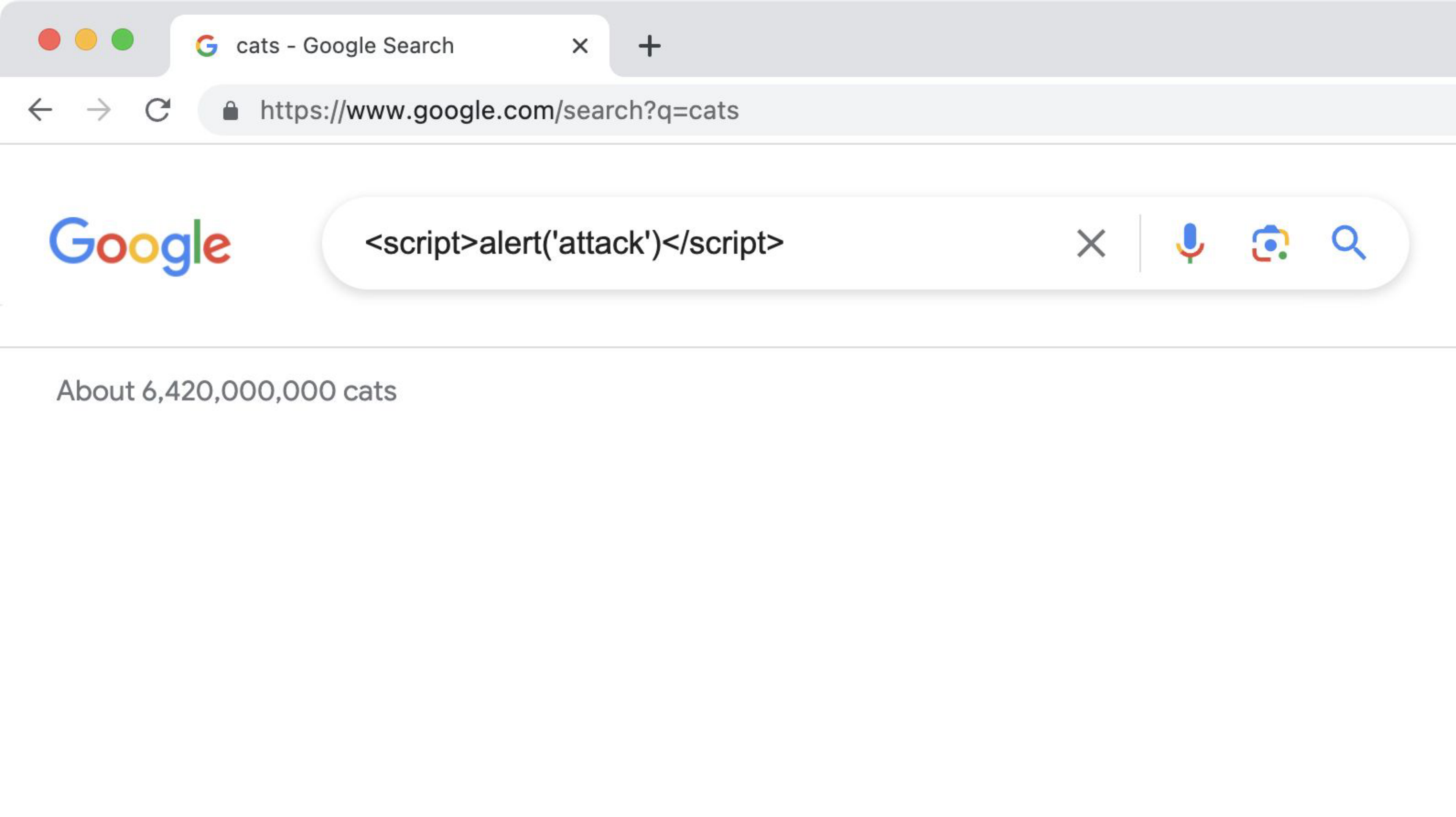
```html
<p>About 6,420,000,000 cats</p>
```



https://www.google.com/search?q=cats

cats

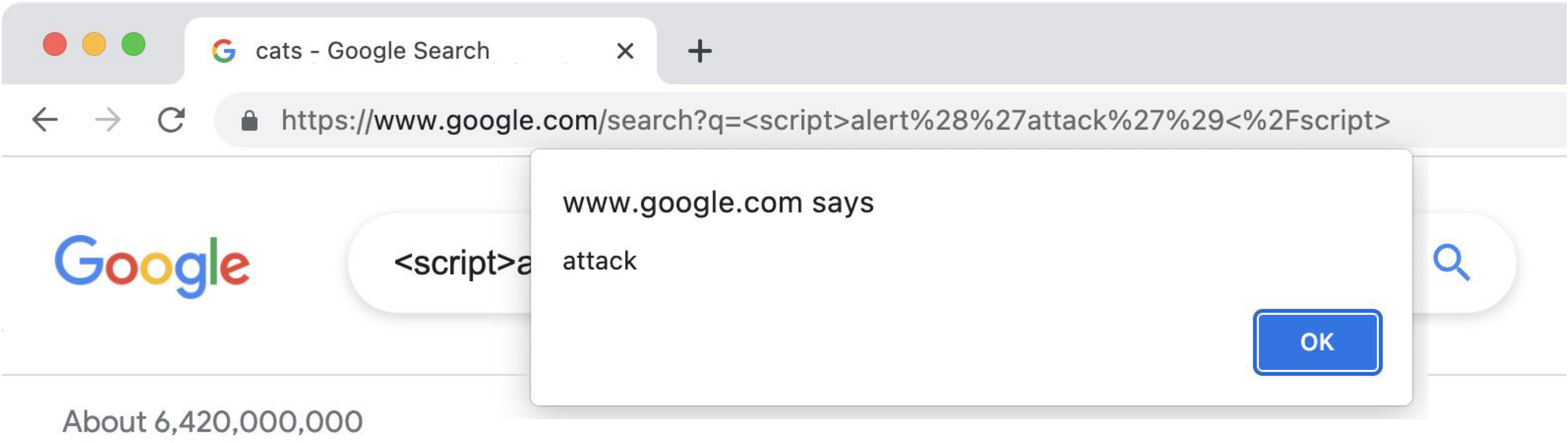
About 6,420,000,000 cats



https://www.google.com/search?q=cats

```
<script>alert('attack')</script>
```

About 6,420,000,000 cats



cats - Google Search

https://www.google.com/search?q=<script>alert%28%27attack%27%29<%2Fscript>

<script>a

www.google.com says

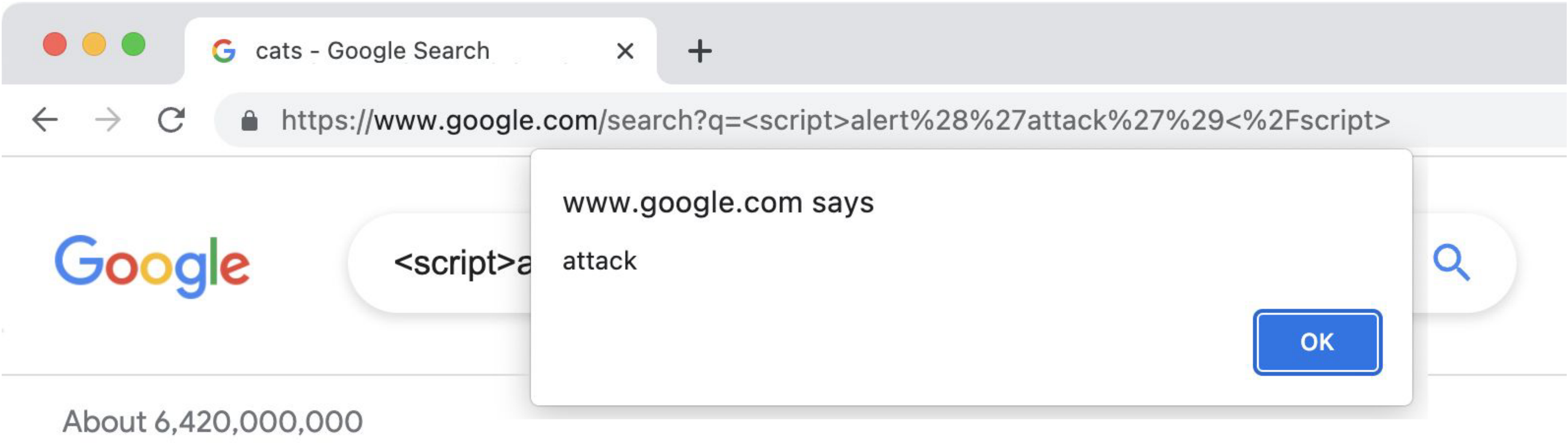
attack

About 6,420,000,000

```
<p>About 6,420,000,000 cats</p>
```

```
<p>About 6,420,000,000 <script>alert('attack')</script></p>
```

```
<p>About 6,420,000,000 <script>alert('attack')</script></p>
```



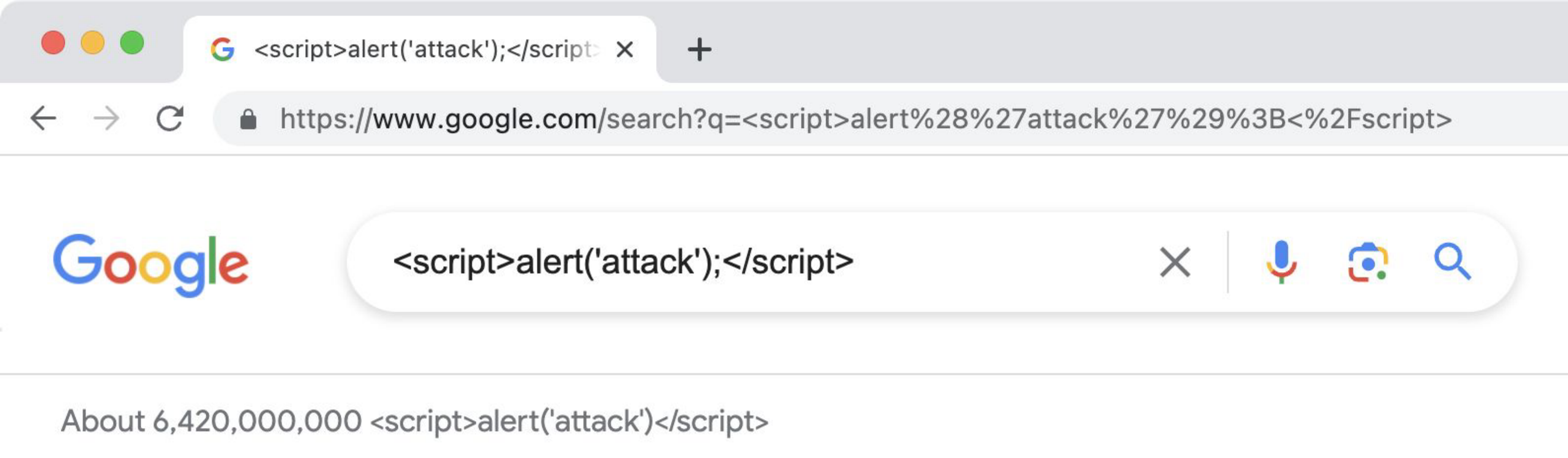
https://www.google.com/search?q=<script>alert%28%27attack%27%29<%2Fscript>

<script>a

www.google.com says

attack

About 6,420,000,000



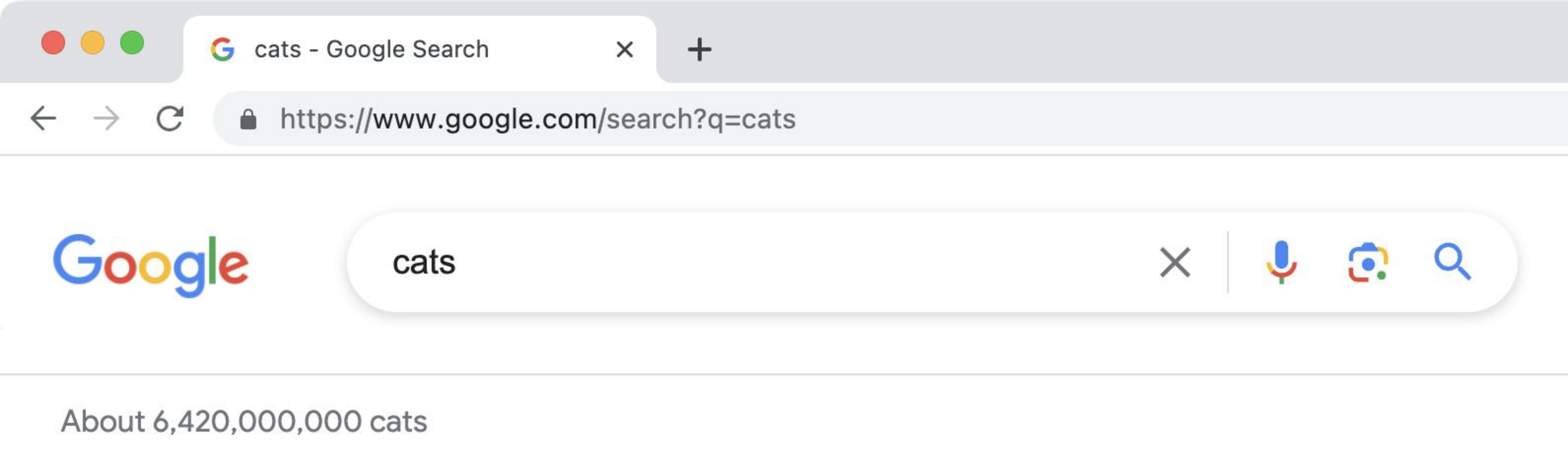
https://www.google.com/search?q=<script>alert%28%27attack%27%29%3B<%2Fscript>

<script>alert('attack');</script>

About 6,420,000,000 <script>alert('attack')</script>

Reflected

```
<a href="…">…</a>
```



https://www.google.com/search?q=cats

cats

About 6,420,000,000 cats

```
<a href="…">…</a>
```

```
<a href="https://www.google.com/search?q=cats">cats</a>
```

```
<a href="https://www.google.com/search?q=cats">cats</a>
```

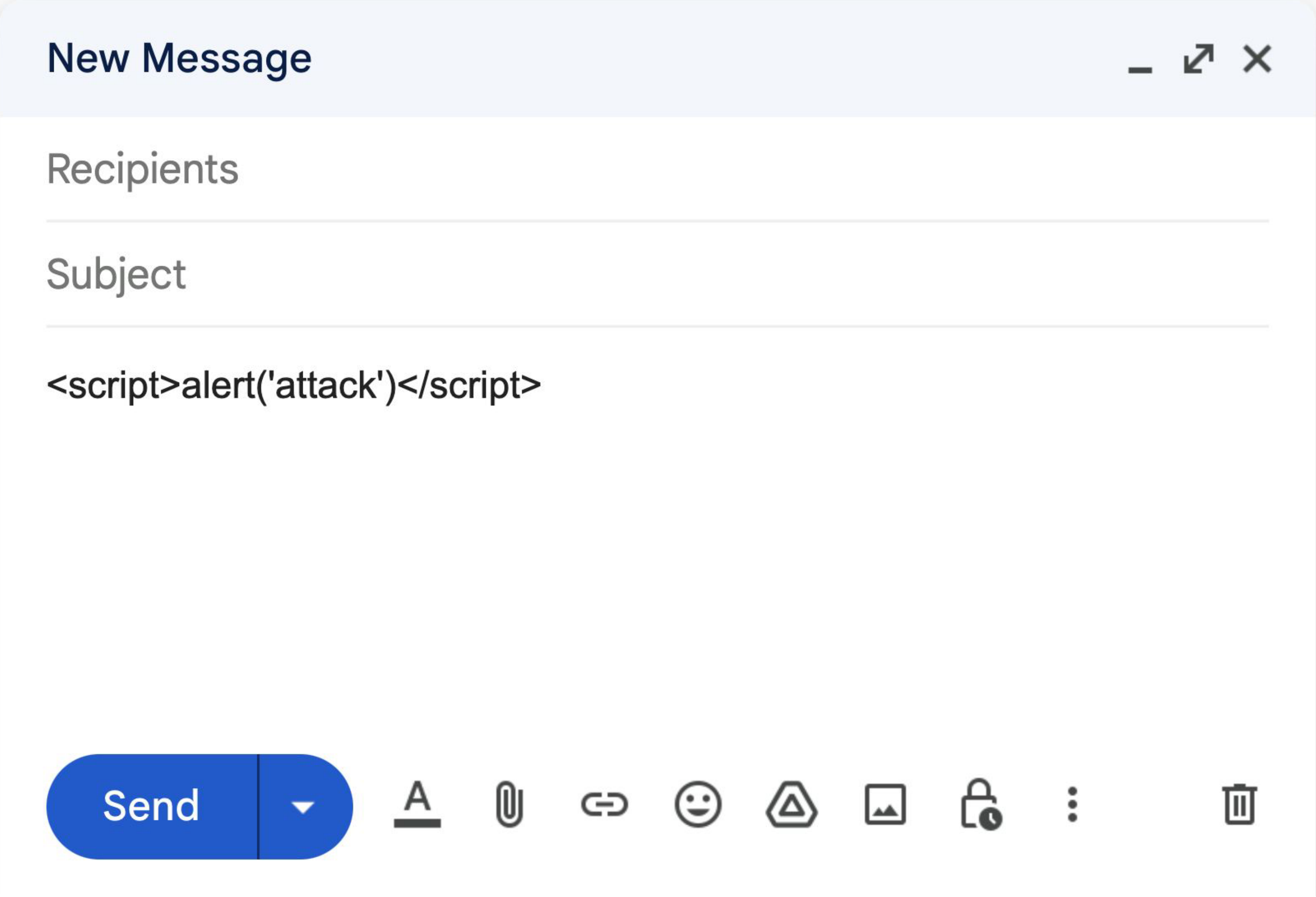
```
<a href="https://www.google.com/search?q=cats">cats</a>
```

```
<a href="https://www.google.com/search?q=%3Cscript%3Ealert%28%27attack%27%29%3C%2Fscript%3E">cats</a>
```

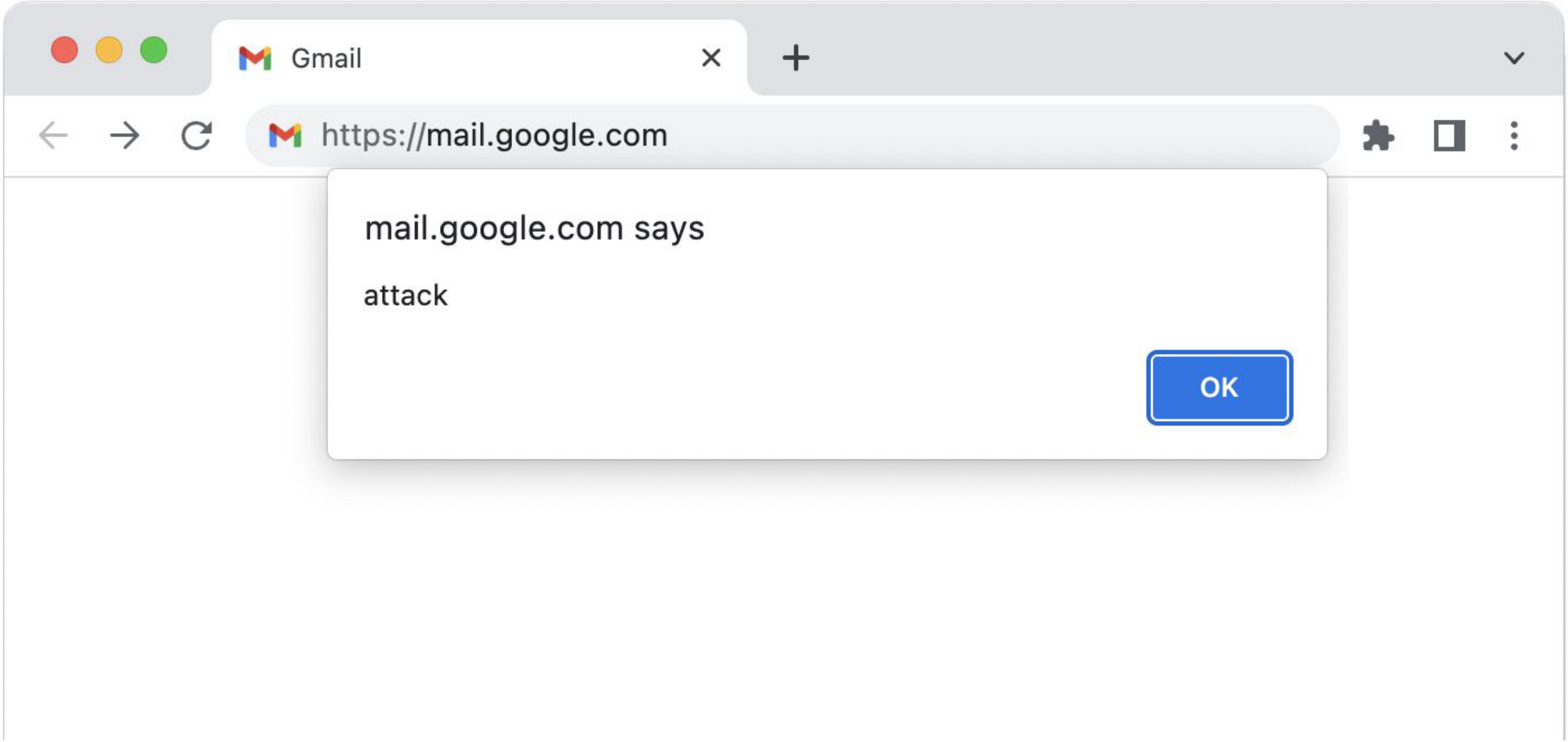
```
<script>alert('attack')</script>
```

```
<script>alert(document.cookie)</script>
```

Stored

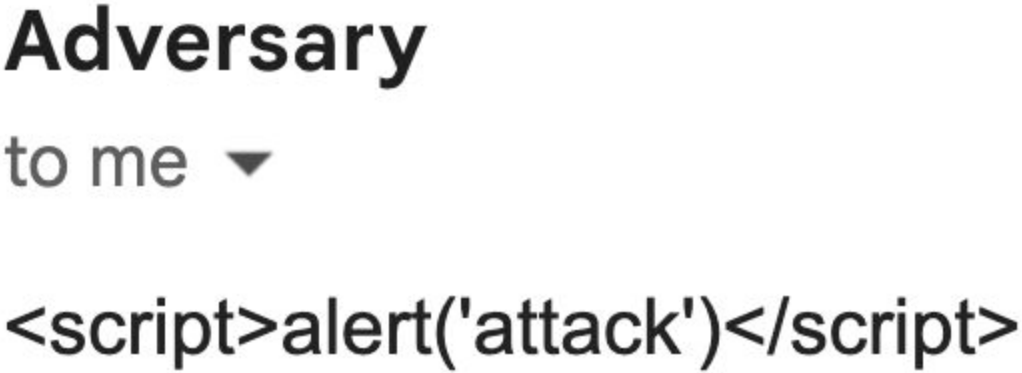


```
<script>alert('attack')</script>
```



mail.google.com says

attack



Adversary

to me ▾

```
<script>alert('attack')</script>
```

Character Escapes

```
<p>About 6,420,000,000 <script>alert('attack')</script></p>
```

```
<p>About 6,420,000,000 &lt;script&gt;alert('attack')&lt;/script&gt;</p>
```

```
<p>About 6,420,000,000 &lt;script&gt;alert('attack')&lt;/script&gt;</p>
```

```
&lt; (<)
&gt; (>)
&amp; (&)
&quot; (")
&apos; (')
…
```

```
Content-Security-Policy: script-src https://example.com/
```

```
<script src="…"></script>
```

```
Content-Security-Policy: style-src https://example.com/
```

```
<link href="…" rel="stylesheet">
```

SQL Injection

```
SELECT * FROM users
WHERE username = '{username}'
```

```
SELECT * FROM users
WHERE username = '{username}'
```

```
malan
```

```
malan'; DELETE FROM users; –-
```

```sql
SELECT * FROM users
WHERE username = '{username}'
```

```
SELECT * FROM users
WHERE username = 'malan'; DELETE FROM users; --'
```

```
SELECT * FROM users
WHERE username = 'malan';

DELETE FROM users;
```

```
SELECT * FROM users
WHERE username = '{username}' AND password = '{password}'
```

```
SELECT * FROM users
WHERE username = '{username}' AND password = '{password}'
```

```
malan
```

```
' OR '1'='1
```

```
SELECT * FROM users
WHERE username = 'malan' AND password = '' OR '1'='1'
```

```
SELECT * FROM users
WHERE username = 'malan' AND password = ''
OR '1'='1'
```

```
SELECT * FROM users
WHERE (username = 'malan' AND password = '')
OR '1'='1'
```

```
SELECT * FROM users
WHERE '1'='1'
```

Prepared Statements

'

' '

```
SELECT * FROM users
WHERE username = '{username}'
```

```
SELECT * FROM users
WHERE username = ?
```

```
SELECT * FROM users
WHERE username = 'malan''; DELETE FROM users; --'
```

```
SELECT * FROM users
WHERE username = '{username}' AND password = '{password}'
```

```
SELECT * FROM users
WHERE username = ? AND password = ?
```

```
SELECT * FROM users
WHERE username = 'malan' AND password = ''' OR ''1''=''1'
```

Command Injection

system

`eval`

Developer Tools

```
<input disabled type="checkbox">
```

```
<input disabled type="checkbox">
```

```
<input type="checkbox">
```

Client-Side Validation

```
<input required type="text">
```

```
<input required type="text">
```

```
<input type="text">
```

Server-Side Validation

Cross-Site Request Forgery (CSRF)

GET

```
<a href="https://www.amazon.com/dp/B07XLQ2FSK">Buy Now</a>
```

```
<a href="https://www.amazon.com/dp/B07XLQ2FSK">Buy Now</a>
```

```
<img src="https://www.amazon.com/dp/B07XLQ2FSK">
```

POST

```
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
<script>
  document.forms[0].submit();
</script>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
<script>
  document.forms[0].submit();
</script>
```

```html
<form action="https://www.amazon.com/" method="post">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="csrf_token" type="hidden" value="1234abcd">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

```
<form action="https://www.amazon.com/" method="post">
  <input name="csrf_token" type="hidden" value="1234abcd">
  <input name="dp" type="hidden" value="B07XLQ2FSK">
  <button type="submit">Buy Now</button>
</form>
```

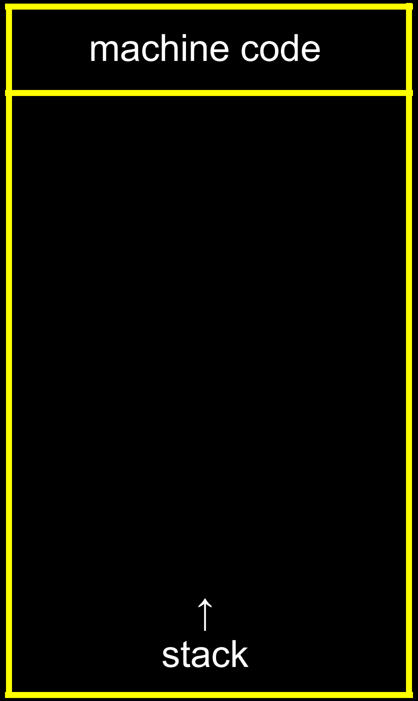
```
POST / HTTP/3
Host: amazon.com
X-CSRFToken: 1234abcd
```

Open Worldwide Application Security Project (OWASP)

Arbitrary Code Execution (ACE)

Remote Code Execution (RCE)

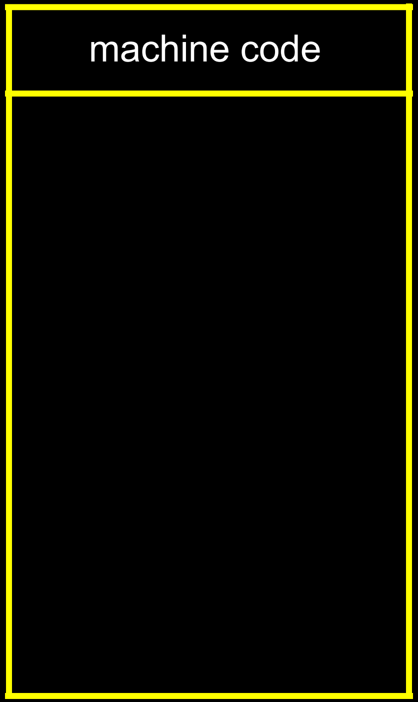
Buffer Overflow



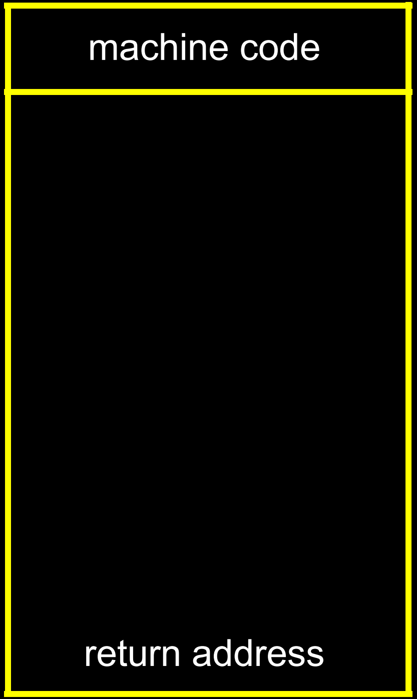
machine code

↑

stack

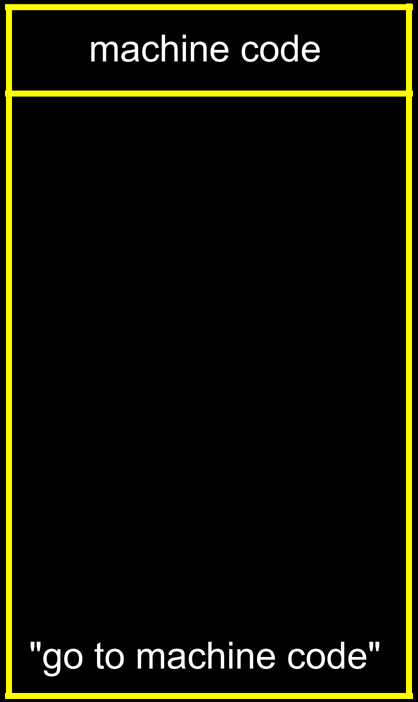


machine code



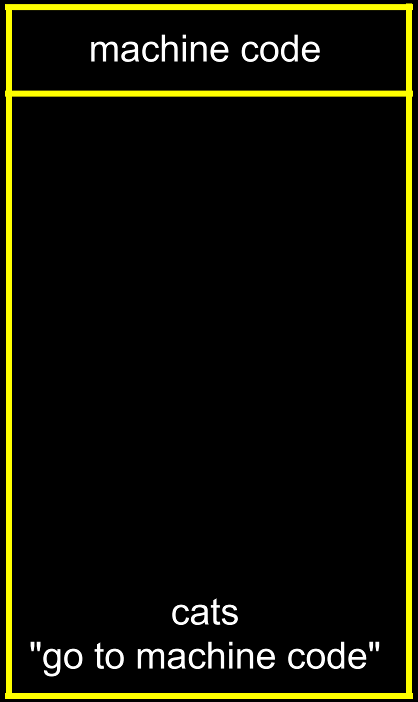
machine code

return address



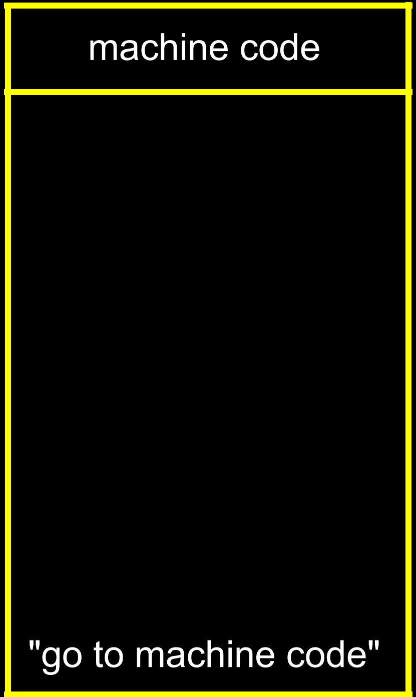
machine code

"go to machine code"



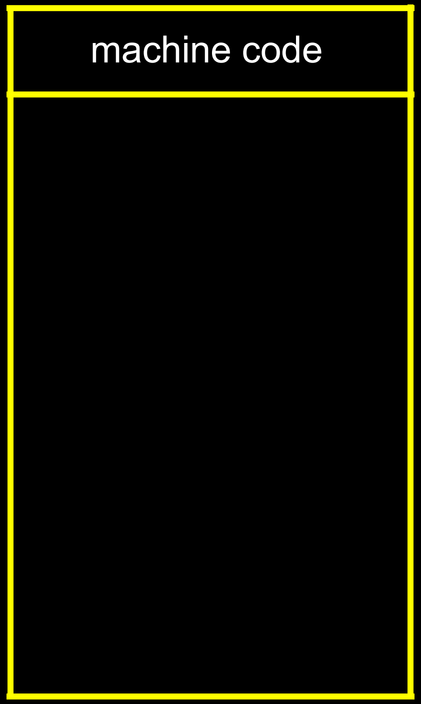
machine code

cats
"go to machine code"

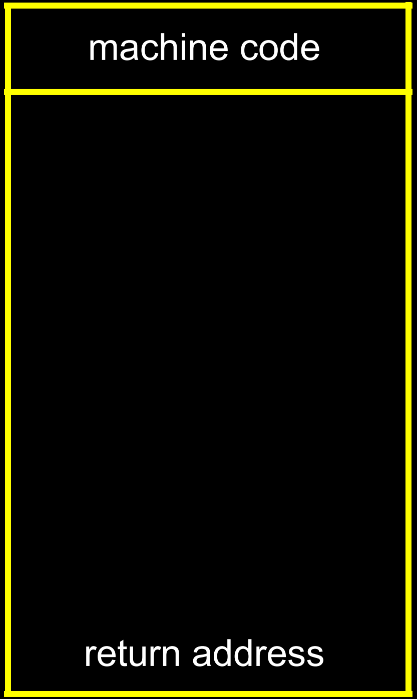


machine code

"go to machine code"

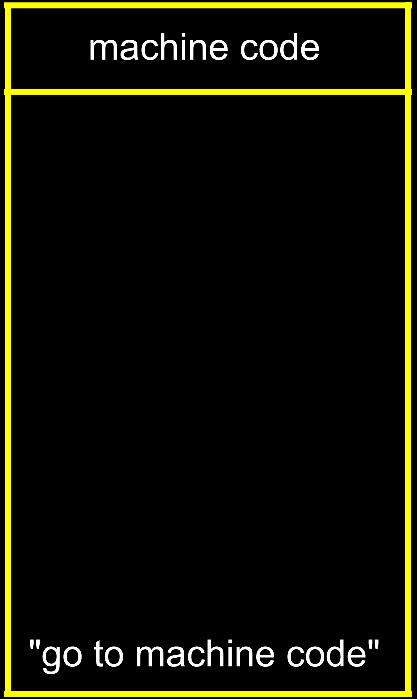


machine code



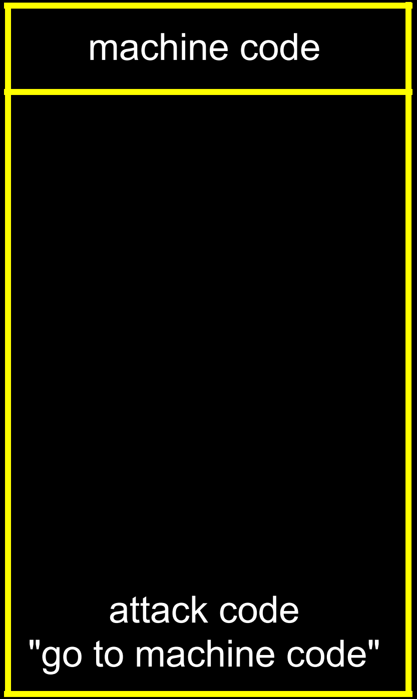
machine code

return address



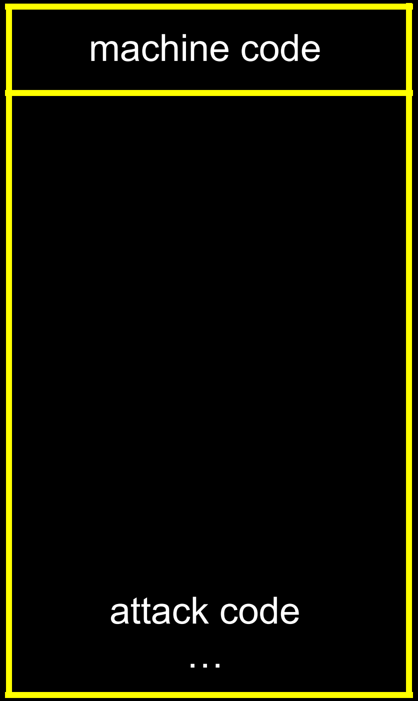
machine code

"go to machine code"



machine code

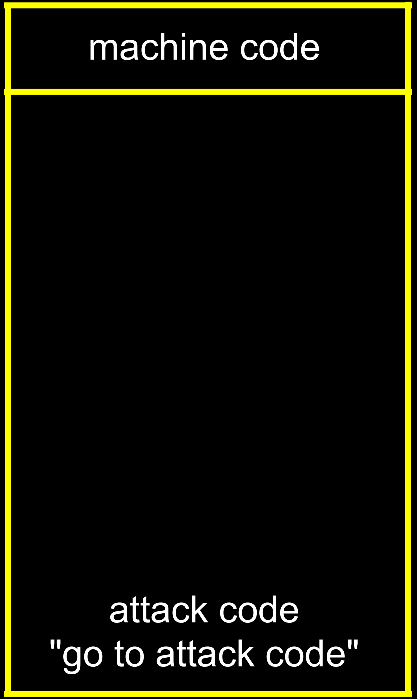
attack code
"go to machine code"



machine code

attack code

…

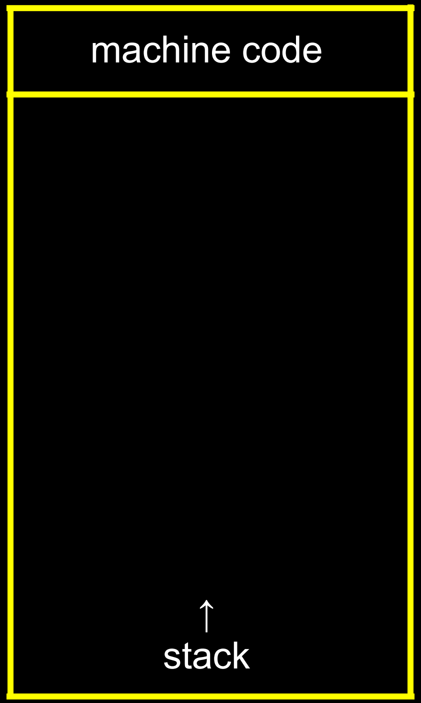


machine code

attack code

"go to attack code"

Stack Overflow



machine code

↑
stack

Cracking

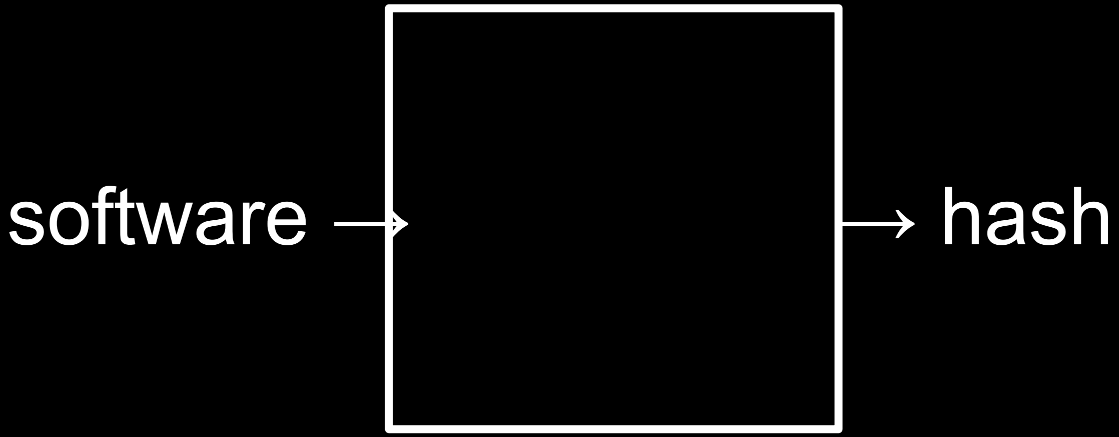
Reverse Engineering

Malware Analysis

Open-Source Software

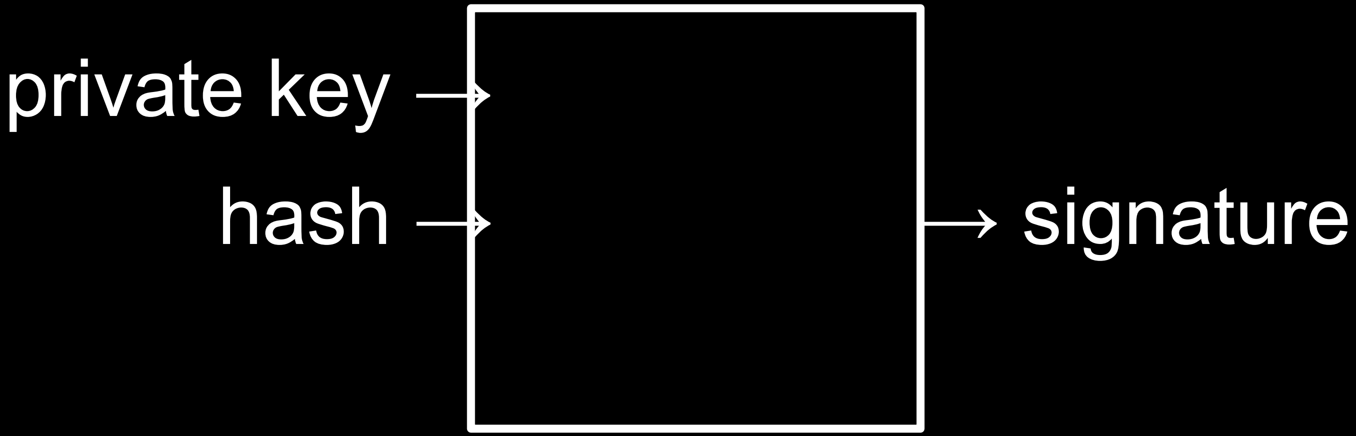
Closed-Source Software

App Stores



software →

→ hash



private key

hash

signature

Package Managers

Operating Systems

Bug Bounty

Common Vulnerabilities and Exposures (CVE)

Common Vulnerability Scoring System (CVSS)

Exploit Prediction Scoring System (EPSS)

Known Exploited Vulnerabilities Catalog (KEV)

Introduction to

Cybersecurity

David J. Malan
malan@harvard.edu