12. Web Security & Privacy

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CMSC 23210 / 33210

THE UNIVERSITY OF CHICAGO

UCHICAGO SUPER GROUP

Security, Usability, & Privacy Education & Research

Today's class

- Trust on the web
  - SSL notifications
- Online tracking
  - Privacy tools

Trust on the web

Overview

- Secure Sockets Layer (SSL) and its successor, Transport Layer Security (TLS) enable secure communication
- Frequently encountered with web browsing (HTTPS) and more behind the scenes in app, VOIP, etc.

What we want to defend against

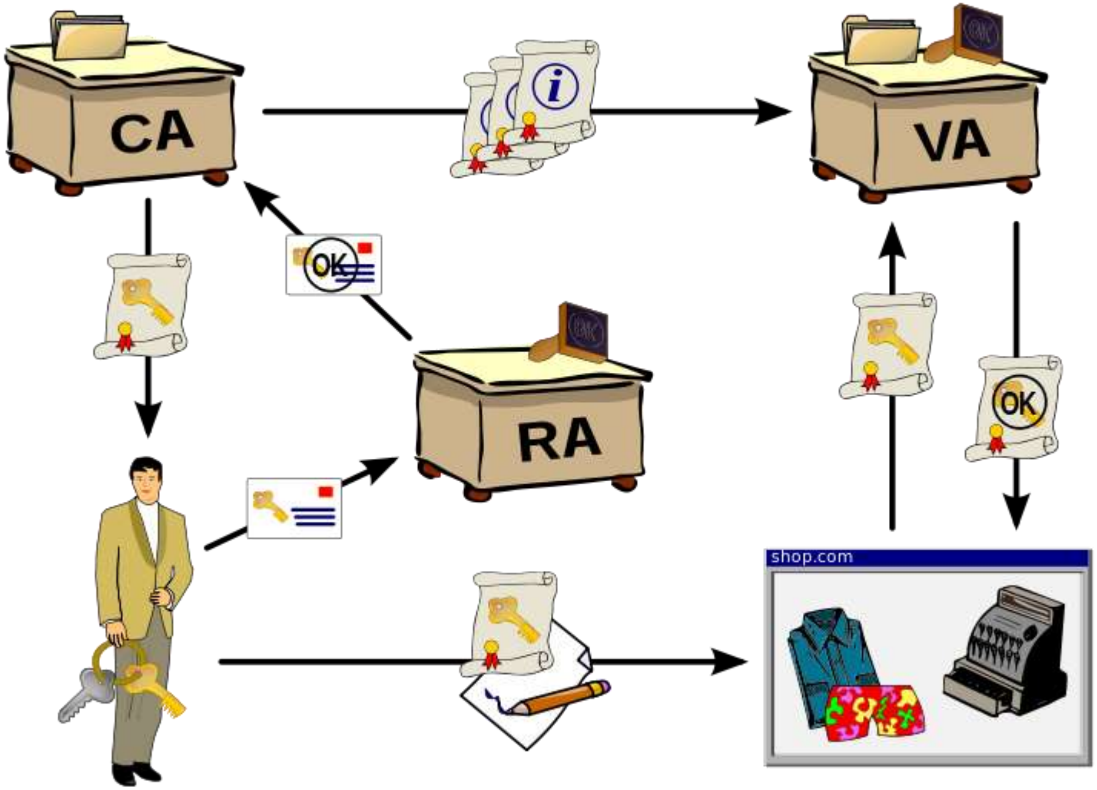
- People snooping on our communications
  - The contents of what we’re sending
  - Session tokens (see, e.g., Firesheep)
- Man-in-the-middle attacks
  - We want to authenticate that we are talking to the right site, not an imposter
  - Use certificates inside a public-key infrastructure

How we could obtain trust

- Web of trust
  - People you already trust introduce you to people they trust
  - Can get complicated, doesn’t scale well
  - Infrequently seen in practice
- Public-Key Infrastructure (PKI)
  - Certificates are issued by certificate authorities that bind cryptographic keys to identities

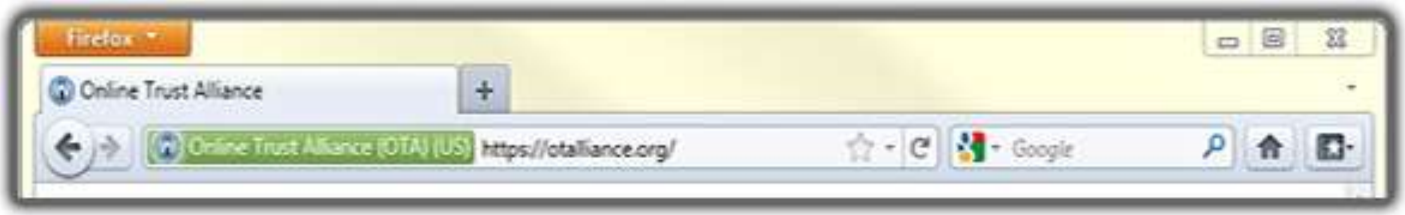
Public-Key Infrastucture

- Binding of keys to identities

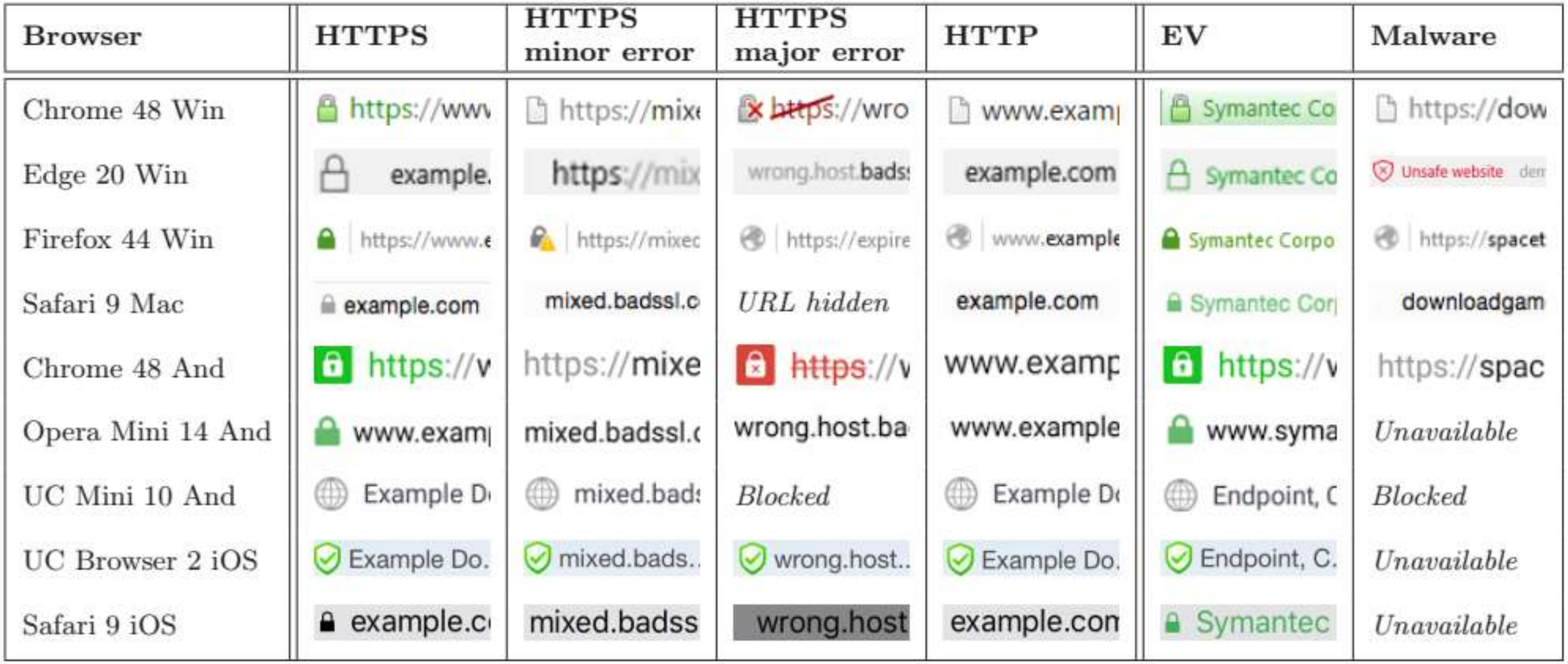


What does SSL look like to users?

- Compare, e.g., the following:
  - https://www.google.com (normal certificate)
  - Go to Google images and then click on an image and see what happens (mixed content)
  - https://www.thawte.com (EV certificate)



What does SSL look like to users?



Browser	HTTPS	HTTPS minor error	HTTPS major error	HTTP	EV	Malware
Chrome 48 Win	https://www	https://mixe	~~https~~://wro	www.examp	Symantec Co	https://dow
Edge 20 Win	example.	https://mix	wrong.host.badss	example.com	Symantec Co	Unsafe website dem
Firefox 44 Win	https://www.e	https://mixec	https://expire	www.example	Symantec Corpo	https://spacet
Safari 9 Mac	example.com	mixed.badssl.c	*URL hidden*	example.com	Symantec Cor	downloadgam
Chrome 48 And	https://v	https://mixe	~~https~~://v	www.examp	https://v	https://spac
Opera Mini 14 And	www.examp	mixed.badssl.c	wrong.host.ba	www.example	www.syma	*Unavailable*
UC Mini 10 And	Example D	mixed.bads	*Blocked*	Example D	Endpoint, C	*Blocked*
UC Browser 2 iOS	Example Do.	mixed.bads..	wrong.host..	Example Do.	Endpoint, C.	*Unavailable*
Safari 9 iOS	example.c	mixed.badss	wrong.host	example.con	Symantec	*Unavailable*

(From Felt et al. SOUPS 2016)

How does PKI look to browsers?

- Hundreds of trusted certificate authorities
  - Certificate authorities (CAs) sign the certificates binding identities to keys
  - See, e.g., Firefox’s advanced settings

How does PKI look to site admins?

- Apply for a certificate
  - Validation process
  - Certificate authorities (CAs) delegate trust (“chain of trust”)
  - CAs sell you a certificate

Issues with SSL/TLS/PKIs

- Implementation issues
- Communicating to users what is happening
- Compromised Certificate Authorities
- Man-in-the-middle attacks
  - Downgrade/dumbing-down attacks
  - Addition of “rogue” certificates
- Revocation
- Timing attacks and other side channels

One famous implementation issue

- OpenSSL bug
  - Heartbleed (CVE-2014-0160)
  - TLS heartbeat extension misses a bounds check and thus lets an attacker “read” memory

Compromised CAs

- Comodo and Diginotar both suffered breaches in 2011 that let attackers issue rogue certificates
- What about untrustworthy CAs?
  - Compelled certificate creation attacks (see, e.g., Soghoian and Stamm FC ’11)

Man-in-the-middle attacks (MITM)

- Effectively, many corporations perform MITM attacks by adding certificates to users' computers and presenting "fake" certificates to users.
- A man in the middle can also tell you a site doesn't support SSL/TLS (downgrade) or any strong ciphers (dumbing down)
  - Why does this create a huge problem?
  - Why is this hard to deal with?

Important question 1

- How do you know if a site supports HTTPS?
  - – EFF’s HTTPS Everywhere
  - – HTTP Strict Transport Security (HSTS)
  - – In both cases, how do you bootstrap/maintain?

Important question 2

- How do you know you have the right certificate for a site?
  - Certificate transparency
  - Public key pinning
  - Perspectives (originally a CMU project)

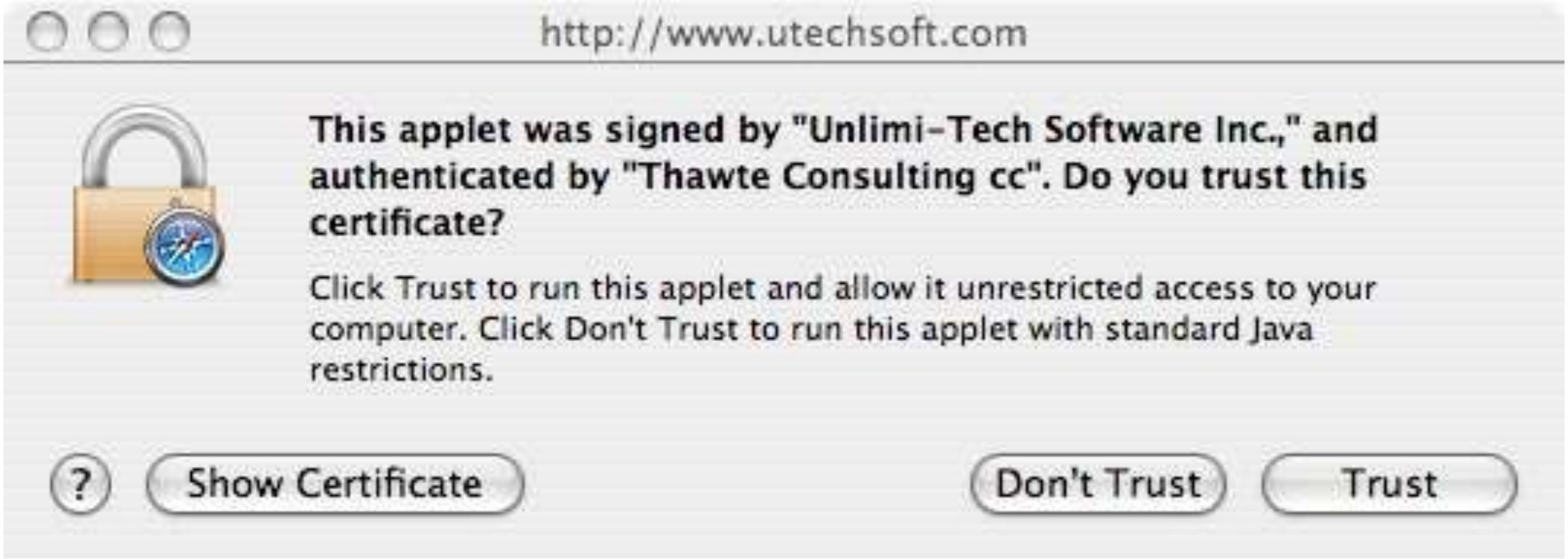
How do you know a cert is valid?

- Certificates can be revoked in case of a compromise
- Certificate Revocation Lists (CRLs) were used, but they got really large
  - Incremental updates were better
- Online Certificate Status Protocol (OCSP)
  - How does this impact privacy?
- OCSP Stapling

Self-signed certificates

- What happens if someone signs their own certificate and chooses not to use the PKI infrastructure?
  - – You get a warning!

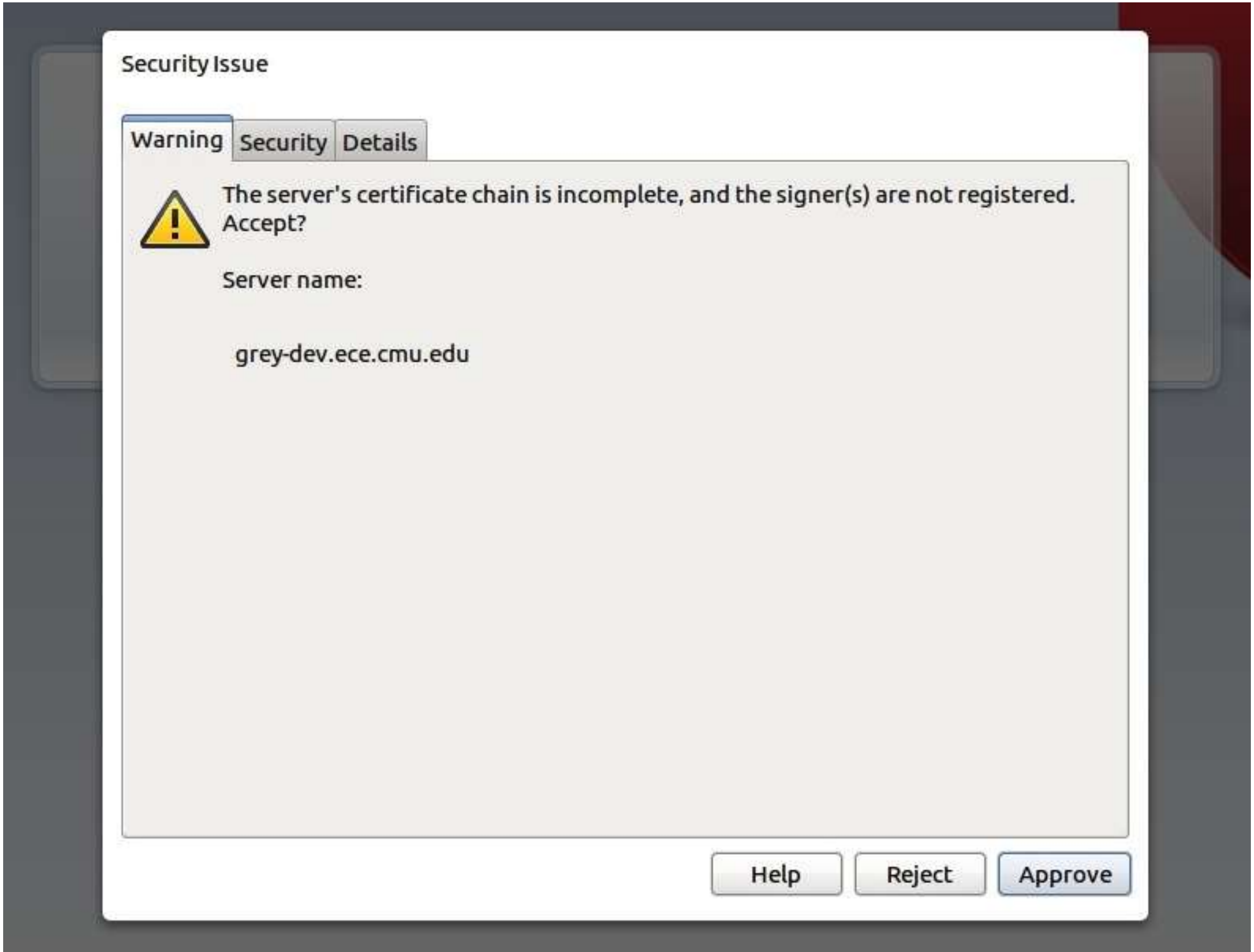
Warnings



This applet was signed by "Unlimi-Tech Software Inc.," and authenticated by "Thawte Consulting cc". Do you trust this certificate?

Click Trust to run this applet and allow it unrestricted access to your computer. Click Don't Trust to run this applet with standard Java restrictions.

Opera

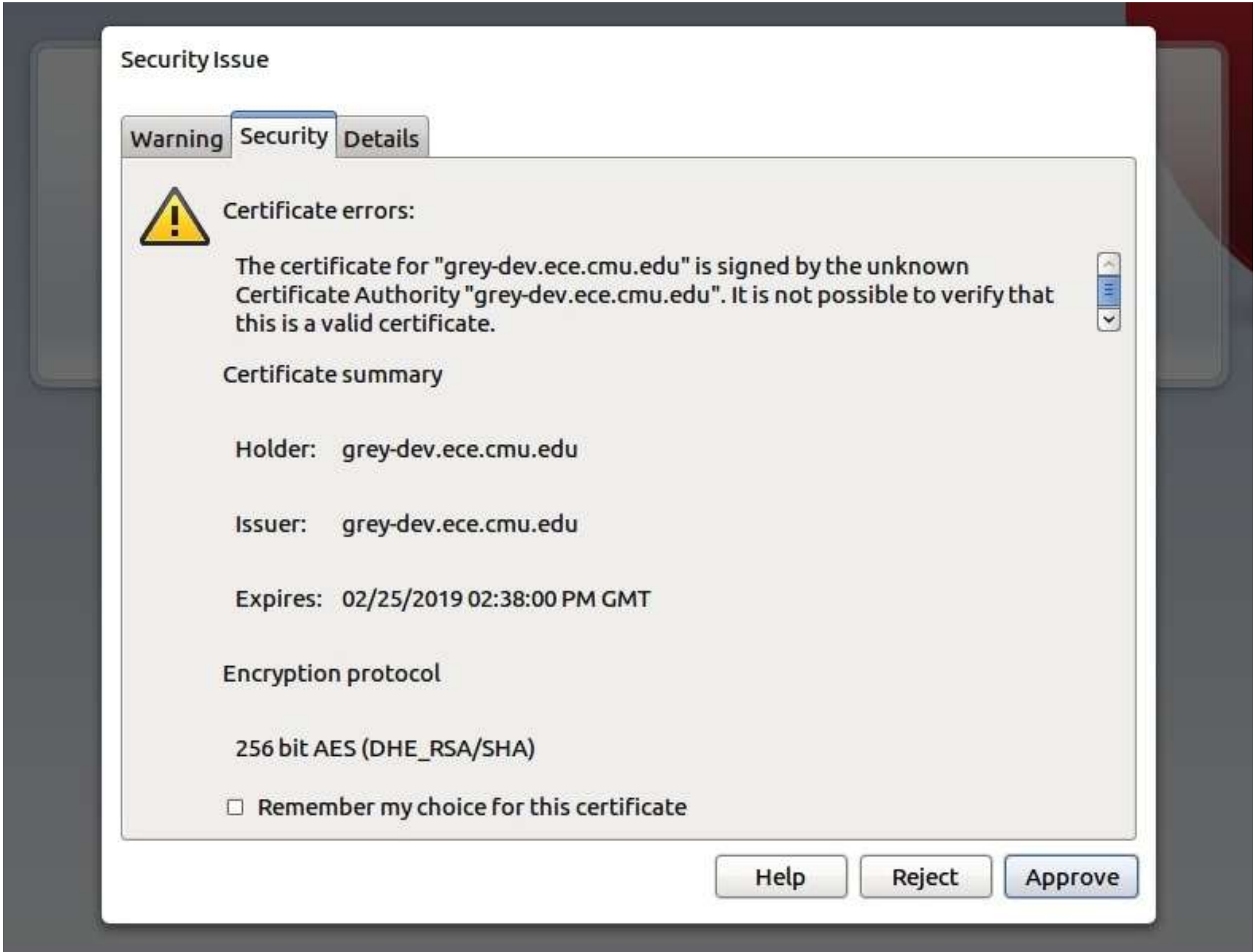


The server's certificate chain is incomplete, and the signer(s) are not registered. Accept?

Server name:

grey-dev.ece.cmu.edu

Opera



Security Issue

Certificate errors:

The certificate for "grey-dev.ece.cmu.edu" is signed by the unknown Certificate Authority "grey-dev.ece.cmu.edu". It is not possible to verify that this is a valid certificate.

Certificate summary

Holder: grey-dev.ece.cmu.edu

Issuer: grey-dev.ece.cmu.edu

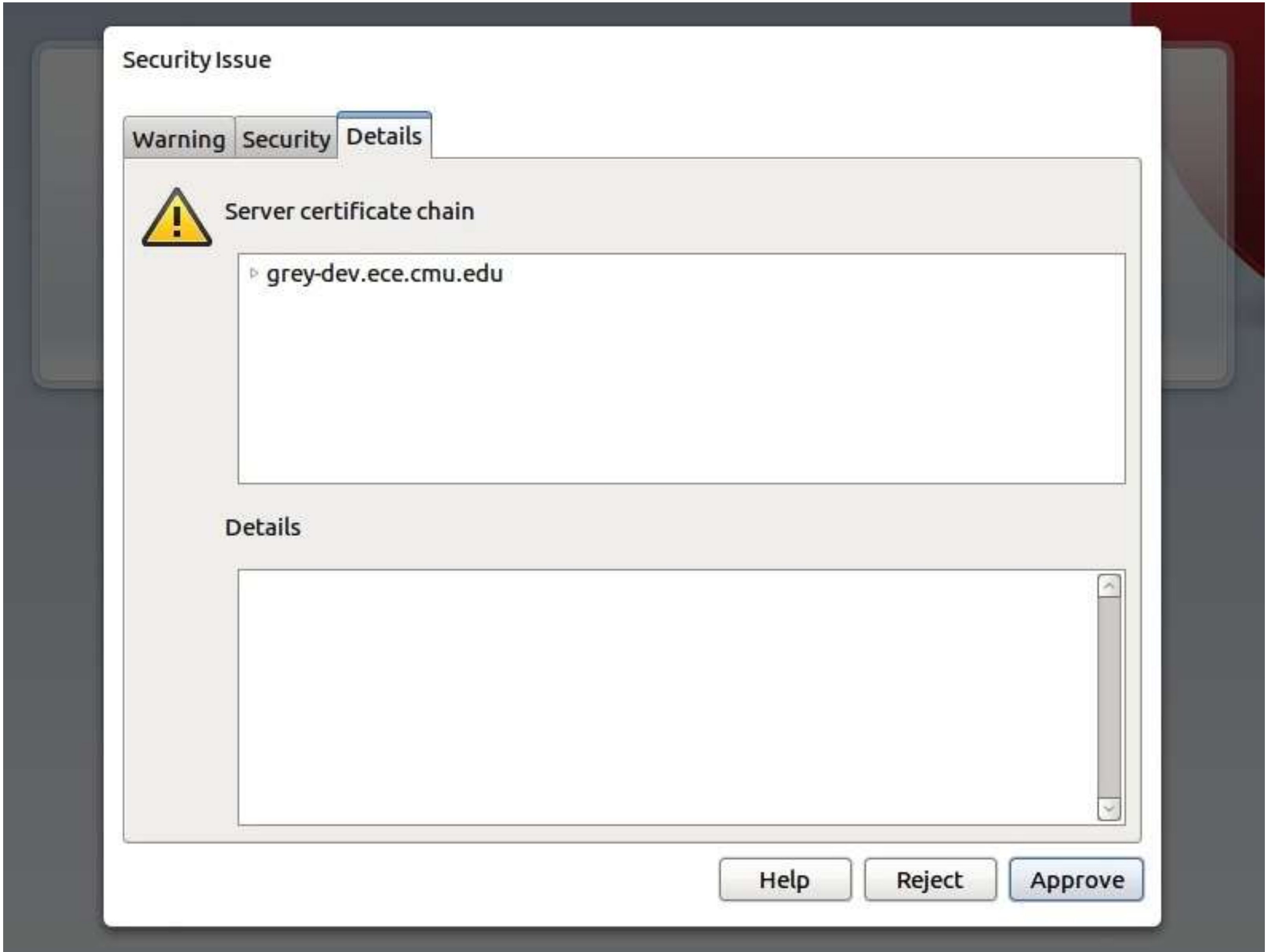
Expires: 02/25/2019 02:38:00 PM GMT

Encryption protocol

256 bit AES (DHE_RSA/SHA)

□ Remember my choice for this certificate

Opera



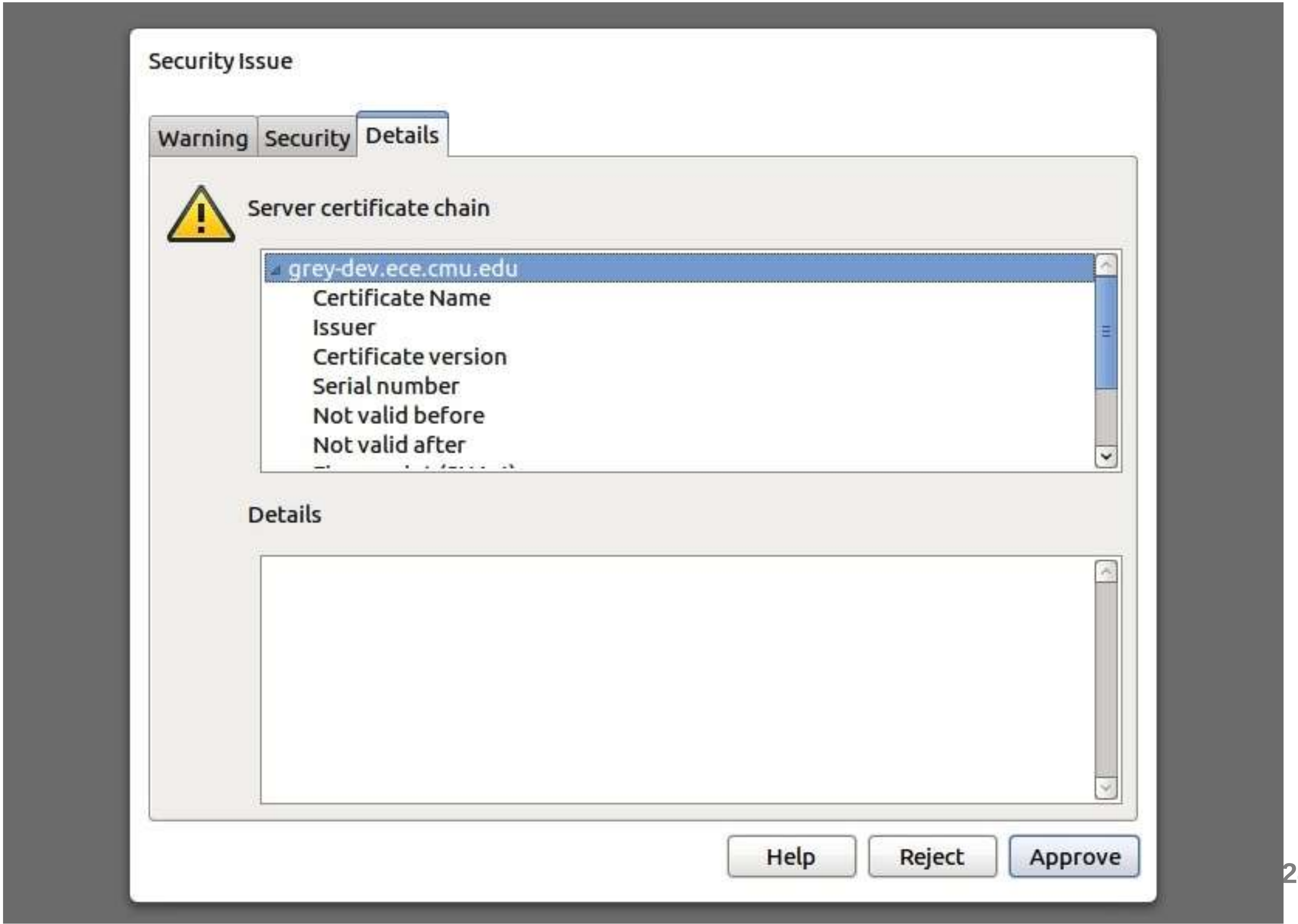
Security Issue

Server certificate chain

grey-dev.ece.cmu.edu

Details

Opera



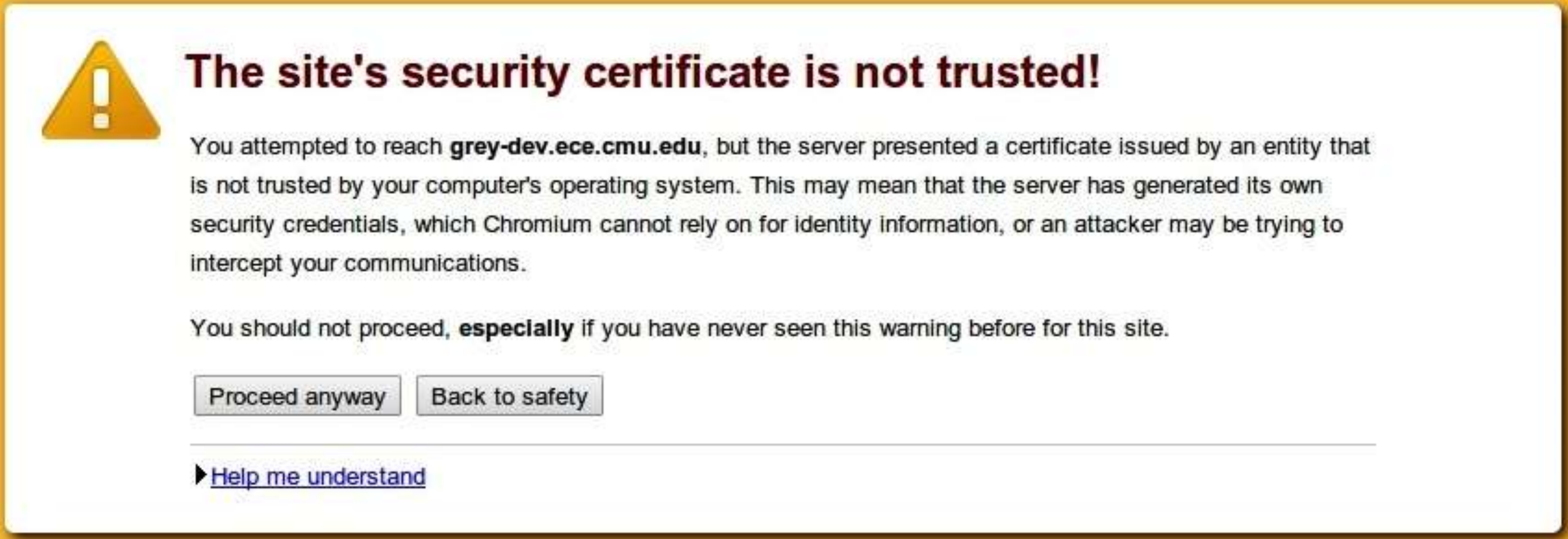
Security Issue

Server certificate chain

- grey-dev.ece.cmu.edu
  - Certificate Name
  - Issuer
  - Certificate version
  - Serial number
  - Not valid before
  - Not valid after

Details

Chromium

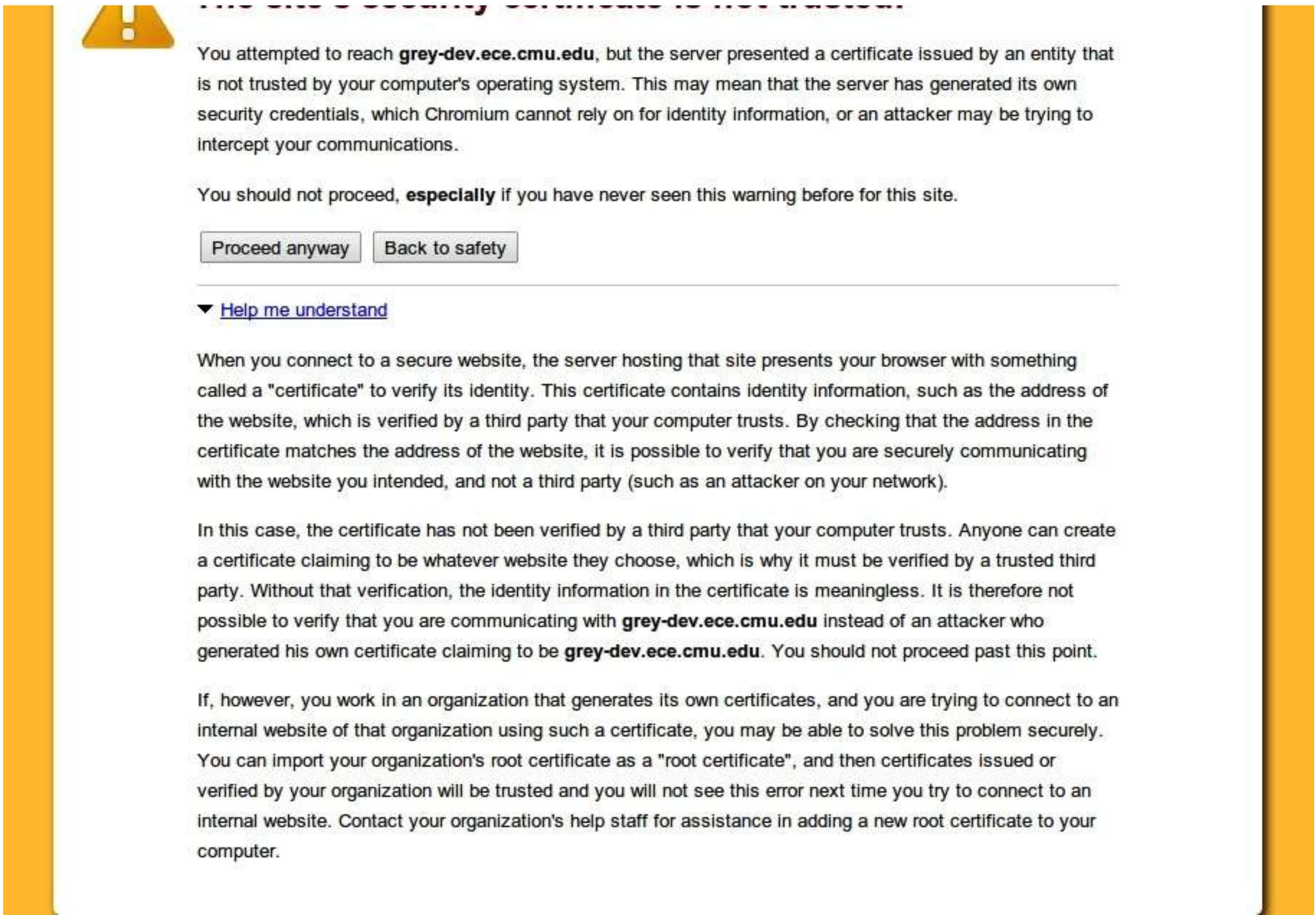


The site's security certificate is not trusted!

You attempted to reach **grey-dev.ece.cmu.edu**, but the server presented a certificate issued by an entity that is not trusted by your computer's operating system. This may mean that the server has generated its own security credentials, which Chromium cannot rely on for identity information, or an attacker may be trying to intercept your communications.

You should not proceed, **especially** if you have never seen this warning before for this site.

Chromium



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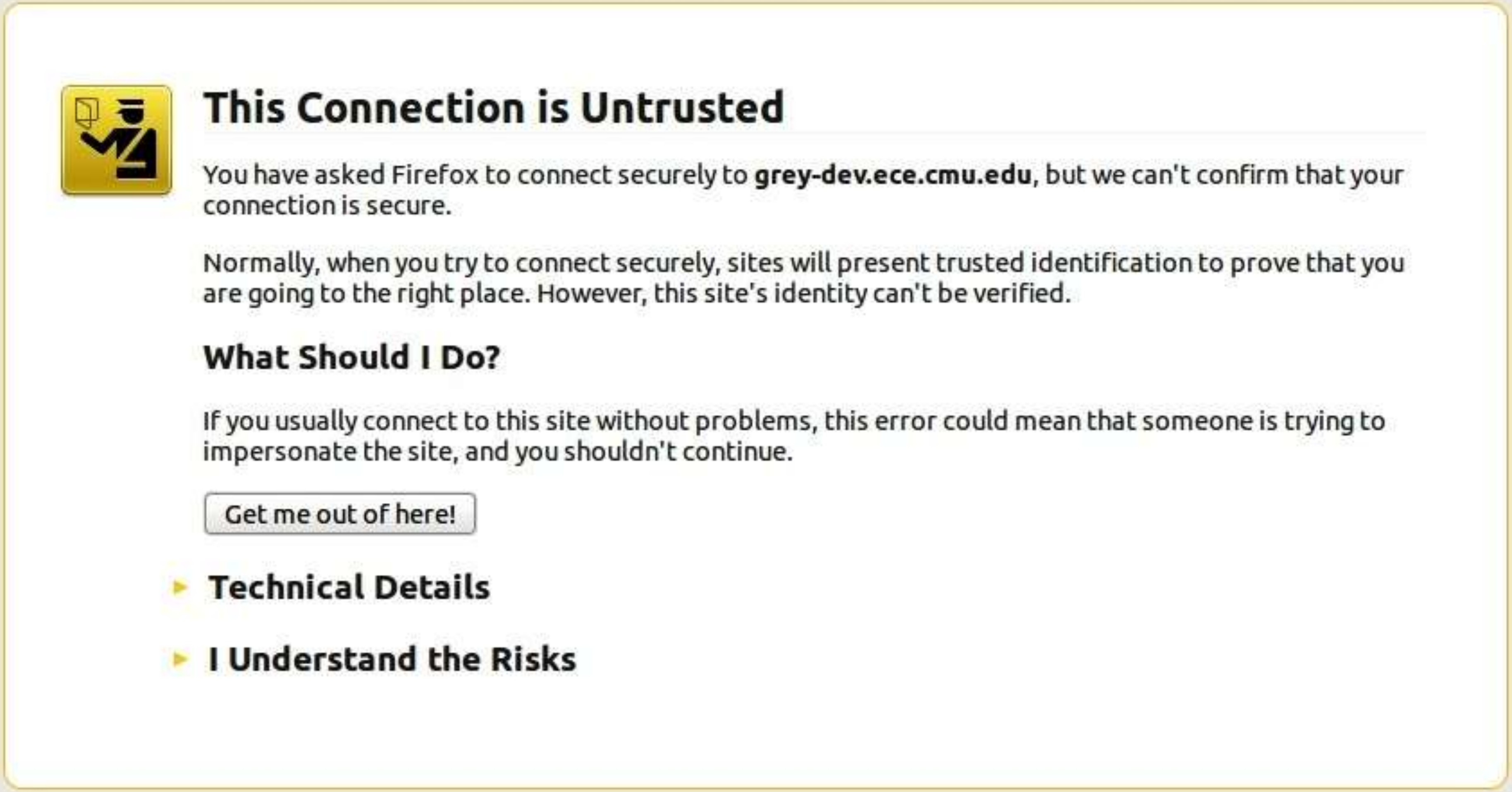
When you connect to a secure website, the server hosting that site presents your browser with something called a "certificate" to verify its identity. This certificate contains identity information, such as the address of the website, which is verified by a third party that your computer trusts. By checking that the address in the certificate matches the address of the website, it is possible to verify that you are securely communicating with the website you intended, and not a third party (such as an attacker on your network).

In this case, the certificate has not been verified by a third party that your computer trusts. Anyone can create a certificate claiming to be whatever website they choose, which is why it must be verified by a trusted third party. Without that verification, the identity information in the certificate is meaningless. It is therefore not possible to verify that you are communicating with **grey-dev.ece.cmu.edu** instead of an attacker who generated his own certificate claiming to be **grey-dev.ece.cmu.edu**. You should not proceed past this point.

If, however, you work in an organization that generates its own certificates, and you are trying to connect to an internal website of that organization using such a certificate, you may be able to solve this problem securely. You can import your organization's root certificate as a "root certificate", and then certificates issued or verified by your organization will be trusted and you will not see this error next time you try to connect to an internal website. Contact your organization's help staff for assistance in adding a new root certificate to your computer.

Mozilla Firefox



This Connection is Untrusted

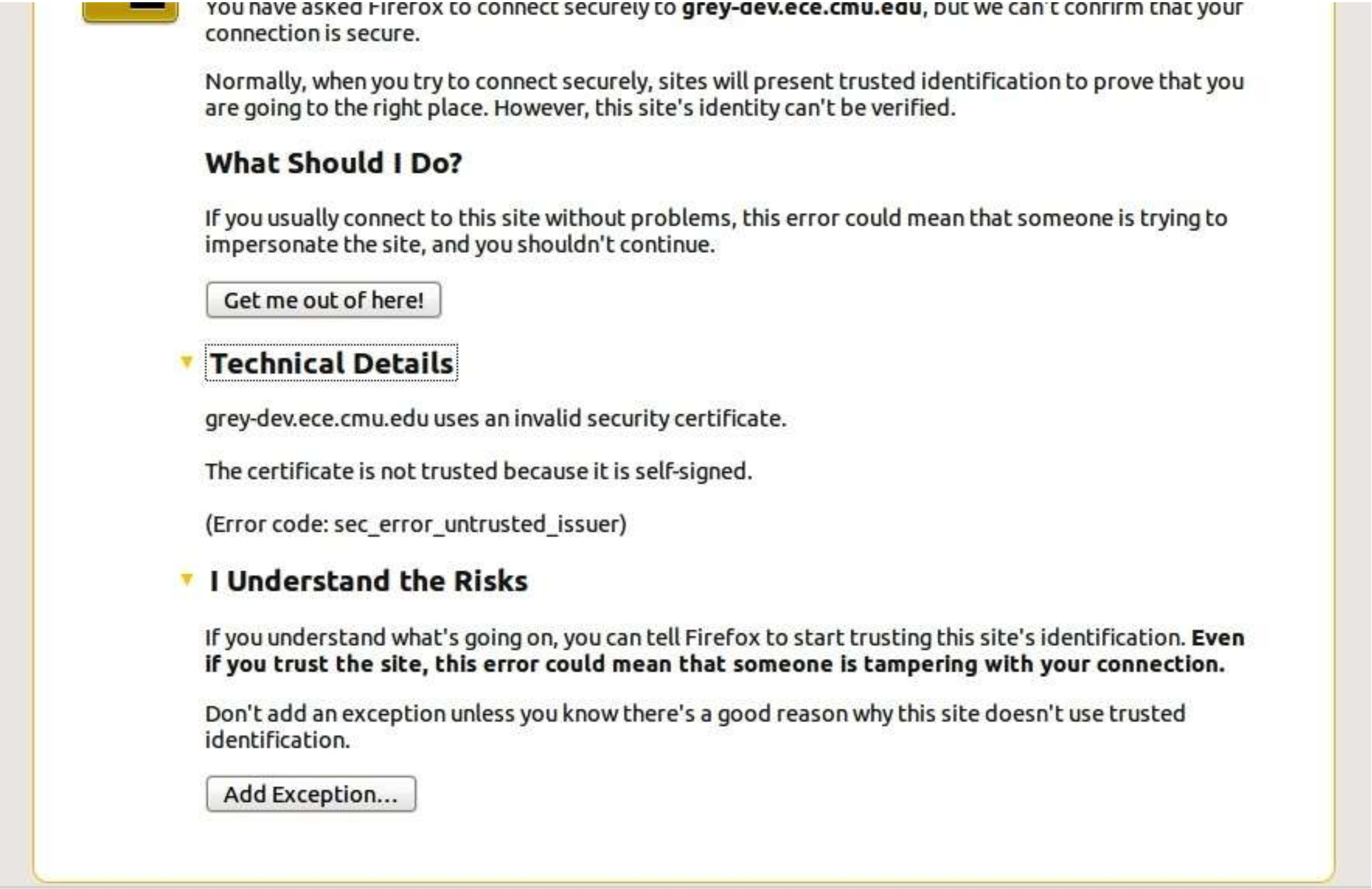
You have asked Firefox to connect securely to **grey-dev.ece.cmu.edu**, but we can't confirm that your connection is secure.

Normally, when you try to connect securely, sites will present trusted identification to prove that you are going to the right place. However, this site's identity can't be verified.

What Should I Do?

If you usually connect to this site without problems, this error could mean that someone is trying to impersonate the site, and you shouldn't continue.

Mozilla Firefox



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Technical Details

grey-dev.ece.cmu.edu uses an invalid security certificate.

The certificate is not trusted because it is self-signed.

(Error code: sec_error_untrusted_issuer)

I Understand the Risks

If you understand what's going on, you can tell Firefox to start trusting this site's identification. **Even if you trust the site, this error could mean that someone is tampering with your connection.**

Don't add an exception unless you know there's a good reason why this site doesn't use trusted identification.

Discuss Felt et al. 2016

- Coding process
- Scale
  - Not at all to Extremely
- Recruitment

Deploying certs more widely

- EFF’s Let’s Encrypt
  - https://letsencrypt.org/

Online tracking

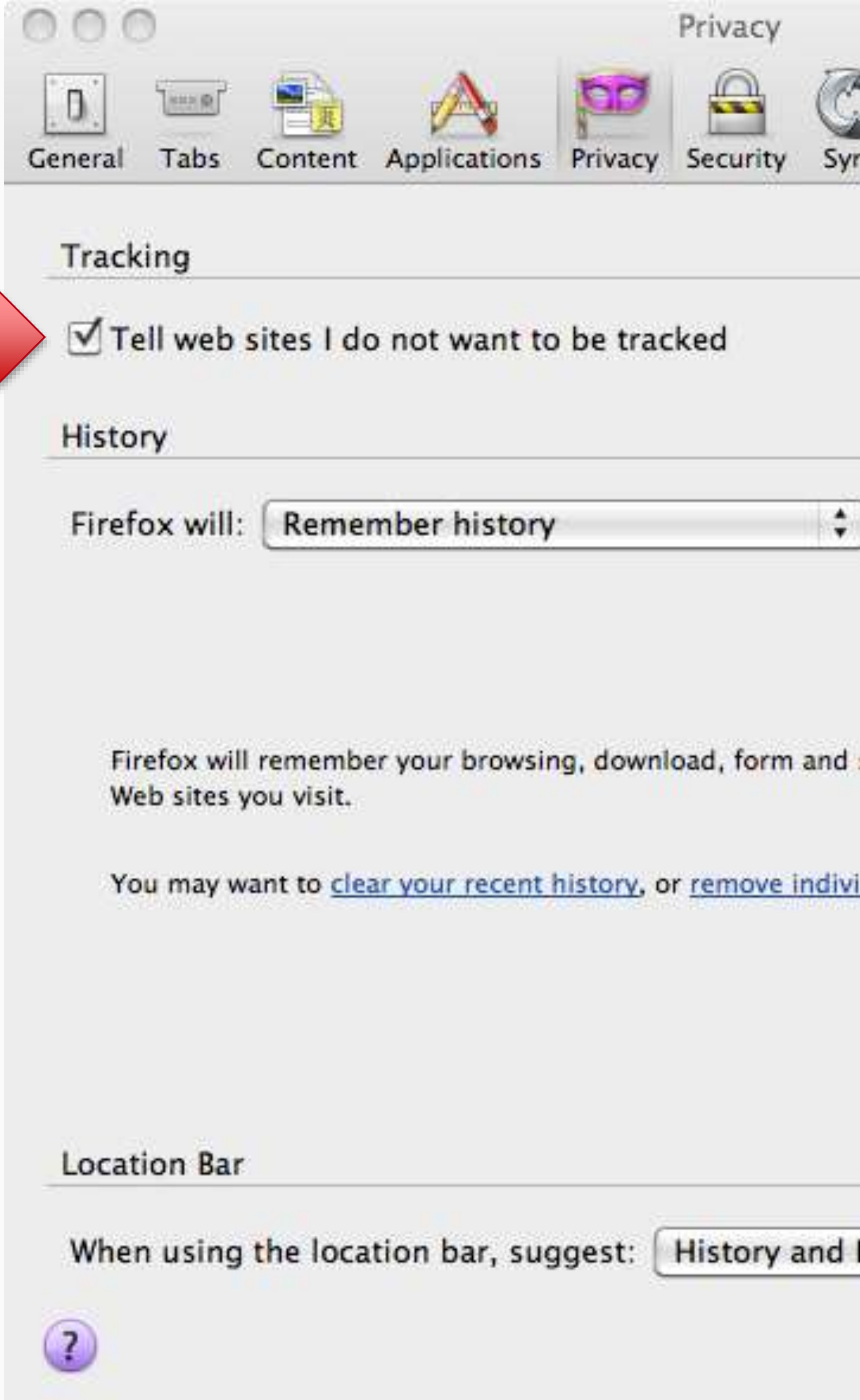
Online Tracking

- First party = the site you are visiting (whose address is in the URL bar)
- Third party = other sites contacted as a result of your visit to that site
- First-party tracking (e.g., for search)
  - Consider DuckDuckGo and alternatives

Online Behavioral Advertising (OBA)

Do not track

- Proposed W3C standard
- User checks a box
- Browser sends “do not track” header to website
- Website stops “tracking”
- W3C working group trying to define what that means



Tracking

☑ Tell web sites I do not want to be tracked

History

Firefox will: Remember history

Firefox will remember your browsing, download, form and
Web sites you visit.

You may want to clear your recent history, or remove indivi

Location Bar

When using the location bar, suggest: History and

Tools to stop tracking, effective?

- Browser privacy settings
  - Cookie blocking
  - P3P
  - Tracking Protection Lists
  - Do Not Track
- Browser add-ons
- Opt-out cookies
- Digital Advertising Alliance (DAA) AdChoices icon and associated opt-out pages

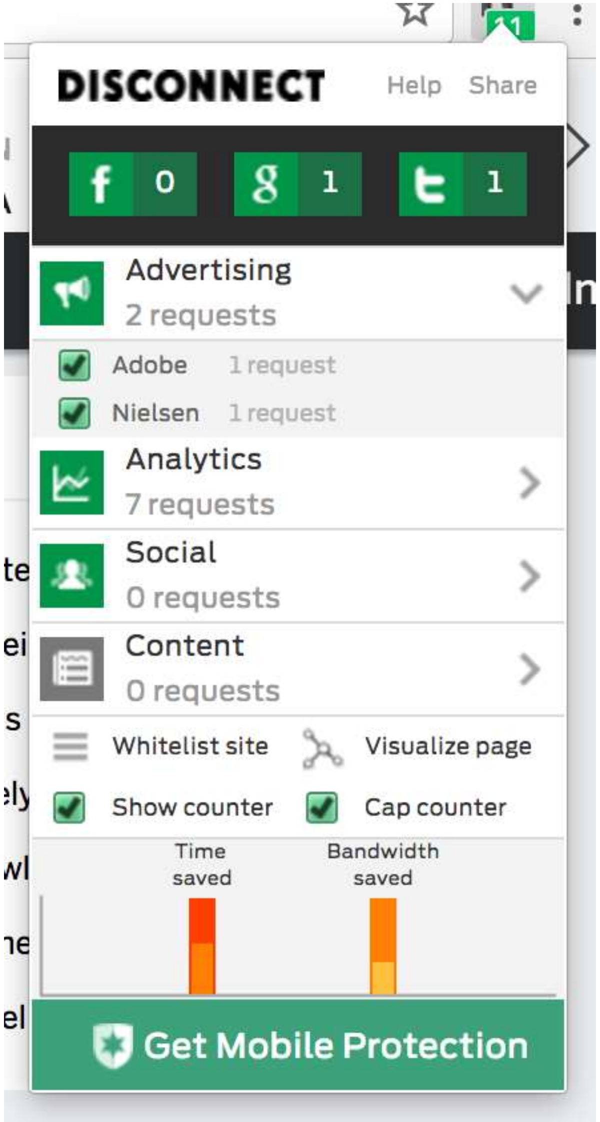
Ghostery™

DoNotTrackMe

ABP

™

Existing Privacy Tools



DISCONNECT Help Share

f 0 | g 1 | t 1

Advertising
2 requests

- ☑ Adobe 1 request
- ☑ Nielsen 1 request

Analytics
7 requests

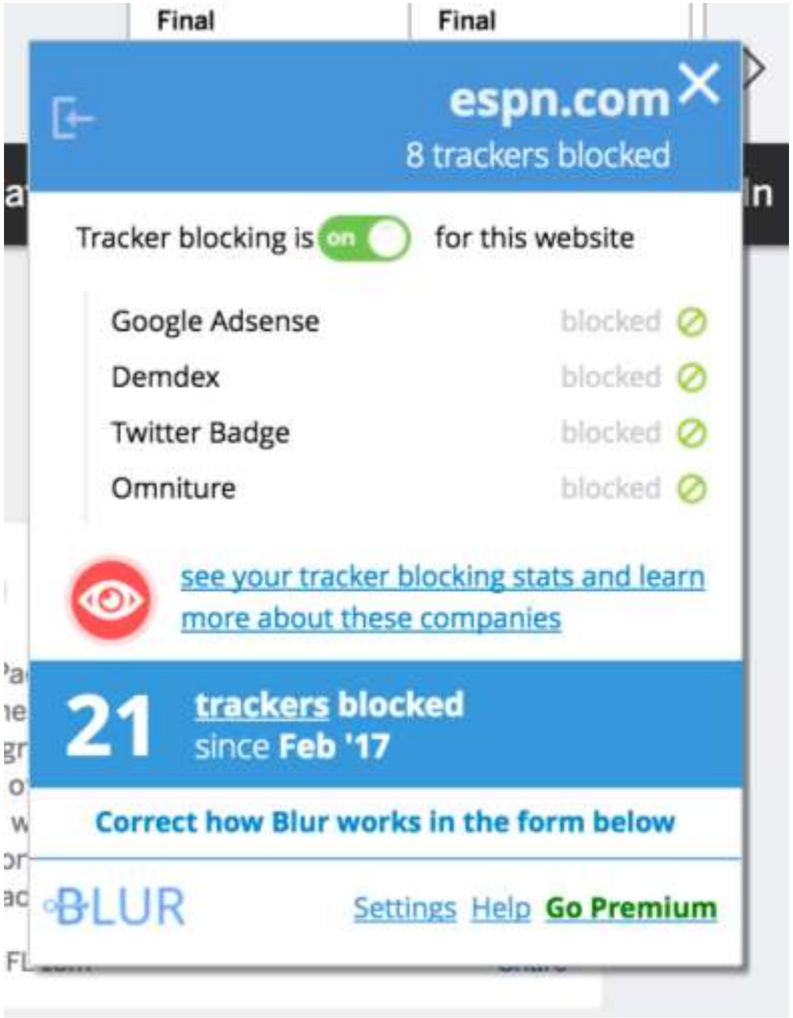
Social
0 requests

Content
0 requests

Whitelist site | Visualize page

☑ Show counter | ☑ Cap counter

Get Mobile Protection



espn.com
8 trackers blocked

Tracker blocking is on for this website

Google Adsense	blocked ⊘
Demdex	blocked ⊘
Twitter Badge	blocked ⊘
Omniture	blocked ⊘

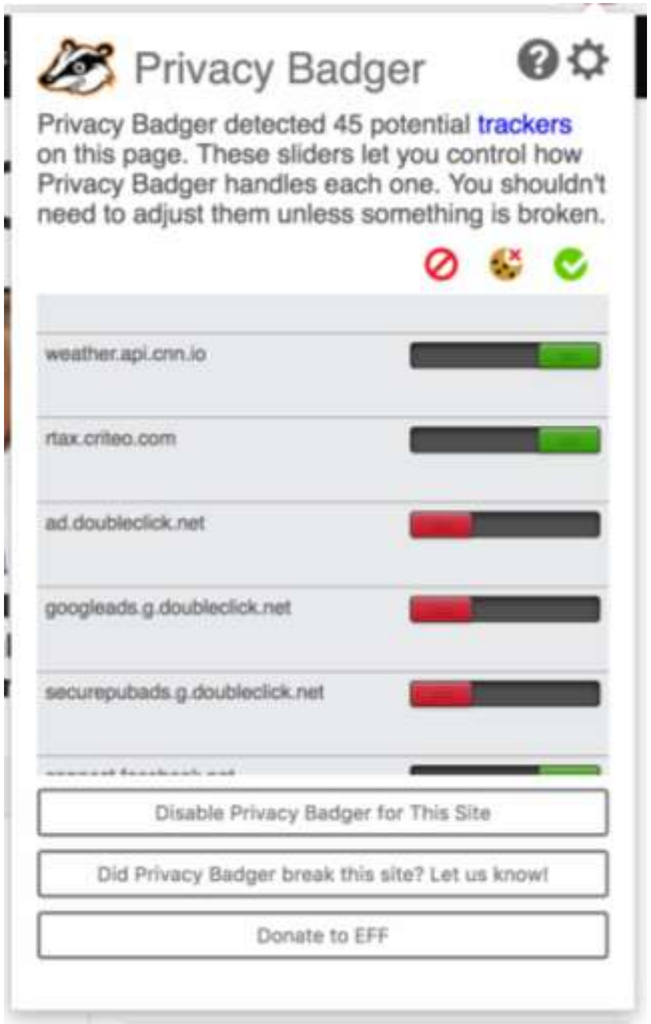
see your tracker blocking stats and learn more about these companies

21 trackers blocked since Feb '17

Correct how Blur works in the form below

BLUR Settings Help Go Premium

Existing Privacy Tools



Privacy Badger

Privacy Badger detected 45 potential trackers on this page. These sliders let you control how Privacy Badger handles each one. You shouldn't need to adjust them unless something is broken.

weather.api.cnn.io

rtax.criteo.com

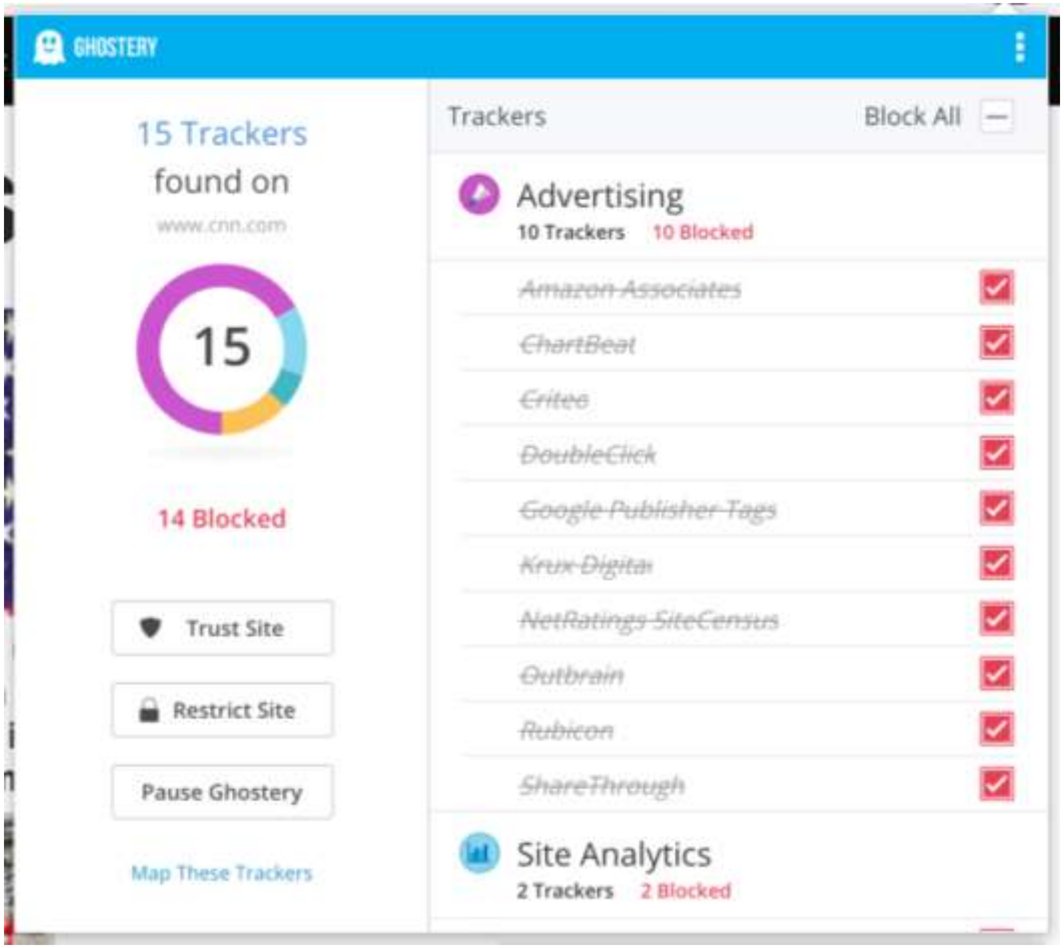
ad.doubleclick.net

googleads.g.doubleclick.net

securepubads.g.doubleclick.net

connect.facebook.net

Disable Privacy Badger for This Site
Did Privacy Badger break this site? Let us know!
Donate to EFF



GHOSTERY

15 Trackers found on www.cnn.com

15

14 Blocked

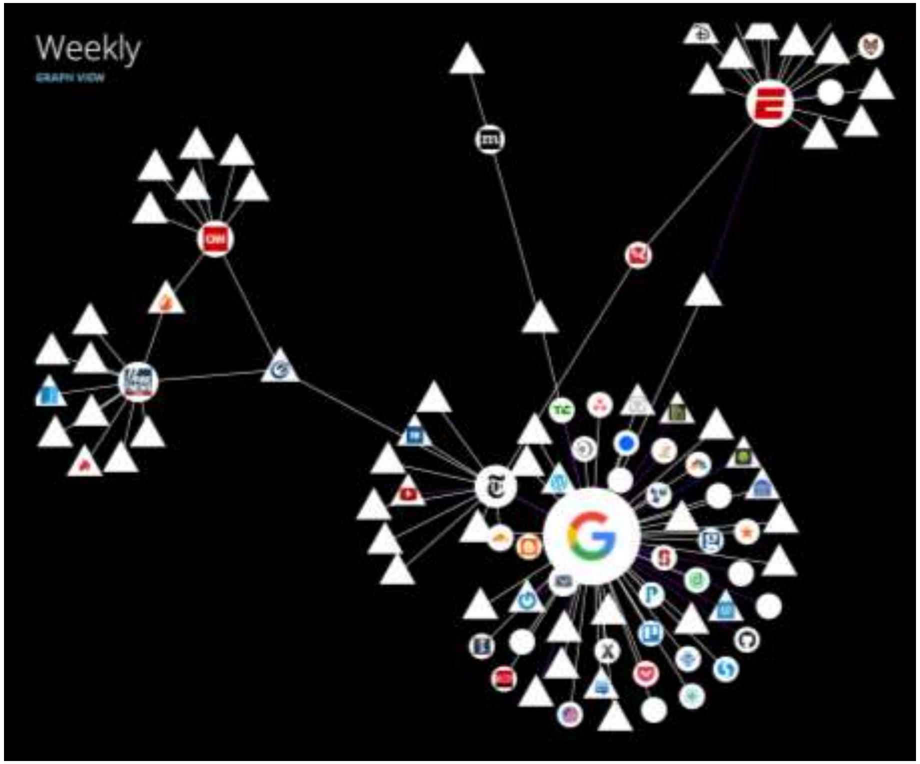
Trackers Block All

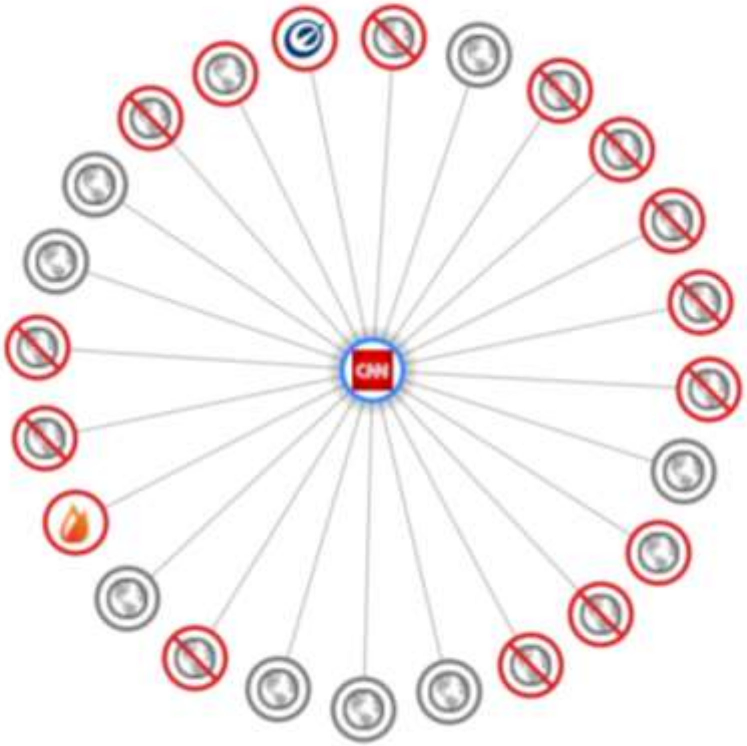
Advertising
10 Trackers 10 Blocked

~~Amazon Associates~~ ☑
~~ChartBeat~~ ☑
~~Criteo~~ ☑
~~DoubleClick~~ ☑
~~Google Publisher Tags~~ ☑
~~Krux Digital~~ ☑
~~NetRatings SiteCensus~~ ☑
~~Outbrain~~ ☑
~~Rubicon~~ ☑
~~ShareThrough~~ ☑

Site Analytics
2 Trackers 2 Blocked

Existing Tools' Connection Graphs





User study results

- Problematic defaults
- Poorly designed interfaces and jargon
- Feedback
- Misconceptions about opt-out tools
- Users unable to make meaningful decisions on a per-company basis

Pedro G. Leon, Blase Ur, Rebecca Balebako, Lorrie Faith Cranor, Richard Shay, and Yang Wang. Why Johnny Can’t Opt Out: A Usability Evaluation of Tools to Limit Online Behavioral Advertising. CHI 2012.

Do people understand OBA + tools?

- Opinions about OBA mixed – both useful and creepy
- Participants did not understand OBA technologies
- Some of the worst fears based on misconceptions
- Participants did not know how to effectively exercise choice

Blase Ur, Pedro G. Leon, Lorrie Faith Cranor, Richard Shay, and Yang Wang. Smart, Useful, Scary, Creepy: Perceptions of Behavioral Advertising. SOUPS 2012.

Browser fingerprinting

- Use features of the browser that are relatively unique to your machine
  - Fonts
  - GPU model anti-aliasing (Canvas fingerprinting)
  - User-agent string
  - *(Often not)* IP address *(Why not?)*

Browser fingerprinting

- https://panopticlick.eff.org/