Lecture 2: Security Principles

https://cs161.org

Don't Blame The Users...

- Often we blame the user when an attacker takes advantage of them...
  - Yet we've consistently constructed systems that encourage users to do the wrong thing!
- Phishing is a classic example:
  - Which is a phishing email and which is an actual email from Chase?

☆ **learningcenter@berkeley.edu** Decemb

UC Cyber Security Awareness Training assigned to Nicholas C Weaver

To: nweaver@cs.berkeley.edu

As part of system-wide efforts to address the increasing threats
our information systems and data, all employees on payroll with a
required to complete the Cyber Security Awareness Training. This
employees.
The training must be completed by January 31st, 2016 and within 6
subsequent new hires.

This mandated training is now assigned to Nicholas C Weaver.

Activity Name: UC Cyber Security Awareness Training
Due Date: 1/29/2016

To access the e-course, click on the UC learning deep link below
the training:

https://uc.sumtotalsystems.com/Shibboleth.sso/WAYF?
target=https://uc.sumtotalsystems.com/secure/auth.aspx?
ru=https://uc.sumtotalsystems.com/sumtotal/app/management/Registr
tion.aspx?ActivityId=230054&entityID=urn:mace:incommon:berkeley.e

For technical questions or concerns contact Campus Shared Service

Email: itcsshelp@berkeley.edu
Telephone: (510) 664-9000, option 1

☆ **Costas Spanos** Inbox - Fastmail 6:21 PM CS

Are you on campus

To: daw@cs.berkeley.edu

Available?
--
Are you available?

No calls only text 7034199290

BEST REGARD

COSTAS SPANOS
Director, CITRIS and the Banatao Institute

Website
University of California, Berkeley 510 Cory Hall Berkeley, CA 94720
Costas Spanos is the Director of CITRIS and the Banatao Institute. He is also the Andrew S. Grove Distinguished Professor of Electrical Engineering and Computer Sciences at UC Berkeley, and the Chief Technical Officer of the Berkeley Education Alliance for Research in Singapore (BEARS). He has served as the EECS Department Chair and the Associate Dean for Research in the College of Engineering at Berkeley. His present research is focusing on energy and sustainability.

David Wagner 6:35 PM DW

Re: Are you on campus

To: Costas Spanos

I am, I am down at Hearst Annex preparing for a lecture this evening. You can call me on my cell if you want, or I can check in after lecture.

See More from Costas Spanos

(703) 419-9290

Hi David

Costas

(703) 419-9290 • 6:50 PM

Hi! D

6:51 PM

What's up, I'm in a meeting right now and I need you to get something done for me.

Costas

(703) 419-9290 • 6:52 PM

Ok, what can I do? D

6:52 PM

Okay, I need you to help me purchase an amazon gift card now, I'll reimburse you back when the meeting is over.

Costas

(703) 419-9290 • 6:55 PM

Today's my friend son birthday

(703) 419-9290 • 6:56 PM

What would you like me to do? D

6:57 PM

I need you to help me purchase an amazon gift card from the nearest store around.

(703) 419-9290 • 6:58 PM

Security often comes down to money...

- You don't put a $10 lock on a $1 item...
  - Unless the attacker can leverage that $1 item to attack something more important
- You don't risk exposing a $1M zero-day on a nobody
  - So I'm quite content to use my iPhone in a hostile network:
    free market cost of a zero-day (unknown/unpatchable) exploit chain for iOS is somewhere between $500k to $1.5M
- Cost/benefit analyses appear all throughout security

Prevention

- The goal of prevention is to stop the "bad thing" from happening at all
- On one hand, if prevention works its great
  - E.g. if you write in a memory-safe language (like Python) you are immune from buffer overflow exploits
- On the other hand, if prevention fails, it can fail hard
  - Example: $68M stolen from a Bitcoin exchange, car
  - Or Ethereum's July 2018: four separate multi-millior theft incidents
  - Or Coinbase accounts: Averaging a theft a day!


Hacked Bitcoin Exchange Says Users May Share $68 Million Loss

by Lulu Yilun Chen t luluyilun Yuji Nakamura t ynakamura56

Detection & Response

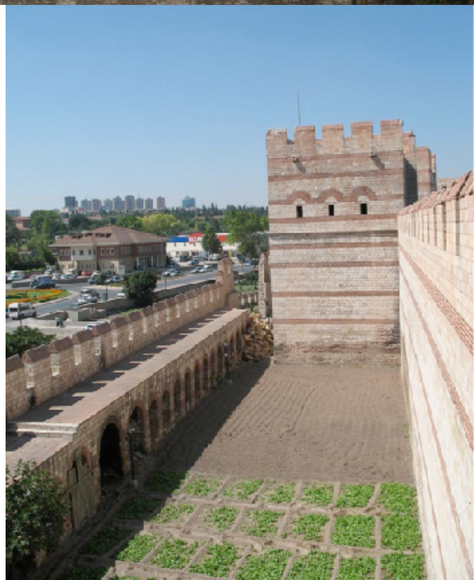
- Detection: See that something is going wrong
- Response: Do something about it
  - Example: Reverse the harmful actions (restore from backup), prevent future harm (block attacker)
  - Need both — no point in detection without a way to respond and remediate

False Positive and False Negatives

- False positive:
  - You alert when there is nothing there
- False negative:
  - You fail to alert when something is there
- Cost of detection:
  - Responding to false positives is not free, and if there are too many false positives, detector gets removed or ignored
  - False negatives mean a failure

Defense in Depth

- The notion of layering multiple types of protection together
  - EG, the Theodesian Walls of Constantinople:
    Moat -> wall -> depression -> even bigger wall
- Idea: attacker needs to breach all the defenses to gain access
- But defense in depth isn't free:
  - You are throwing more resources at the problem



Composing Detectors for Defense In Depth

- The best case: the two detectors are ***independent***
  - With FP1 and FP2 false positive rates and FN1 and FN2 false negative rates
    - Rate is 0-1:
      0 is it never has a false positive/negative,
      1 is it is always a false positive/negative...
- Parallel composition: ***either*** detector may alert to trigger a response
  - ***Reduces*** false negatives: new rate is FN1*FN2
  - ***Increases*** false positive rate: new rate is FP1 + (1-FP1)*FP2
- Serial composition: ***both*** detectors must alert
  - ***Reduces*** false positives: new rate is FP1*FP2
  - ***Increases*** false negatives: new rate is FN1 + (1-FN1) * FN2

Password authentication

- People have a hard time remembering multiple strong passwords, so they reuse them on multiple sites
  - Consequence: security breach of one site causes account compromise on other sites
- Solution: password manager
  - Remember one strong password, which unlocks access to site passwords
- Solution: two-factor authentication
  - Need both correct password and separate device to access account
- Free advice: to protect yourself, use a password manager and two-factor authentication

The Properties We Want in a Safe

- We want the contents to be inaccessible to an attacker
  - But what ***sort*** of attacker?
  - But ***how much time*** does the attacker have?
- We want to ***measure*** how much time & capabilities needed for an attacker
  - For a safe, ratings communicate how much based on experts performing the attack
    - Such security ratings are much harder in the computer security side

Security Rating:
A Real Safe

- TL-15:
  - An expert with common tools will take >= 15 minutes to break in

Security Rating: A Stronger Safe

- TL-30:
  - The same expert and tools now takes 30 minutes

Security Rating: A Real Safe

- TL-15:
  - An expert with common tools will take >= 15 minutes to break in

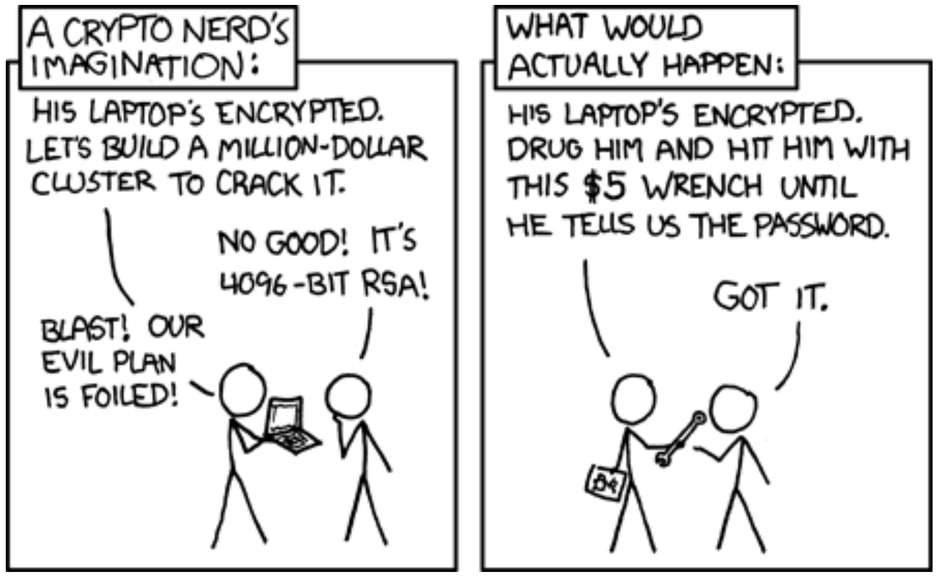
- Quiz: Suppose we sign up for a security alarm service. What guarantees do we need from it, for TL-15 to be adequate?

Security Rating: Now We Are Talking

- TRTL-30
  - 30 minute to break with tools and/or a cutting torch

Security Rating: Maximum Overkill...

- TXTL-60:
  - 60 minutes with tools, torches, and up to 4 oz of ***explosives!***
  - Far easier to use "Rubber Hose Cryptanalysis" on someone who knows the combination



Lesson:
Security is economics

- More security often costs more
  - Need to balance expected loss from undefended system, vs cost of defense
- More purchasers often makes security cheaper...

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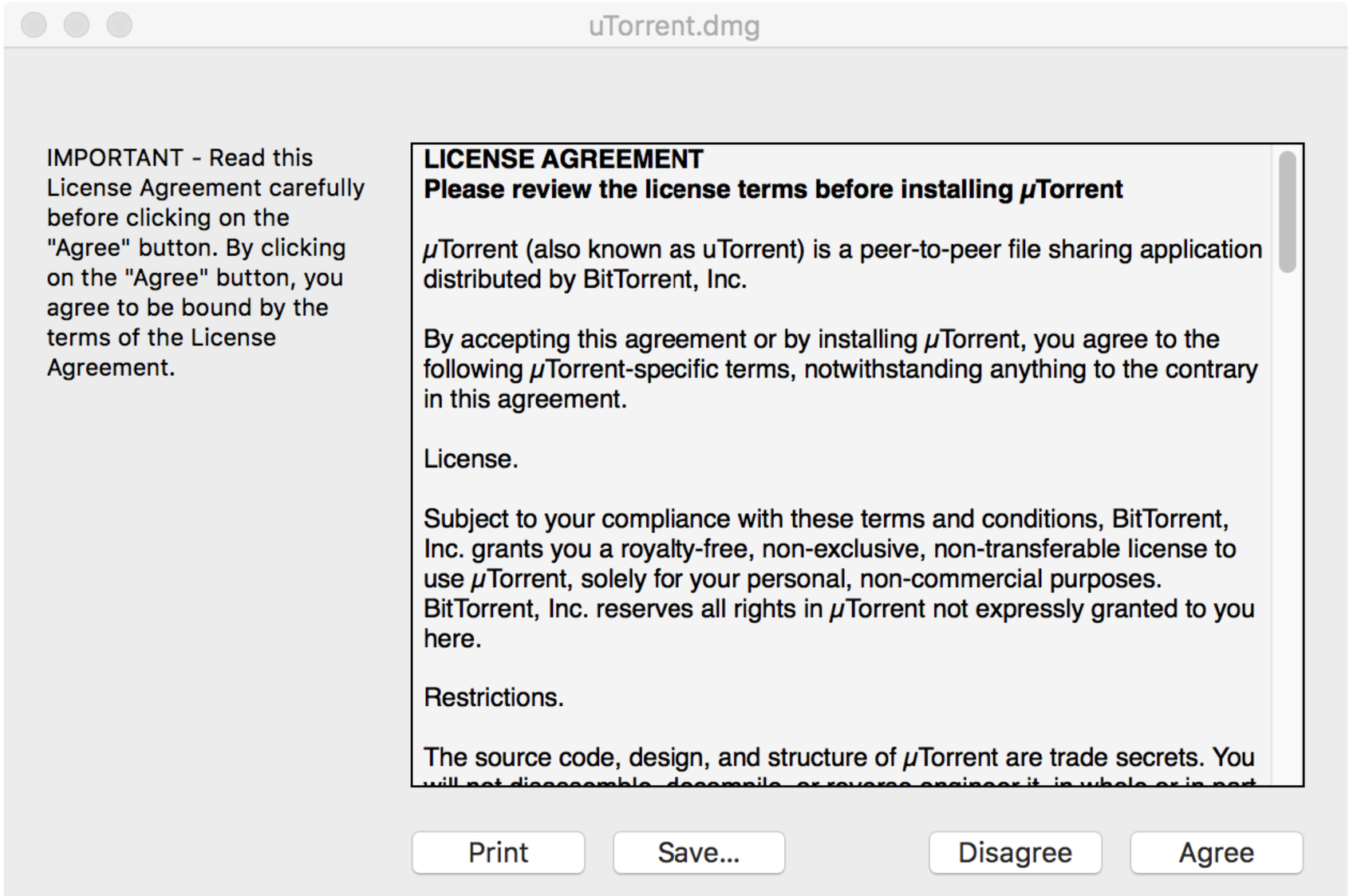
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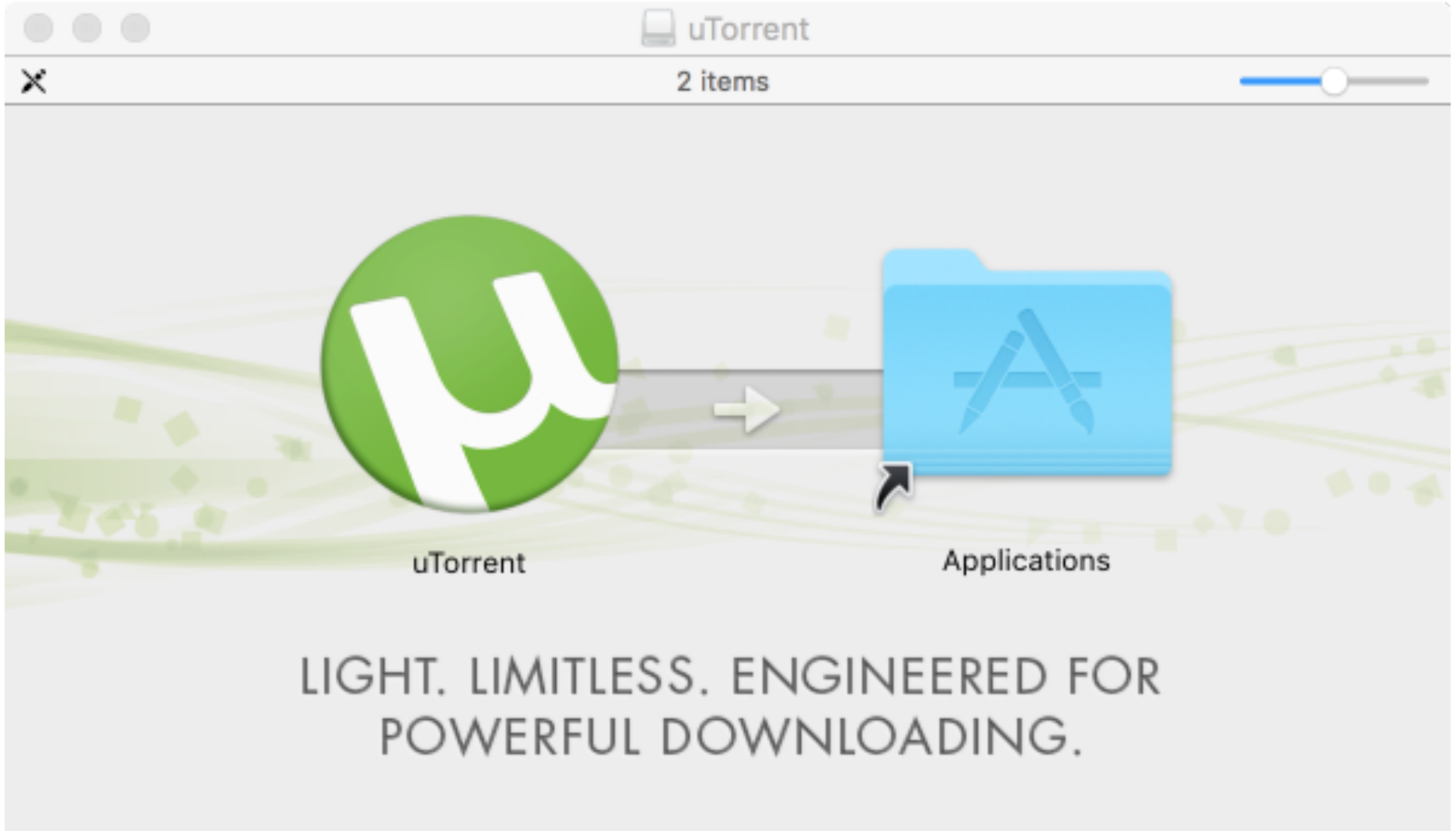
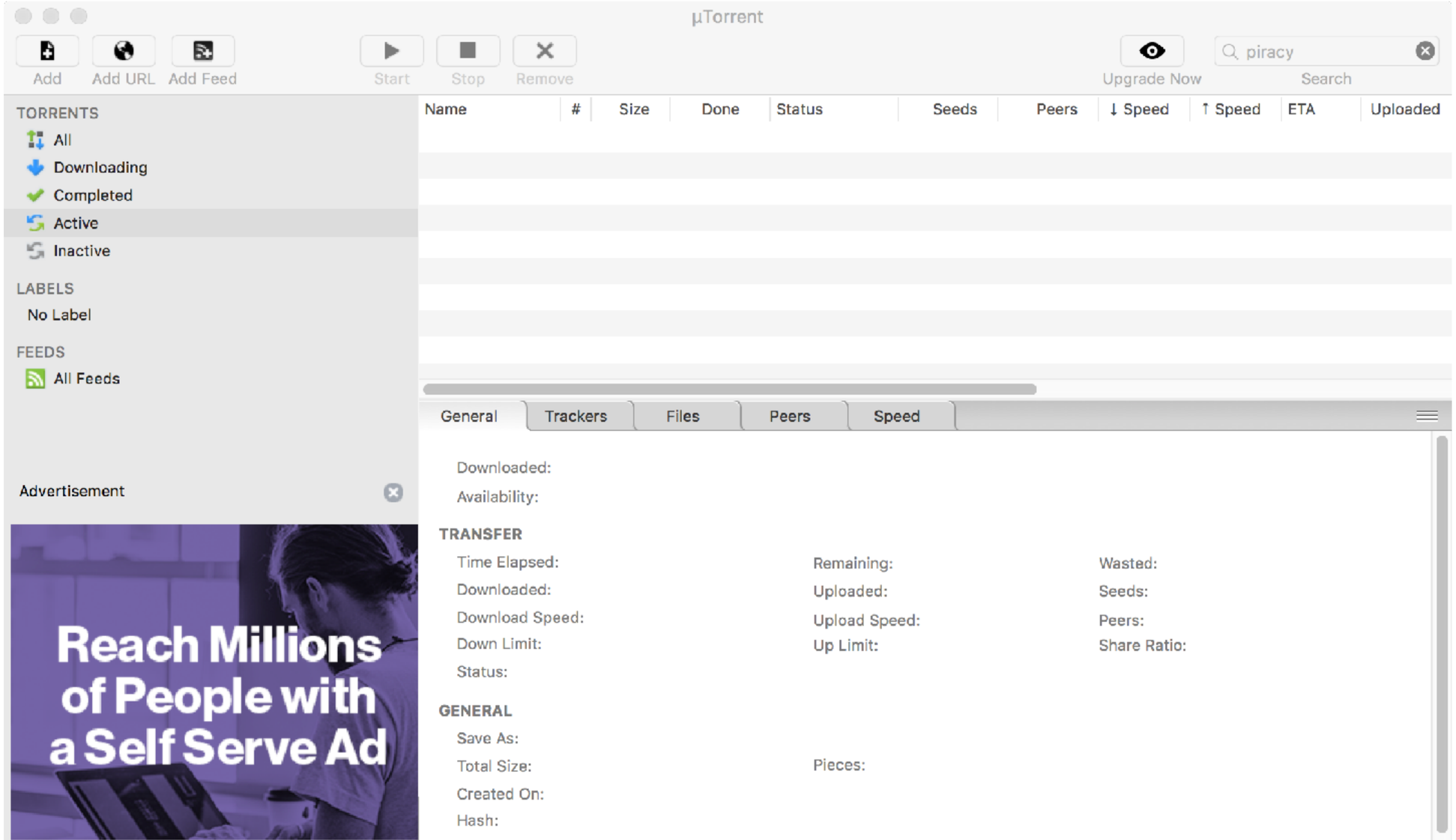

uTorrent
2 items
uTorrent
Applications
LIGHT. LIMITLESS. ENGINEERED FOR
POWERFUL DOWNLOADING.


µTorrent
Add
Add URL
Add Feed
Start
Stop
Remove
Upgrade Now
piracy
Search
TORRENTS
All
Downloading
Completed
Active
Inactive
LABELS
No Label
FEEDS
All Feeds
Name
#
Size
Done
Status
Seeds
Peers
↓ Speed
↑ Speed
ETA
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Trackers
Files
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Downloaded:
Availability:
TRANSFER
Time Elapsed:
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Download Speed:
Down Limit:
Status:
Remaining:
Uploaded:
Upload Speed:
Up Limit:
Wasted:
Seeds:
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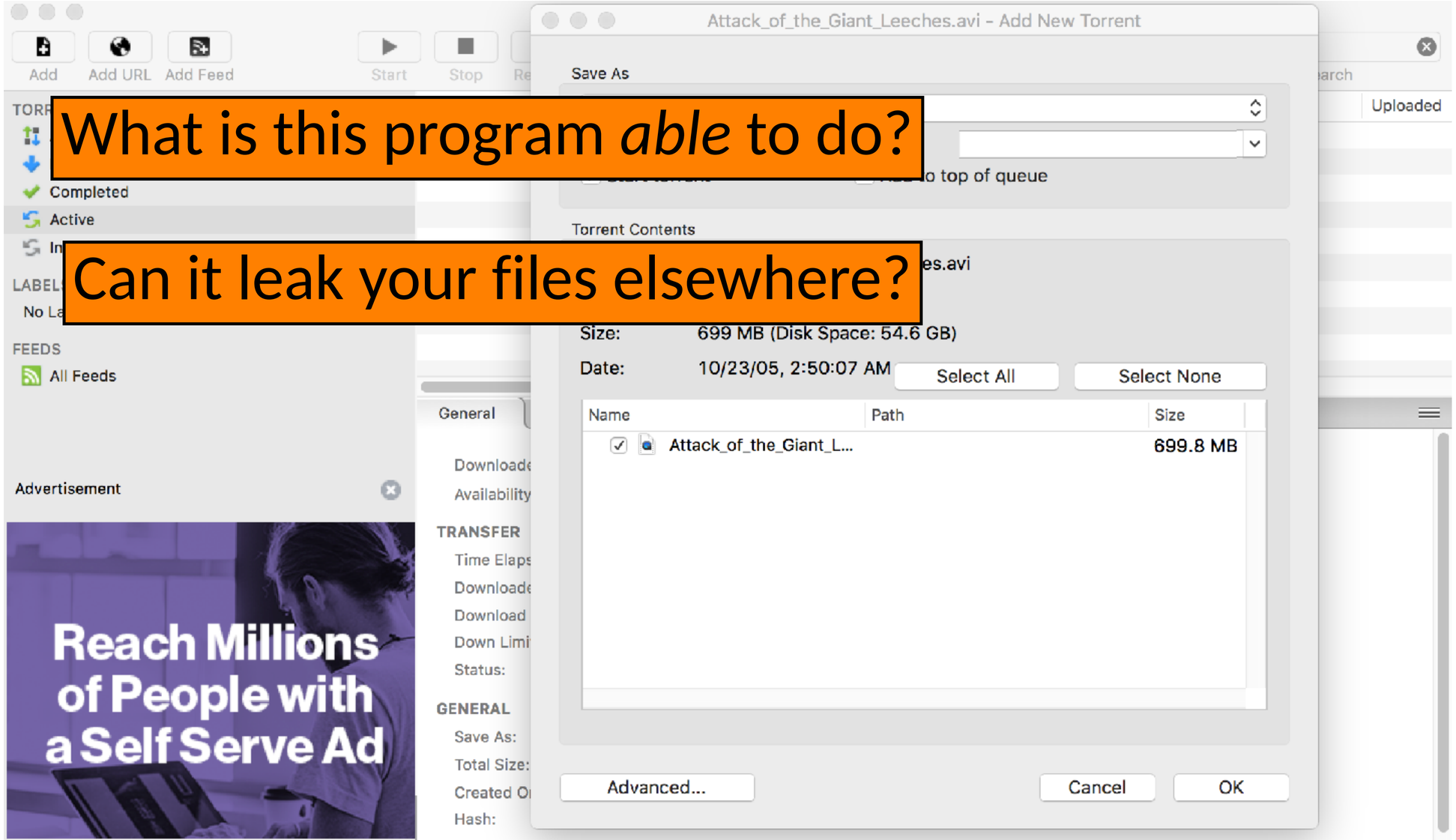
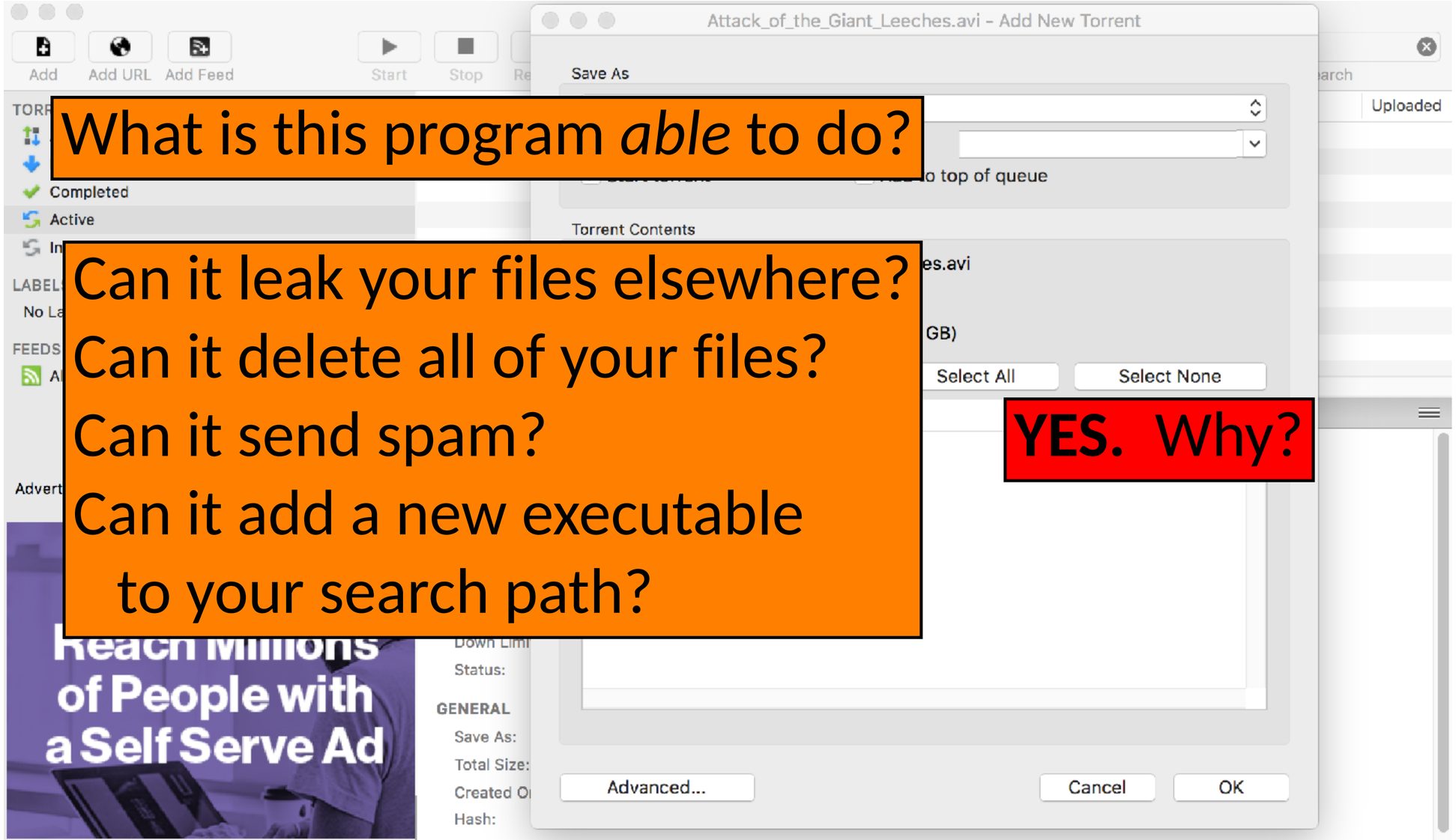
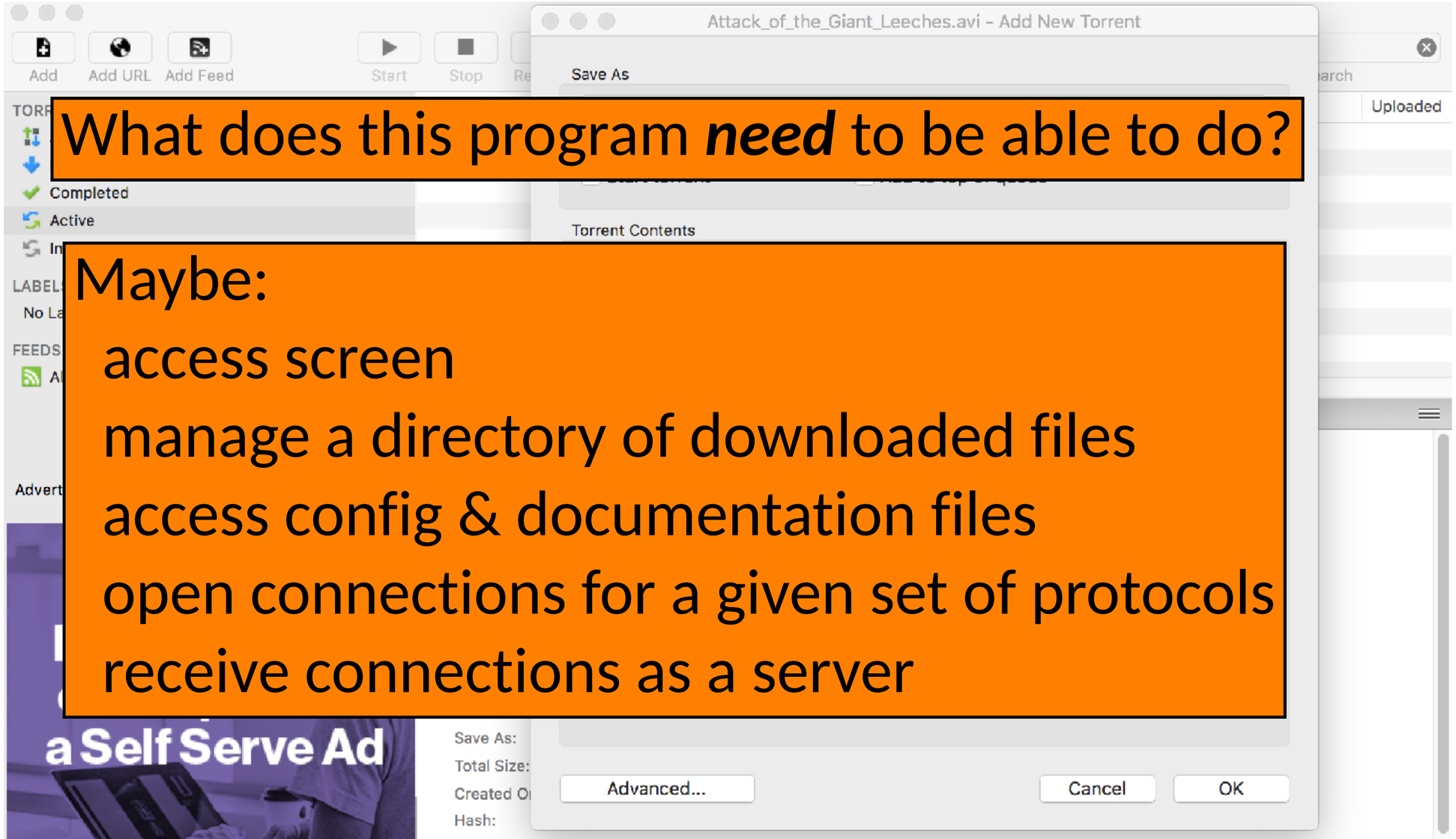
Share Ratio:
GENERAL
Save As:
Total Size:
Created On:
Hash:
Pieces:
Advertisement
Reach Millions of People with a Self Serve Ad


What is this program *able* to do?
Can it leak your files elsewhere?
Add
Add URL
Add Feed
Start
Stop
Completed
Active
FEEDS
All Feeds
Advertisement
Reach Millions of People with a Self Serve Ad
General
TRANSFER
GENERAL
Save As:
Total Size:
Hash:
Uploaded
Attack_of_the_Giant_Leeches.avi - Add New Torrent
Save As
Torrent Contents
Size: 699 MB (Disk Space: 54.6 GB)
Date: 10/23/05, 2:50:07 AM
Select All
Select None
Name
Path
Size
Attack_of_the_Giant_L...
699.8 MB
Advanced...
Cancel
OK


What is this program *able* to do?
Can it leak your files elsewhere?
Can it delete all of your files?
Can it send spam?
Can it add a new executable
to your search path?
YES. Why?
Attack_of_the_Giant_Leeches.avi - Add New Torrent
Save As
Torrent Contents
Select All
Select None
Advanced...
Cancel
OK
Add
Add URL
Add Feed
Start
Stop
Completed
Active
Uploaded
Status:
GENERAL
Save As:
Total Size:
Hash:
Reach Millions of People with a Self Serve Ad

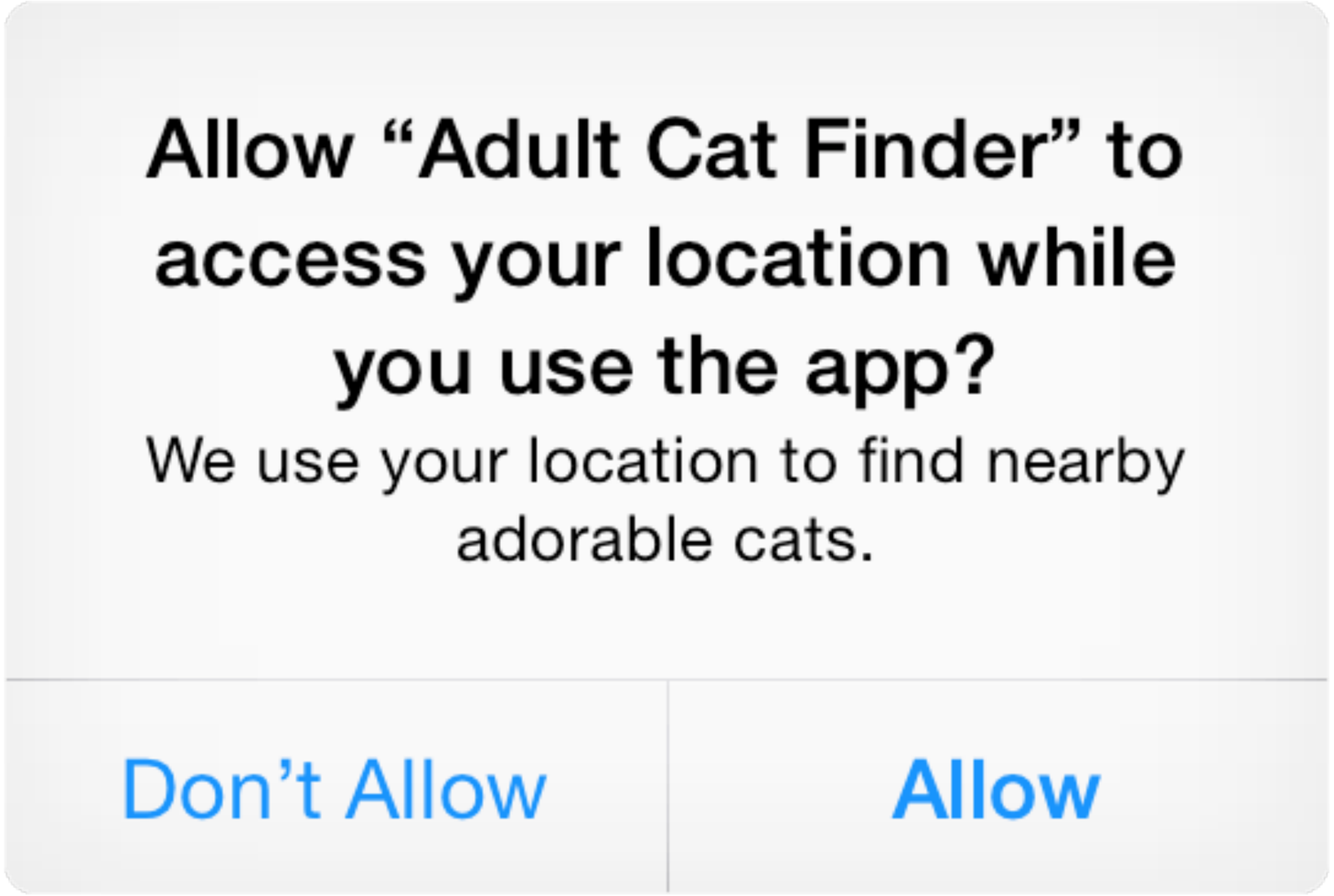

What does this program *need* to be able to do?
Maybe:
access screen
manage a directory of downloaded files
access config & documentation files
open connections for a given set of protocols
receive connections as a server
Attack_of_the_Giant_Leeches.avi - Add New Torrent
Add
Add URL
Add Feed
Start
Stop
Save As
Torrent Contents
Completed
Active
Uploaded
Save As:
Total Size:
Created O
Hash:
Advanced...
Cancel
OK
a Self Serve Ad

Check for Understanding

- We've seen that laptop/desktop platforms grant applications a lot of privileges

- Quiz: Name a platform that does a better job of least privilege

Does this follow the principle of least privilege?



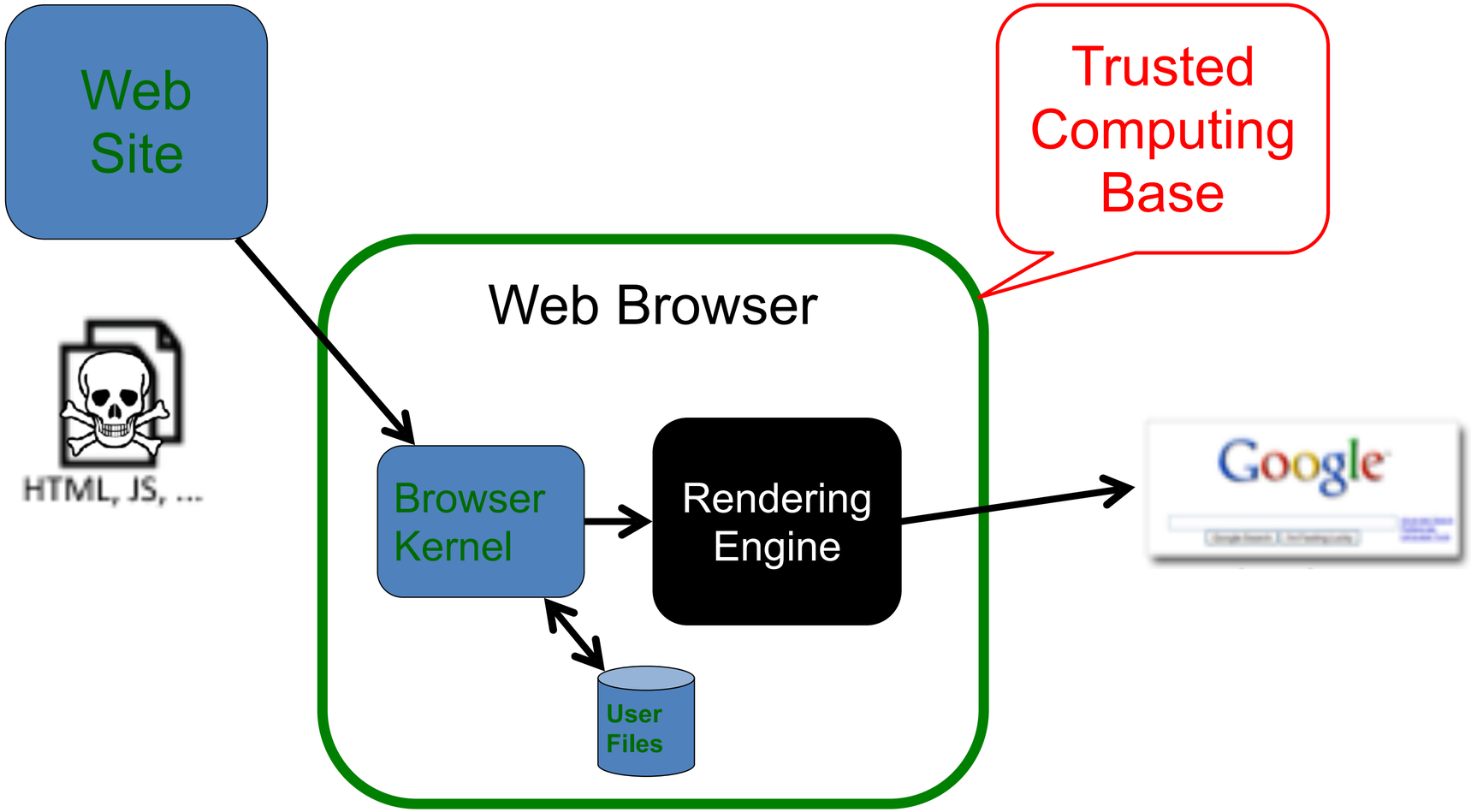
Thinking About Least Privilege

- When assessing the security of a system's design, identify the Trusted Computing Base (TCB).
  - What components does security ***rely upon***?
- Security requires that the TCB:
  - Is correct
  - Is complete (can't be bypassed)
  - Is itself secure (can't be tampered with)
- Best way to be assured of correctness and its security?
  - KISS = Keep It Simple, Stupid!
  - Generally, Simple = Small
- One powerful design approach: privilege separation
  - Isolate privileged operations to as small a component as possible

The Base for Isolation: The Operating System...

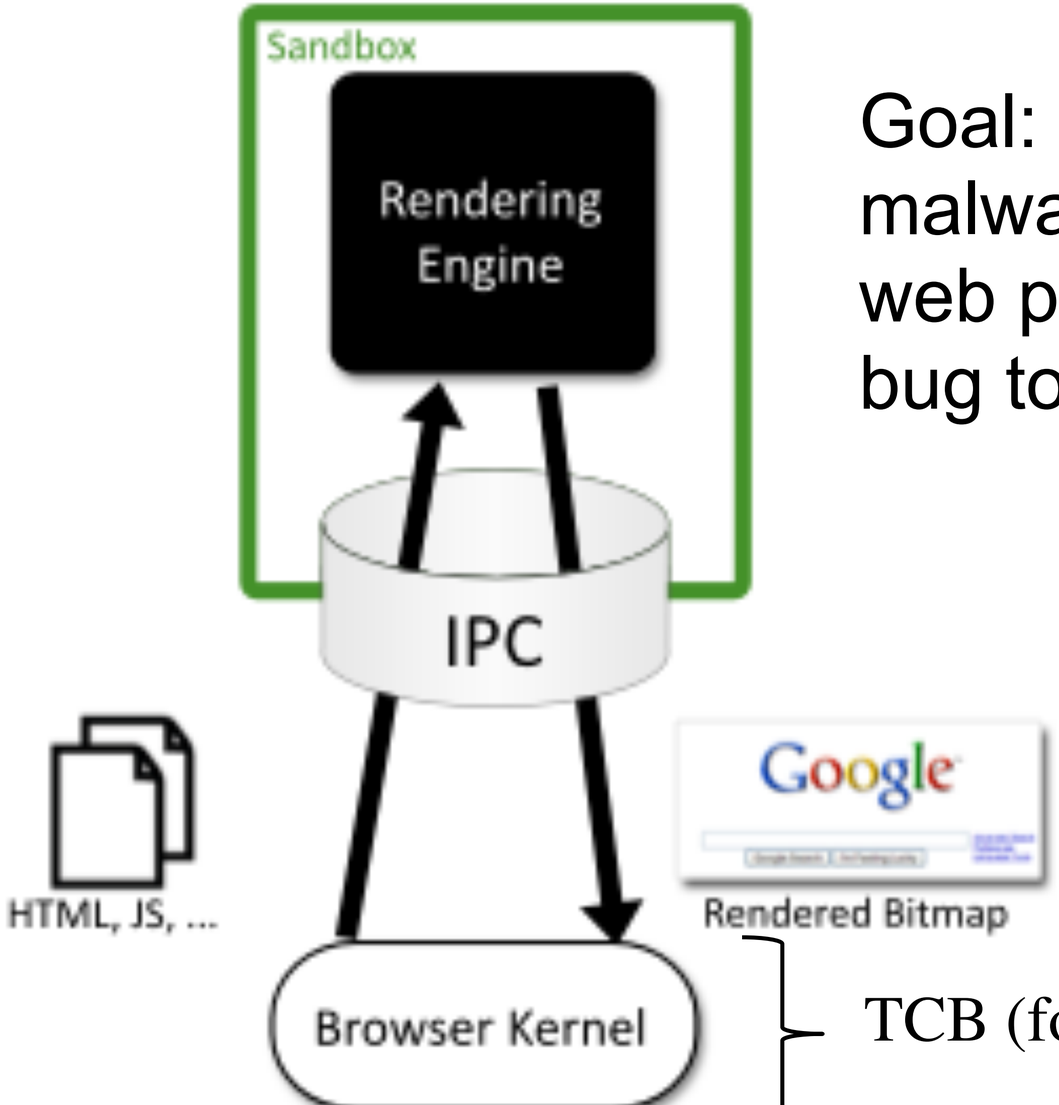
- The operating system provides the following "guarantees"
  - Isolation: A process can not access (read OR write) the memory of any other process
  - Permissions: A process can only change files etc if it has permission to
    - This ***usually*** means "Anything that the user can do" in something like Windows or MacOS
      - It can be considerably less in Android or iOS
    - But even in Windows, MacOS, & Linux one can say "I don't want any permissions"

Web browser



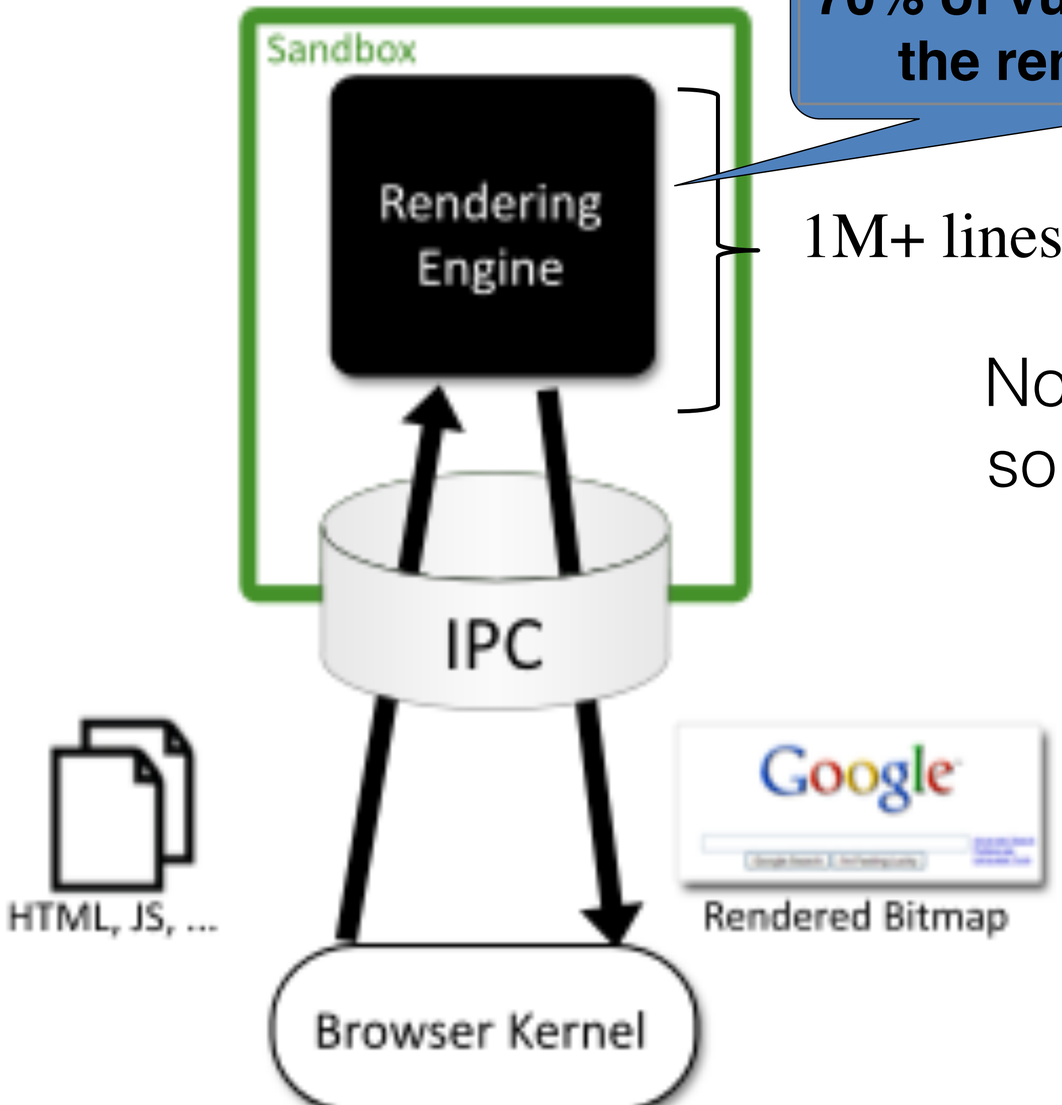
"Drive-by malware": malicious web page exploits browser bug to infect local files

The Chrome browser



Goal: prevent “drive-by malware”, where a malicious web page exploits a browser bug to infect local files

The Chrome browser



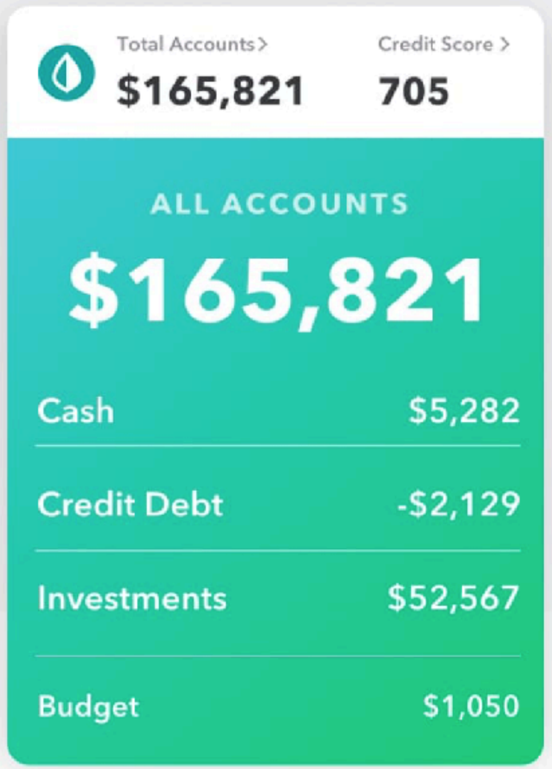
70% of vulnerabilities are in the rendering engine.

1M+ lines of code

Now it sandboxes ***each web context*** so you can't even read out other web page content (E.g. spectre)

intuit mint

Sign up | Sign in



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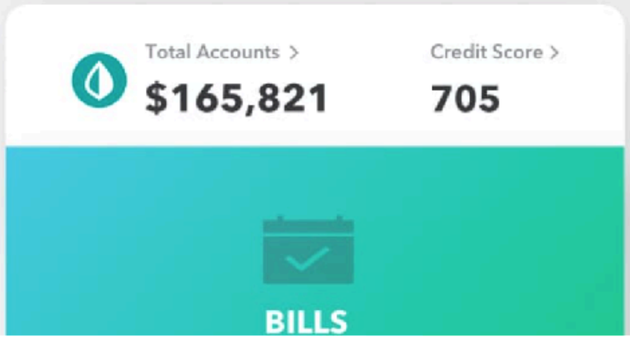

Privacy Settings

3

Discuss with a partner

- How would you architect mint.com to reduce the likelihood of a breach that reveals everyone's bank passwords?

- How would you architect mint.com to reduce the likelihood of a breach that empties everyone's bank account?

Ensuring Complete Mediation

- To secure access to some capability/resource, construct a ***reference monitor***
- Single point through which all access must occur
  - E.g.: a network firewall
- Desired properties:
  - Un-bypassable (“complete mediation”)
  - Tamper-proof (is itself secure)
  - Verifiable (correct)
  - (Note, just restatements of what we want for TCBs)
- One subtle form of reference monitor flaw concerns race conditions …

A Failure of Complete Mediation

More security principles

- Use fail-safe defaults
- Consider human factors
- Only as secure as the weakest link
- Don’t rely on security through obscurity
- Trusted path


Leitura de código de barras


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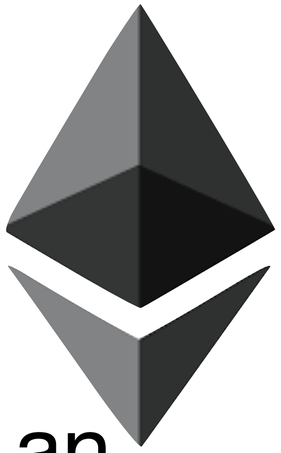
Time of Check to Time of Use Vulnerability: Race Condition


```
procedure withdraw(w)
   // contact central server to get balance
   1. let b := balance

   2. if b < w, abort

   // contact server to set balance
   3. set balance := b - w

   4. dispense $w to user
```

Suppose that *here* an attacker arranges to suspend first call, and calls withdraw again **concurrently**

TOCTTOU = Time of Check To Time of Use

A Hundred Million Dollar TOCTTOU Bug...



- Ethereum is a cryptocurrency which offers "smart" contracts
  - Program you money in a language that makes JavaScript and PHP look beautiful and sane
- The DAO (Distributed Autonomous Organization) was an attempt to make a distributed mutual fund in Ethereum
  - Participants could vote on "investments" that should be made
- The DAO supported withdrawals as well

A "Feature" In The Smart Contract

- To withdraw, the code was:
  - Check the balance, then send the money, then decrement the balance
- But sending money in Ethereum can send to ***another program written by the recipient***
- So someone "invested", then did a withdraw to his program
  - Which would initiate another withdraw...