Software Security: Design, Privilege Separation

CS 161: Computer Security

Prof. David Wagner

January 27, 2016

Robustness

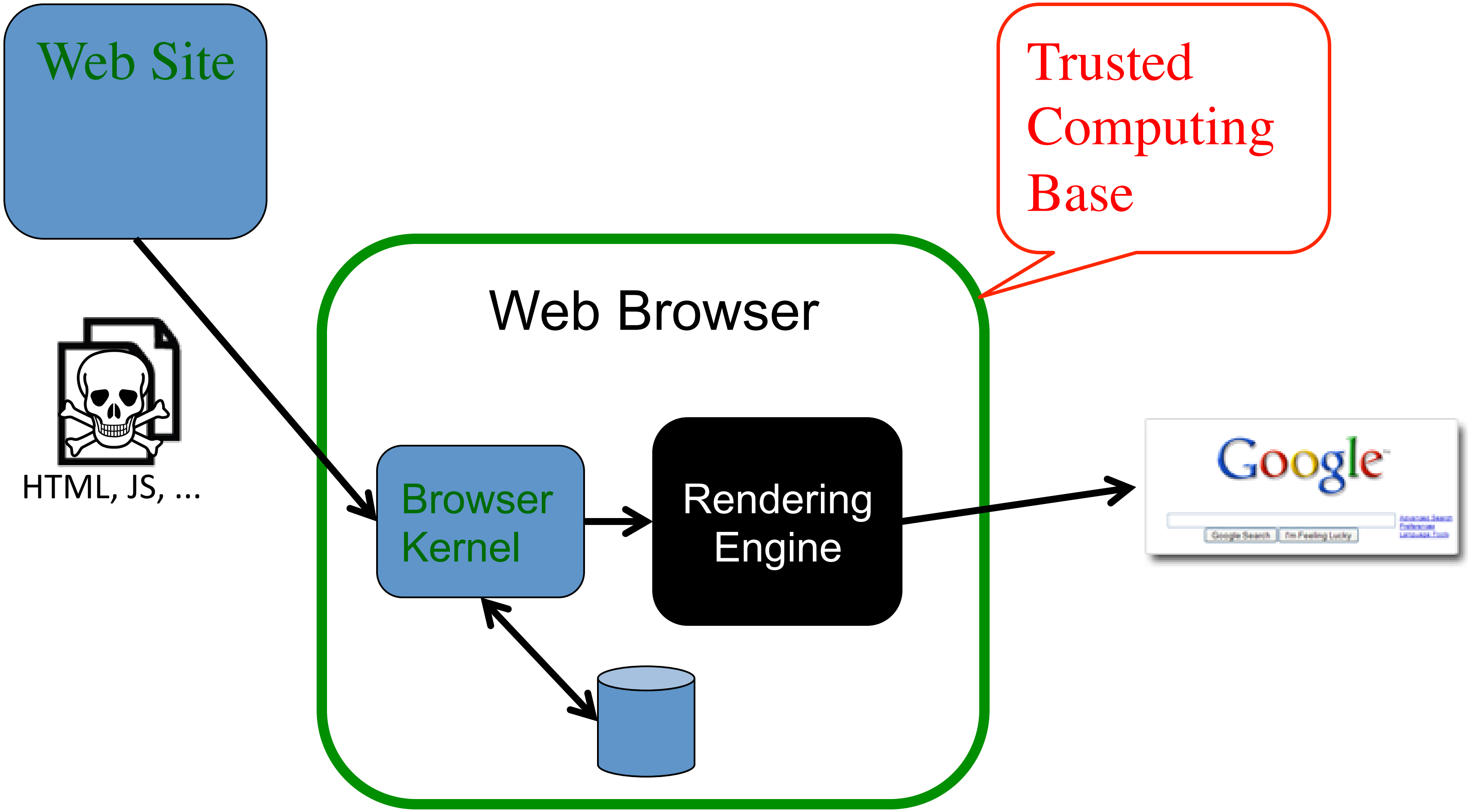
- Security bugs are a fact of life
- How can we use access control to improve the security of software, so security bugs are less likely to be catastrophic?

Privilege separation

- How can we improve the security of software, so security bugs are less likely to be catastrophic?

- Answer: privilege separation. Architect the software so it has a separate, small TCB.
  - Then any bugs outside the TCB will not be catastrophic

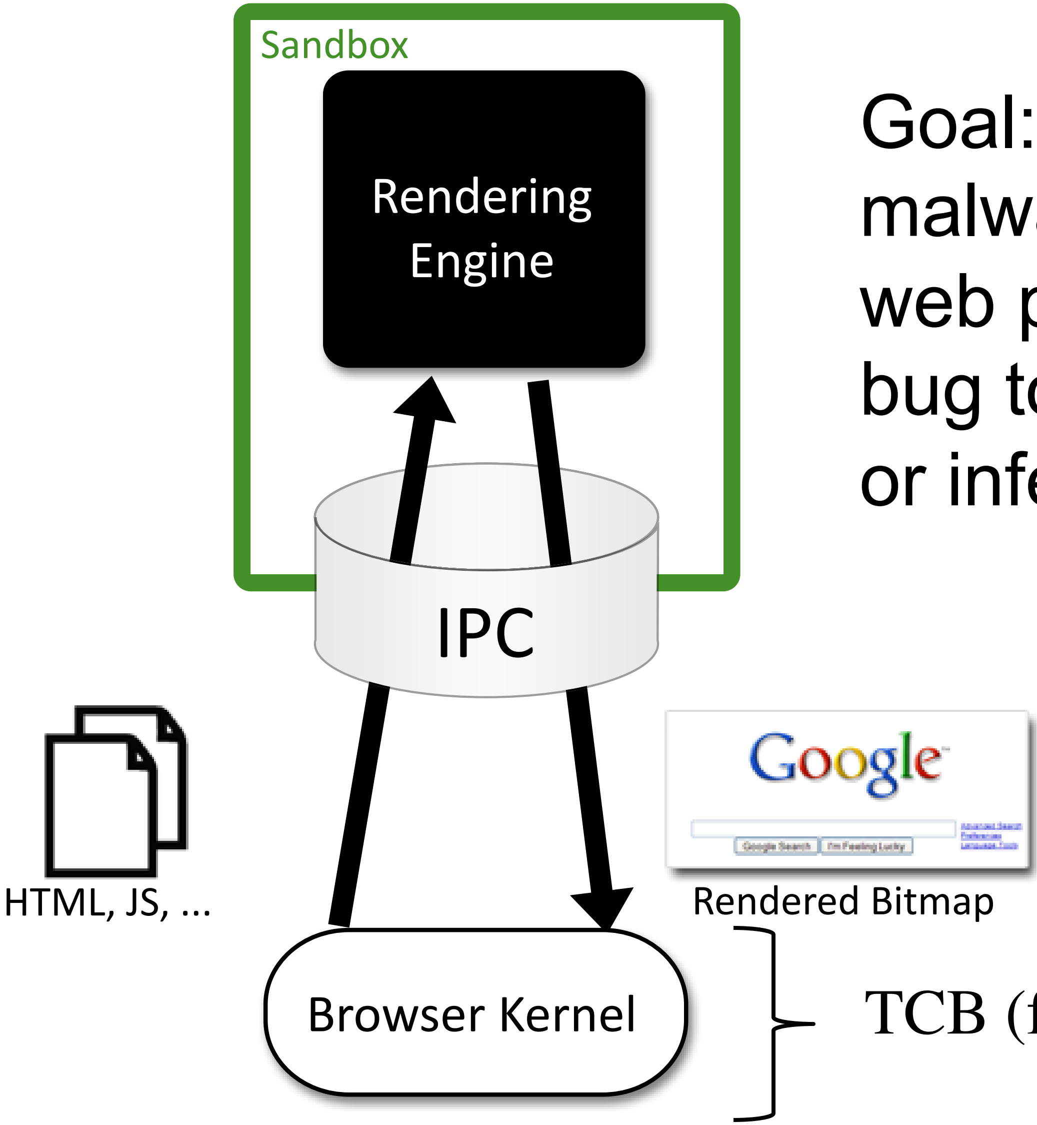
Web browser



“Drive-by malware”: malicious web page exploits a browser bug to read/write local files or infect them with a virus

The Chrome browser

Goal: prevent “drive-by malware”, where a malicious web page exploits a browser bug to read/write local files or infect them with a virus



Sandbox

Rendering Engine

IPC

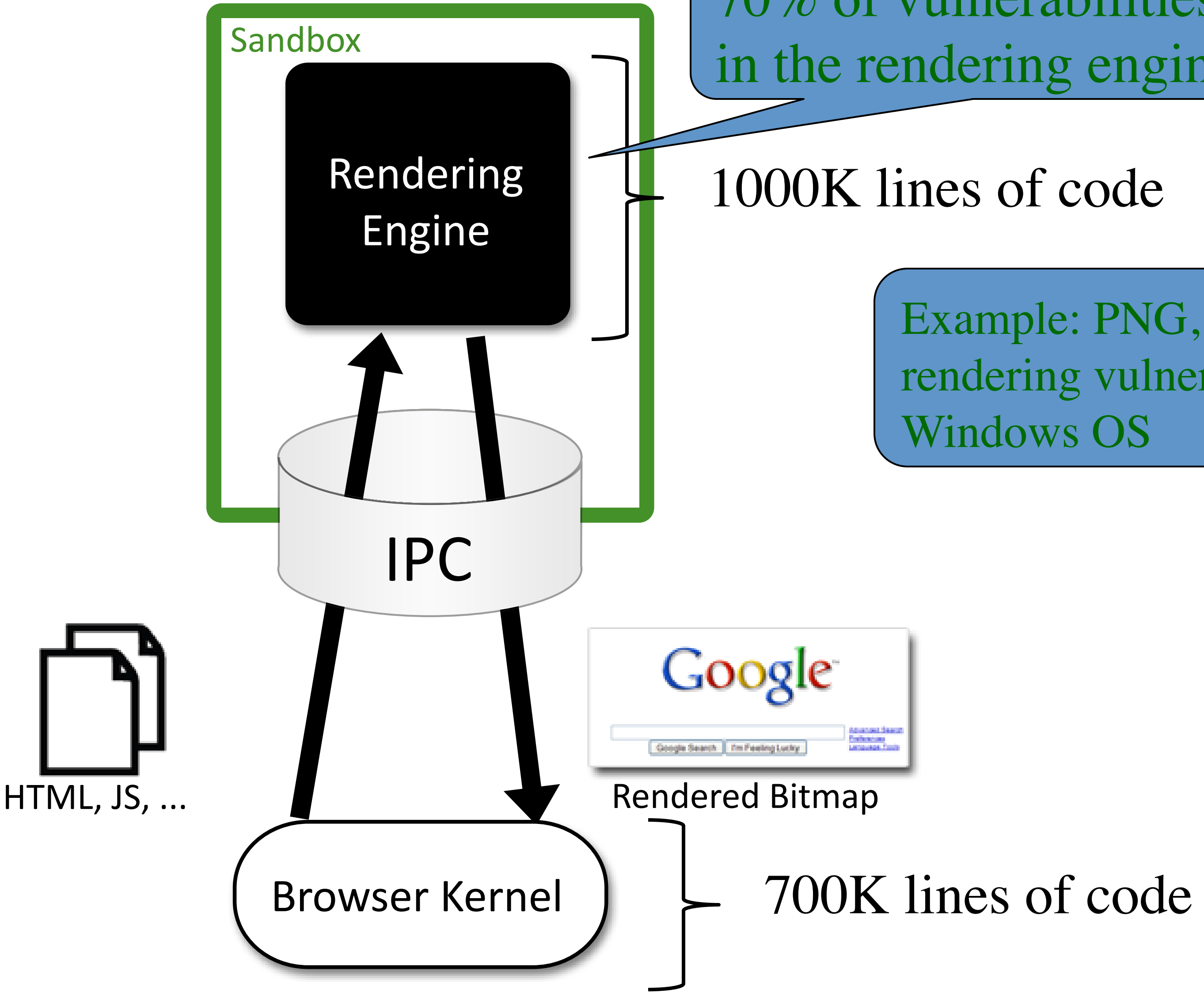
HTML, JS, ...

Rendered Bitmap

Browser Kernel

TCB (for this property)

The Chrome browser



1000K lines of code

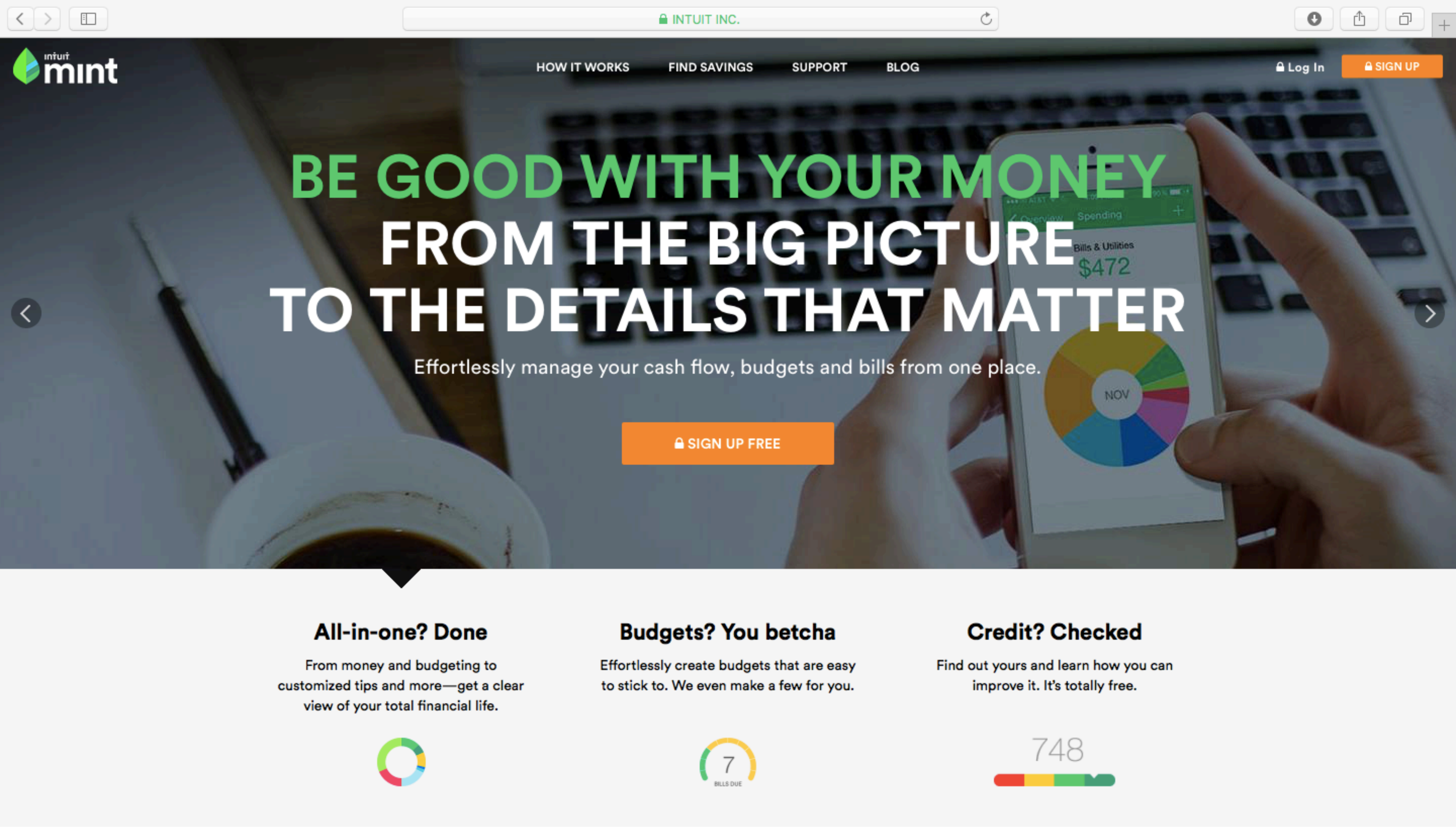
700K lines of code

70% of vulnerabilities are in the rendering engine.

Example: PNG, WMF, GDI+ rendering vulnerabilities in Windows OS

Benefit of Secure Design

Browser	Known unpatched vulnerabilities					
	Secunia					SecurityFocus
	Extremely critical (number / oldest)	Highly critical (number / oldest)	Moderately critical (number / oldest)	Less critical (number / oldest)	Not critical (number / oldest)	Total (number / oldest)
Internet Explorer 6	0	0	4 17 November 2004	8 27 February 2004	12 5 June 2003	534 20 November 2000
Internet Explorer 7	0	0	1 30 October 2006	4 6 June 2006	10 5 June 2003	213 15 August 2006
Internet Explorer 8	0	0	0	1 26 February 2007	8 5 June 2003	123 14 January 2009
Internet Explorer 9	0	0	0	0	2 6 December 2011	26 5 March 2011
Firefox 3.6	0	0	0	0	0	1 20 December 2011
Firefox 38	0	0	0	0	0	0
Google Chrome 42	0	0	0	0	0	0
Opera 11	0	0	0	0	1 6 December 2011	2 6 December 2011
Safari 5	0	0	0	1 8 June 2010	0	2 13 December 2011



BE GOOD WITH YOUR MONEY
FROM THE BIG PICTURE TO THE DETAILS THAT MATTER

Effortlessly manage your cash flow, budgets and bills from one place.

All-in-one? Done

From money and budgeting to customized tips and more—get a clear view of your total financial life.

Budgets? You betcha

Effortlessly create budgets that are easy to stick to. We even make a few for you.

Credit? Checked

Find out yours and learn how you can improve it. It's totally free.

Discuss with a partner

- How would you architect mint.com to reduce the likelihood of a catastrophic security breach?
  - E.g., where attacker steals all users' stored passwords or empties out all their bank accounts overnight

Summary

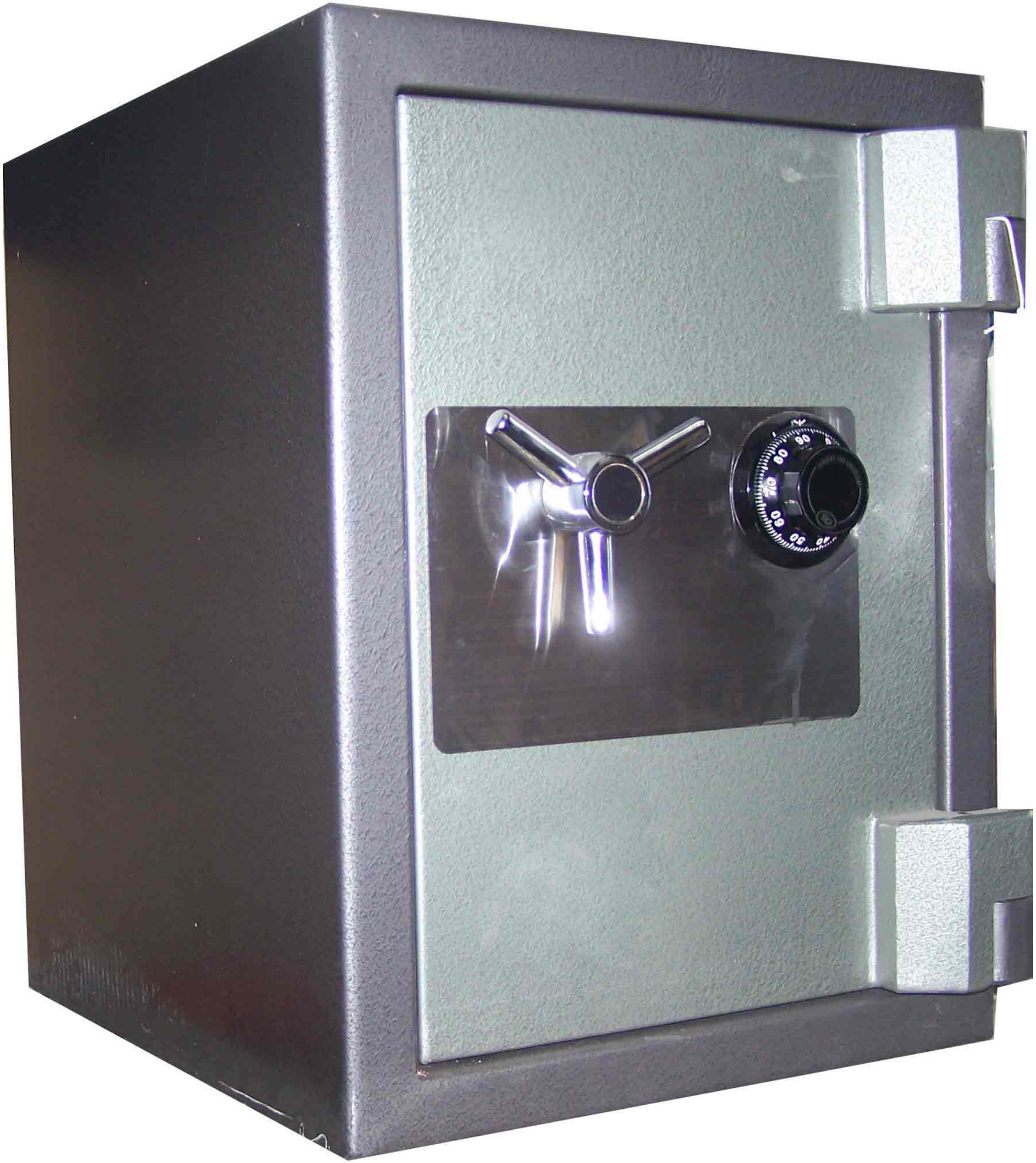
- Access control is a key part of security.
- Privilege separation makes systems more robust: it helps reduce the impact of security bugs in your code.
- Architect your system to make the TCB unbypassable, tamper-resistant, and verifiable (small).

Software Security: Principles

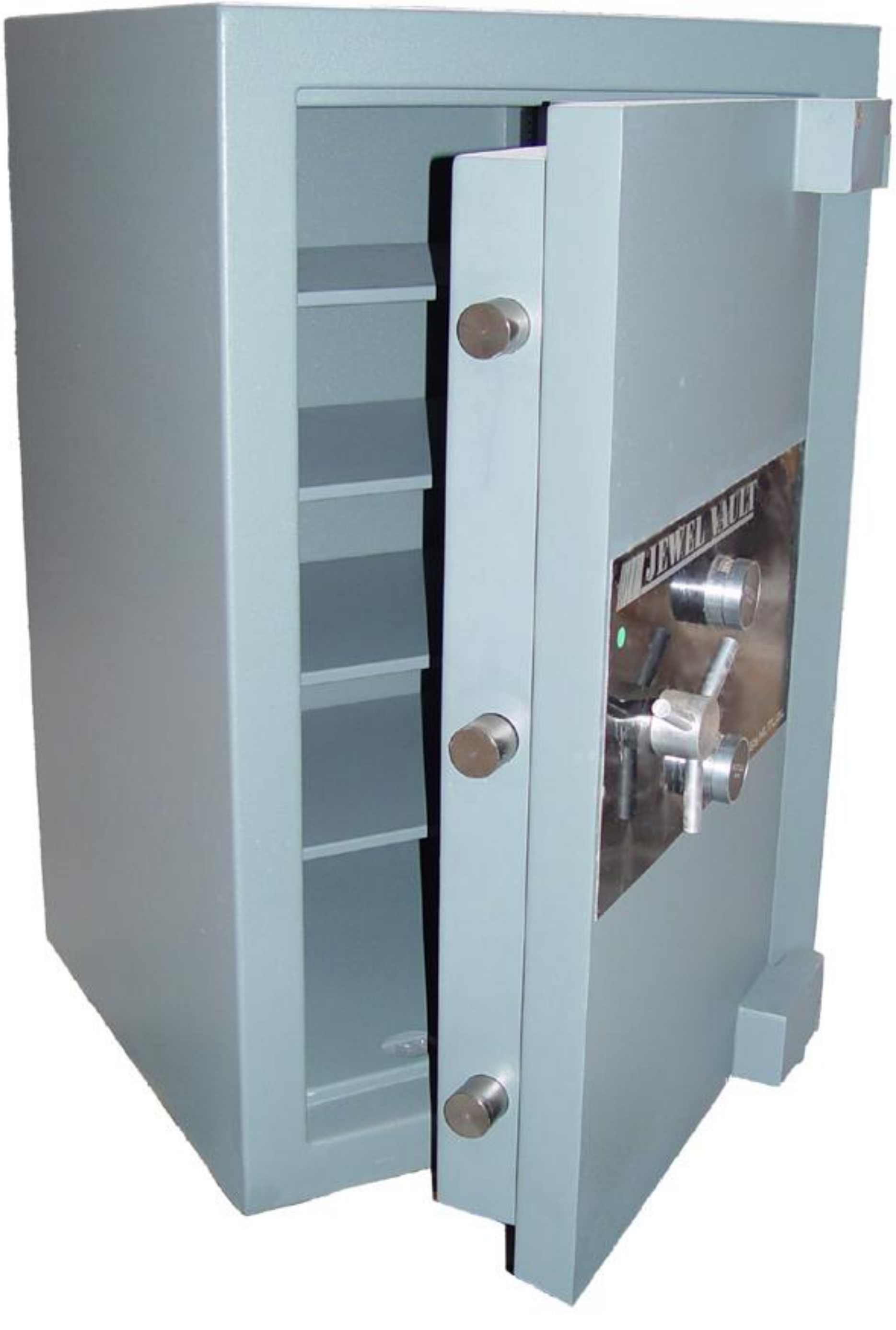
CS 161: Computer Security

Prof. David Wagner

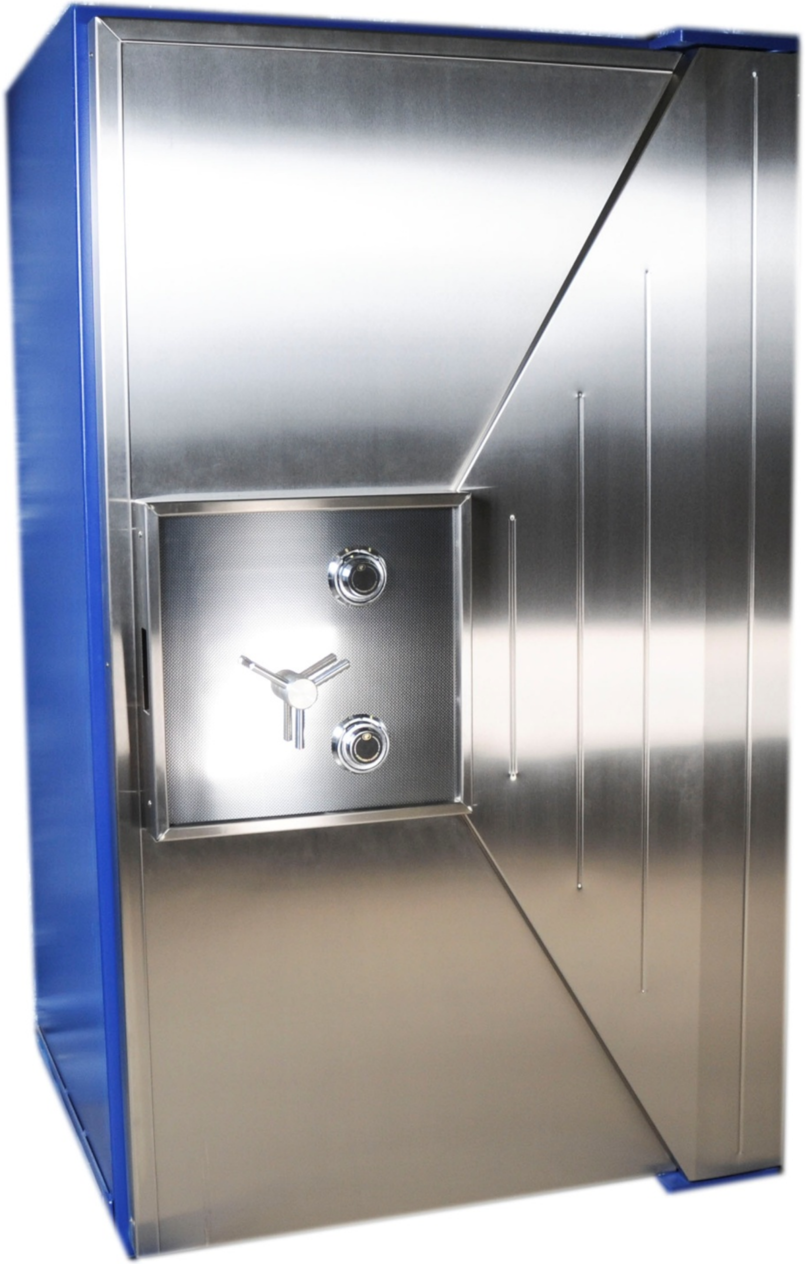
January 29, 2016



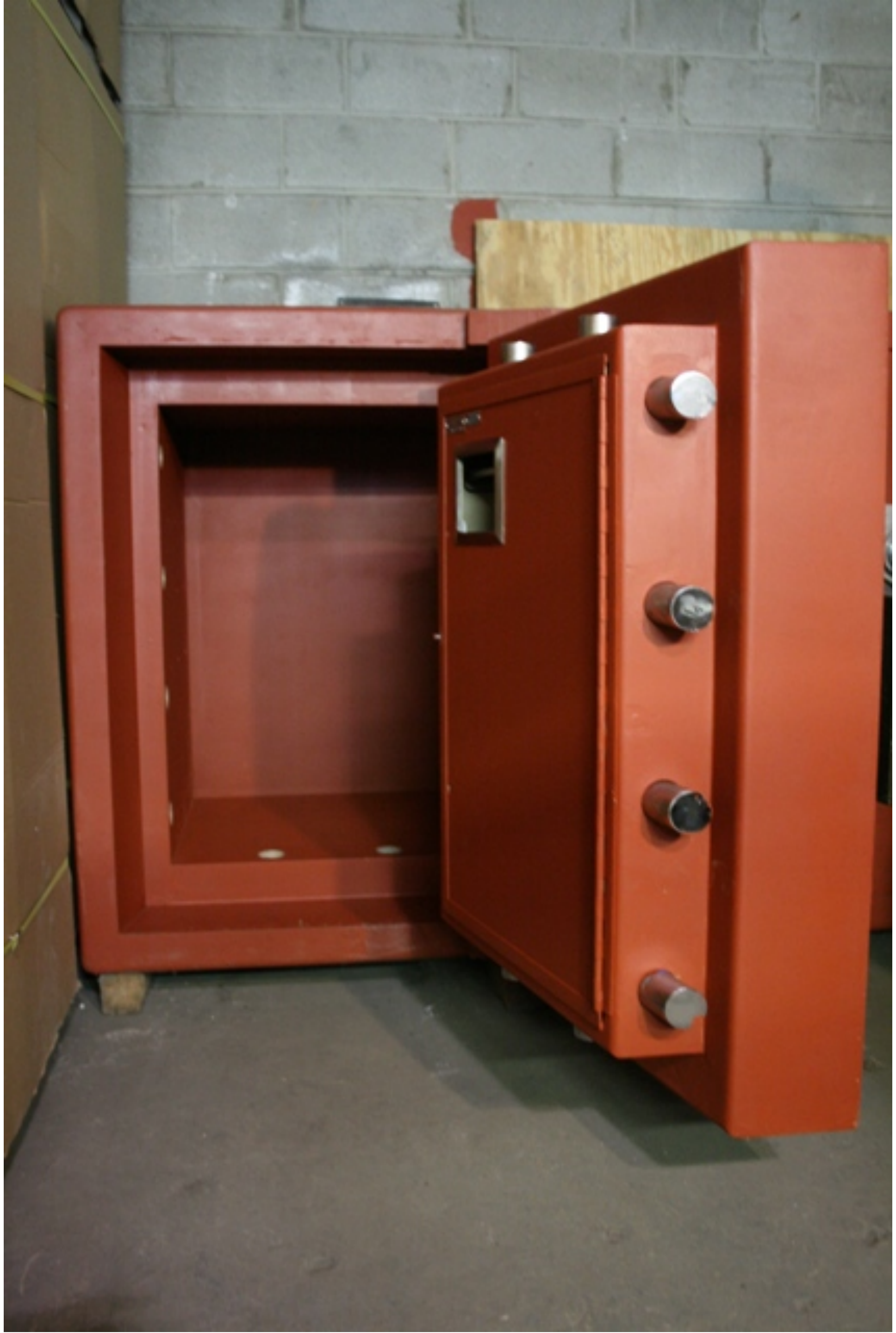
TL-15



TL-30

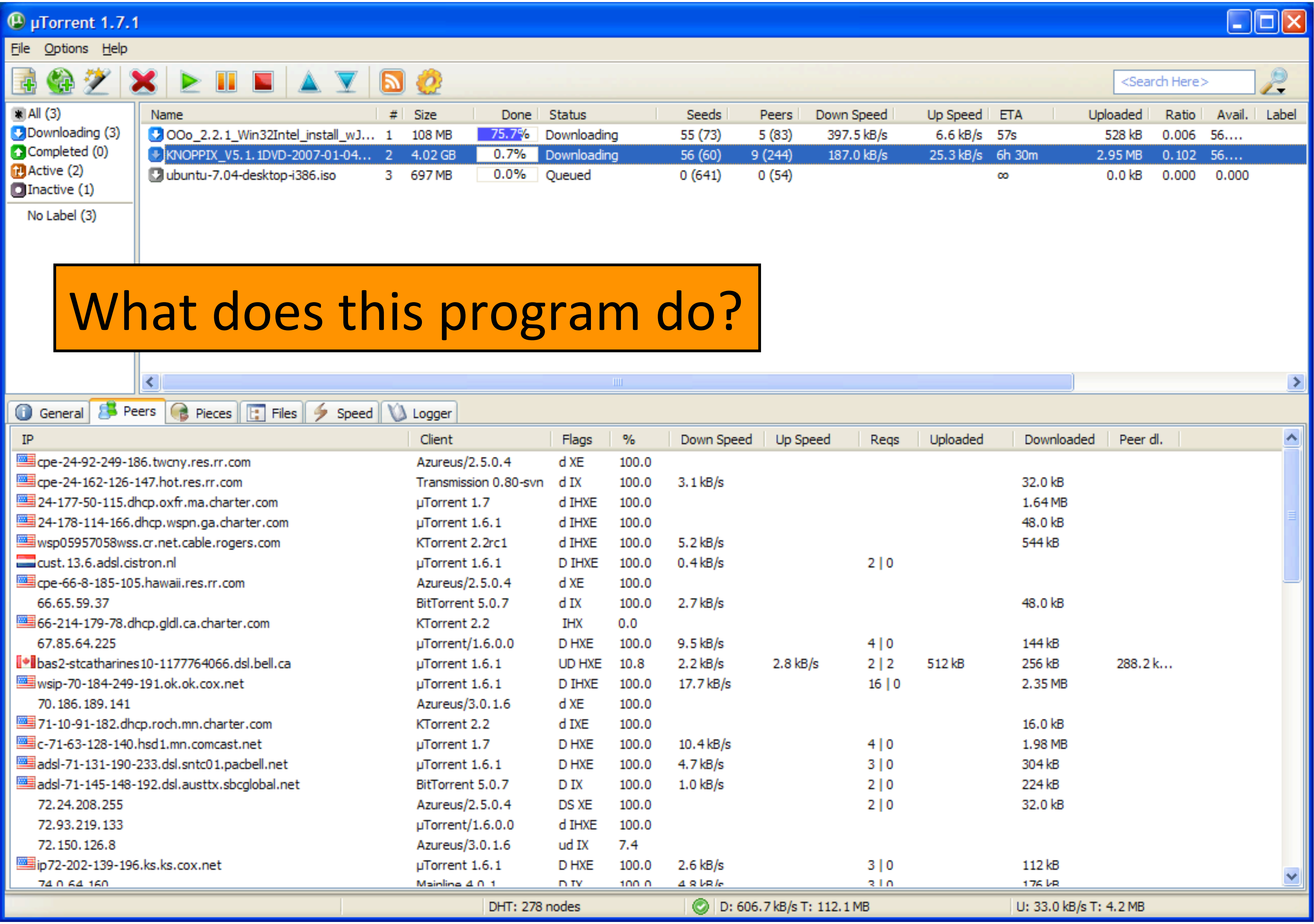


TRTL-30



TXTL-60

“Security is economics.”

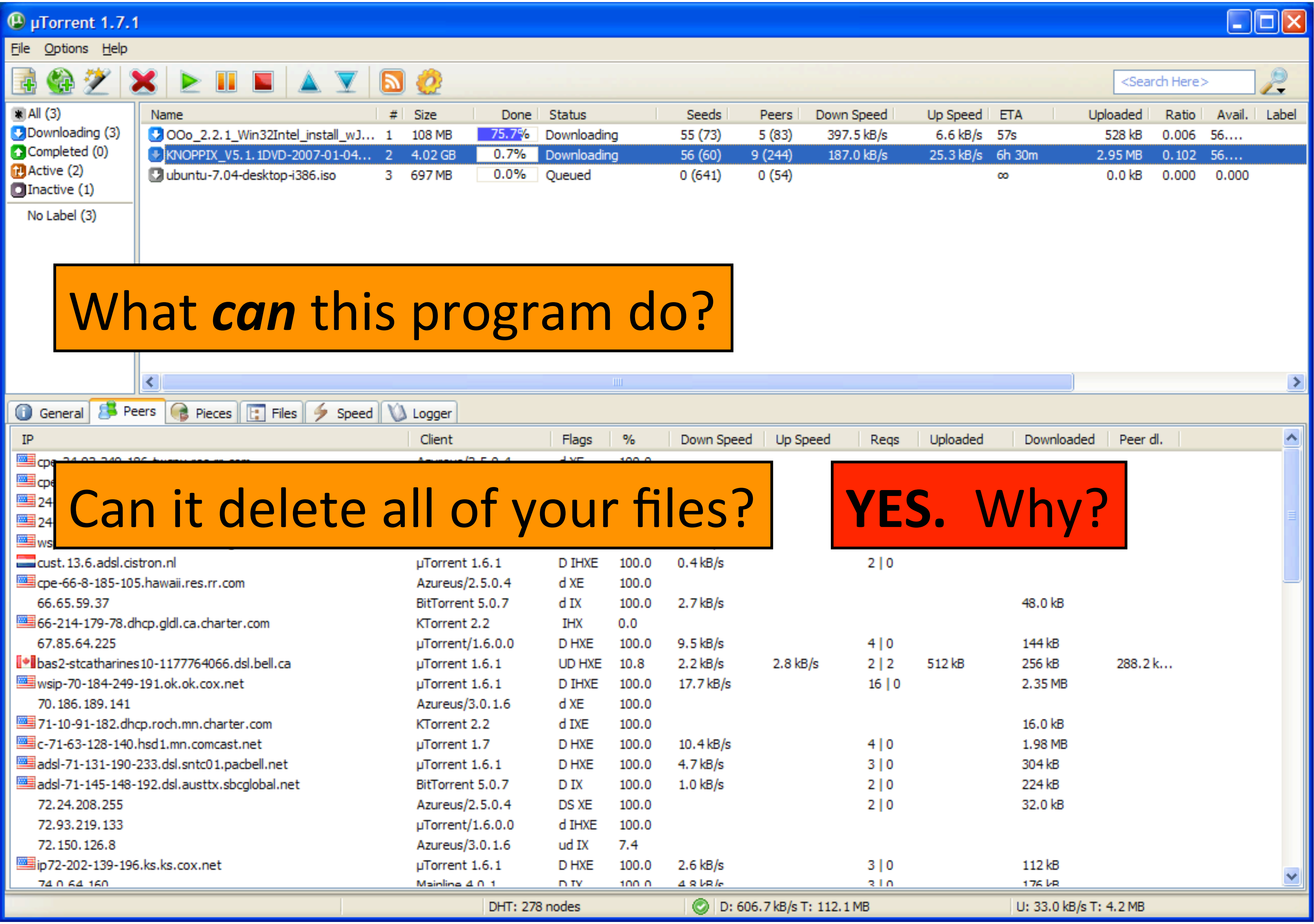


Name	#	Size	Done	Status	Seeds	Peers	Down Speed	Up Speed	ETA	Uploaded	Ratio	Avail.	Label
OOo_2.2.1_Win32Intel_install_wJ...	1	108 MB	75.7%	Downloading	55 (73)	5 (83)	397.5 kB/s	6.6 kB/s	57s	528 kB	0.006	56....	
KNOPPIX_V5.1.1DVD-2007-01-04...	2	4.02 GB	0.7%	Downloading	56 (60)	9 (244)	187.0 kB/s	25.3 kB/s	6h 30m	2.95 MB	0.102	56....	
ubuntu-7.04-desktop-i386.iso	3	697 MB	0.0%	Queued	0 (641)	0 (54)			∞	0.0 kB	0.000	0.000	

What does this program do?

IP	Client	Flags	%	Down Speed	Up Speed	Reqs	Uploaded	Downloaded	Peer dl.
cpe-24-92-249-186.twcny.res.rr.com	Azureus/2.5.0.4	d XE	100.0						
cpe-24-162-126-147.hot.res.rr.com	Transmission 0.80-svn	d IX	100.0	3.1 kB/s				32.0 kB	
24-177-50-115.dhcp.oxfr.ma.charter.com	µTorrent 1.7	d IHXE	100.0					1.64 MB	
24-178-114-166.dhcp.wspn.ga.charter.com	µTorrent 1.6.1	d IHXE	100.0					48.0 kB	
wsp05957058wss.cr.net.cable.rogers.com	KTorrent 2.2rc1	d IHXE	100.0	5.2 kB/s				544 kB	
cust.13.6.adsl.cistron.nl	µTorrent 1.6.1	D IHXE	100.0	0.4 kB/s		2 | 0			
cpe-66-8-185-105.hawaii.res.rr.com	Azureus/2.5.0.4	d XE	100.0						
66.65.59.37	BitTorrent 5.0.7	d IX	100.0	2.7 kB/s				48.0 kB	
66-214-179-78.dhcp.gldl.ca.charter.com	KTorrent 2.2	IHX	0.0						
67.85.64.225	µTorrent/1.6.0.0	D HXE	100.0	9.5 kB/s		4 | 0		144 kB	
bas2-stcatharines10-1177764066.dsl.bell.ca	µTorrent 1.6.1	UD HXE	10.8	2.2 kB/s	2.8 kB/s	2 | 2	512 kB	256 kB	288.2 k...
wsip-70-184-249-191.ok.ok.cox.net	µTorrent 1.6.1	D IHXE	100.0	17.7 kB/s		16 | 0		2.35 MB	
70.186.189.141	Azureus/3.0.1.6	d XE	100.0						
71-10-91-182.dhcp.roch.mn.charter.com	KTorrent 2.2	d IXE	100.0					16.0 kB	
c-71-63-128-140.hsd1.mn.comcast.net	µTorrent 1.7	D HXE	100.0	10.4 kB/s		4 | 0		1.98 MB	
adsl-71-131-190-233.dsl.sntc01.pacbell.net	µTorrent 1.6.1	D HXE	100.0	4.7 kB/s		3 | 0		304 kB	
adsl-71-145-148-192.dsl.austtx.sbcglobal.net	BitTorrent 5.0.7	D IX	100.0	1.0 kB/s		2 | 0		224 kB	
72.24.208.255	Azureus/2.5.0.4	DS XE	100.0			2 | 0		32.0 kB	
72.93.219.133	µTorrent/1.6.0.0	d IHXE	100.0						
72.150.126.8	Azureus/3.0.1.6	ud IX	7.4						
ip72-202-139-196.ks.ks.cox.net	µTorrent 1.6.1	D HXE	100.0	2.6 kB/s		3 | 0		112 kB	
74.0.64.160	Mainline 4.0.1	D IX	100.0	4.8 kB/s		3 | 0		176 kB	

DHT: 278 nodes
D: 606.7 kB/s T: 112.1 MB
U: 33.0 kB/s T: 4.2 MB



µTorrent 1.7.1

Name	#	Size	Done	Status	Seeds	Peers	Down Speed	Up Speed	ETA	Uploaded	Ratio	Avail.	Label
OOo_2.2.1_Win32Intel_install_wJ...	1	108 MB	75.7%	Downloading	55 (73)	5 (83)	397.5 kB/s	6.6 kB/s	57s	528 kB	0.006	56....	
KNOPPIX_V5.1.1DVD-2007-01-04...	2	4.02 GB	0.7%	Downloading	56 (60)	9 (244)	187.0 kB/s	25.3 kB/s	6h 30m	2.95 MB	0.102	56....	
ubuntu-7.04-desktop-i386.iso	3	697 MB	0.0%	Queued	0 (641)	0 (54)			∞	0.0 kB	0.000	0.000	

What *can* this program do?

IP	Client	Flags	%	Down Speed	Up Speed	Reqs	Uploaded	Downloaded	Peer dl.
cpe	Azureus/2.5.0.4	d XE	100.0						
cpe									
24									
24									
ws									
cust.13.6.adsl.cistron.nl	µTorrent 1.6.1	D IHXE	100.0	0.4 kB/s		2 | 0			
cpe-66-8-185-105.hawaii.res.rr.com	Azureus/2.5.0.4	d XE	100.0						
66.65.59.37	BitTorrent 5.0.7	d IX	100.0	2.7 kB/s				48.0 kB	
66-214-179-78.dhcp.gldl.ca.charter.com	KTorrent 2.2	IHX	0.0						
67.85.64.225	µTorrent/1.6.0.0	D HXE	100.0	9.5 kB/s		4 | 0		144 kB	
bas2-stcatharines10-1177764066.dsl.bell.ca	µTorrent 1.6.1	UD HXE	10.8	2.2 kB/s	2.8 kB/s	2 | 2	512 kB	256 kB	288.2 k...
wsip-70-184-249-191.ok.ok.cox.net	µTorrent 1.6.1	D IHXE	100.0	17.7 kB/s		16 | 0		2.35 MB	
70.186.189.141	Azureus/3.0.1.6	d XE	100.0						
71-10-91-182.dhcp.roch.mn.charter.com	KTorrent 2.2	d IXE	100.0					16.0 kB	
c-71-63-128-140.hsd1.mn.comcast.net	µTorrent 1.7	D HXE	100.0	10.4 kB/s		4 | 0		1.98 MB	
adsl-71-131-190-233.dsl.sntc01.pacbell.net	µTorrent 1.6.1	D HXE	100.0	4.7 kB/s		3 | 0		304 kB	
adsl-71-145-148-192.dsl.austtx.sbcglobal.net	BitTorrent 5.0.7	D IX	100.0	1.0 kB/s		2 | 0		224 kB	
72.24.208.255	Azureus/2.5.0.4	DS XE	100.0			2 | 0		32.0 kB	
72.93.219.133	µTorrent/1.6.0.0	d IHXE	100.0						
72.150.126.8	Azureus/3.0.1.6	ud IX	7.4						
ip72-202-139-196.ks.ks.cox.net	µTorrent 1.6.1	D HXE	100.0	2.6 kB/s		3 | 0		112 kB	
74.0.64.160	Mainline 4.0.1	D IX	100.0	4.8 kB/s		3 | 0		176 kB	

DHT: 278 nodes | D: 606.7 kB/s T: 112.1 MB | U: 33.0 kB/s T: 4.2 MB

Can it delete all of your files?

YES. Why?

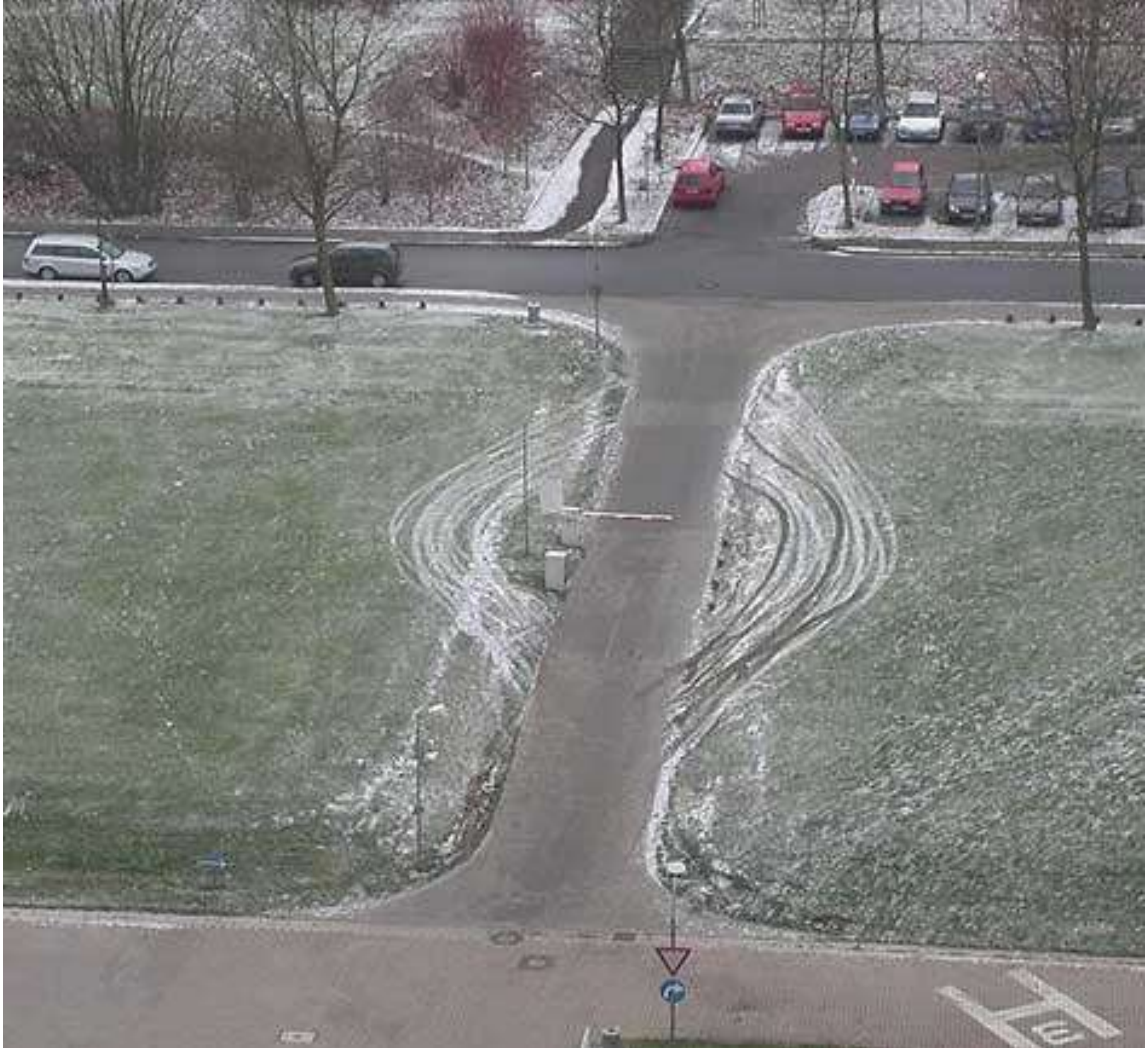
“Least privilege.”

Touchstones for *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
  - (See lecture notes for more discussion)

Check for Understanding

- We’ve seen that PC platforms grant applications a lot of privileges
- Quiz: Name a platform that does a better job of least privilege



“Ensure complete mediation.”

Ensuring Complete Mediation

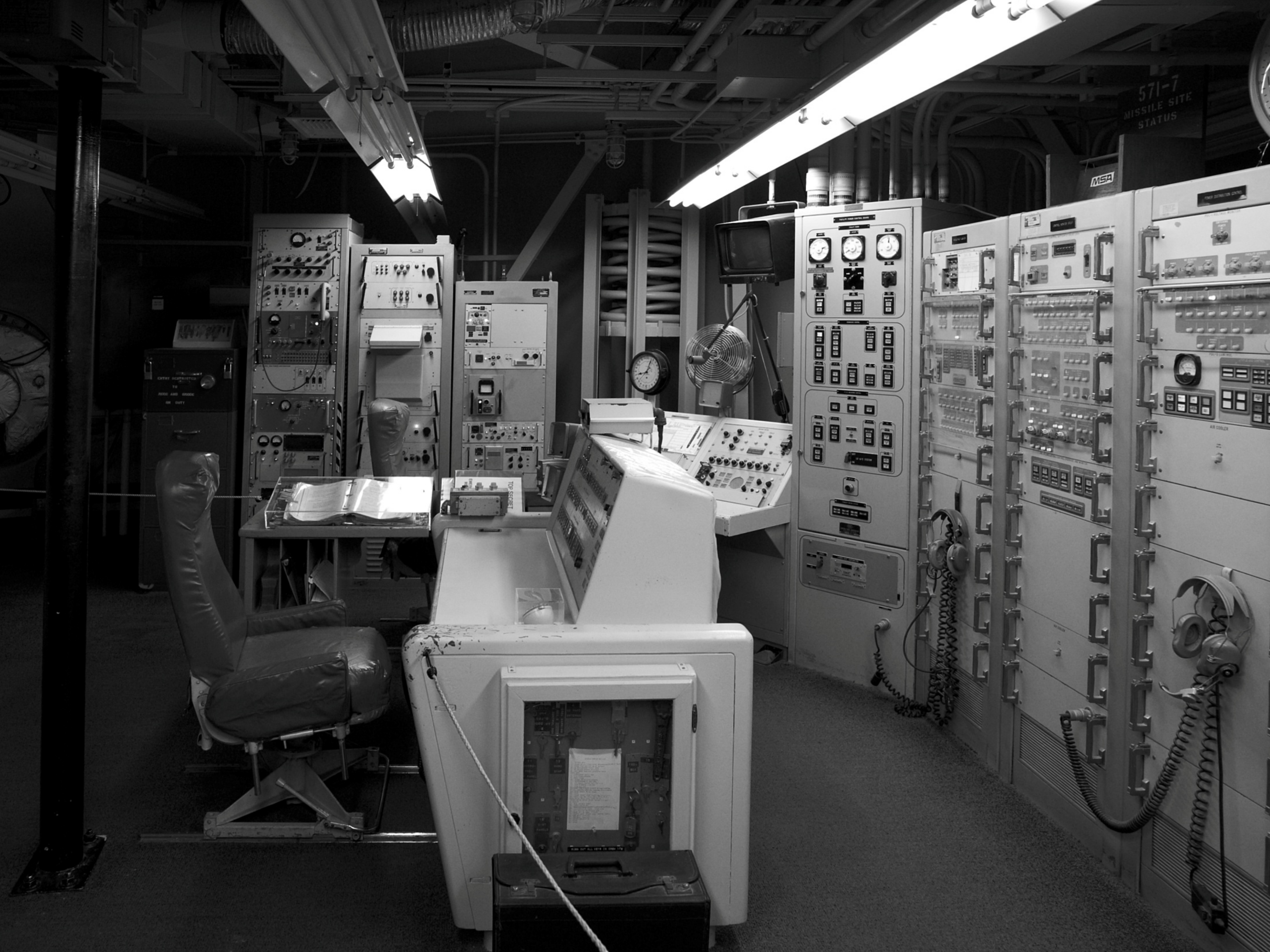
- To secure access to some capability/resource, construct a *reference monitor*
- Single point through which all access must occur
  - E.g.: a network firewall
- Desired properties:
  - Un-bypassable ("complete mediation")
  - Tamper-proof (is itself secure)
  - Verifiable (correct)
  - (Note, just restatements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

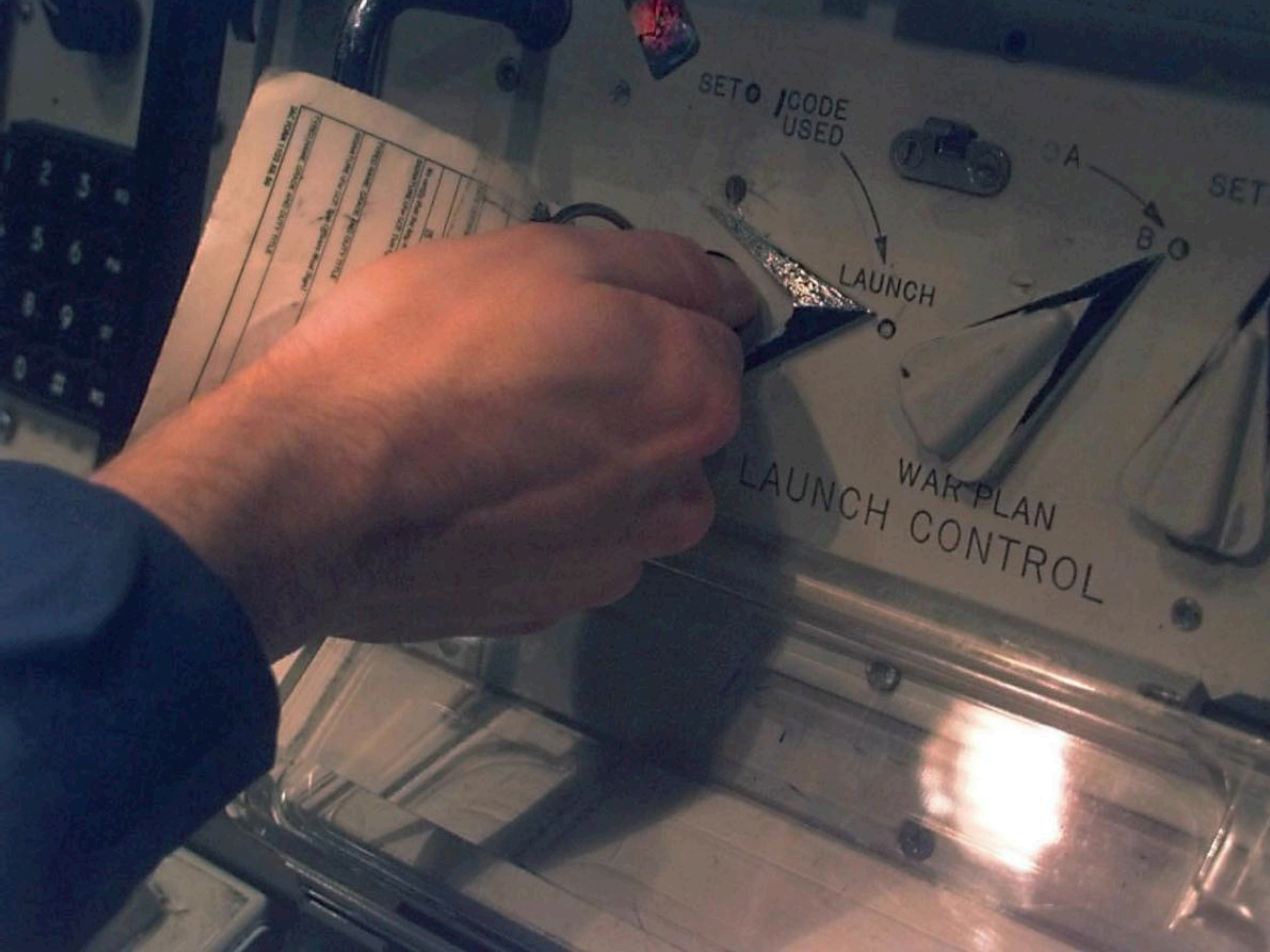
TOCTTOU Vulnerability

```
procedure withdrawal(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
```

TOCTTOU = Time of Check To Time of Use

```
public void buyItem(Account buyer, Item item) {
   if (item.cost > buyer.balance)
     return;
   buyer.possessions.put(item);
   buyer.possessionsUpdated();
   buyer.balance -= item.cost;
   buyer.balanceUpdated();
 }
```


571-7
MISSILE SITE
STATUS
MSA
TOP SECRET


SET
CODE USED
LAUNCH
A
B
SET
WAR PLAN
LAUNCH CONTROL

NO LONE ZONE
SAC TWO MAN POLICY
MANDATORY
CAUTION
DO NOT KEY RTMX IN L/D
EXCEPT IN CASE OF AN
EMERGENCY-MUST BE AT
LEAST 5FT FROM MSL.
E-F-G

“Separation of responsibility.”

California
THE IDES OF MARCH
THE
PARANORMAL ACTVITY 3
RUM DIARY
California

Coming Up …

- Homework 1 due Monday
- Project 1 is now available