CS111, Lecture 16

Trust and Operating Systems + assign4

😷 masks strongly recommended

Respond on PollEv: pollev.com/cs111fall23
or text CS111FALL23 to 22333 once to join.

Do Now:

1. Say hello to your neighbor!
2. Think of an OS you use. Discuss what you use it for and how you trust it. Add any thoughts on pollEV!

CS111 Lecture

Trust and Operating Systems

Benjamin Xie, Ph.D.

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made with William Grant Ray III, Xiyu Zhang, Liana Keesing,
Swayam Parida, Prof. Nick Troccoli, Prof. John Ousterhout

Think of an OS you use. What do you use it for and how do you trust it?

Nobody has responded yet.

Hang tight! Responses are coming in.

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Hi, I’m Benji!

Why I’m here: Embedding ethics into CS courses (14 so far!)

Research: human-data interactions (computing education + HCI research)

My path:

- BS + M.Eng. (“co-term”) in CS at MIT
- Ph.D. at University of Washington
- Embedded Ethics Postdoctoral Fellow at Stanford HAI, Ethics Center

What is an OS that you use?
For what?

How do you trust that OS?

Plan For Today

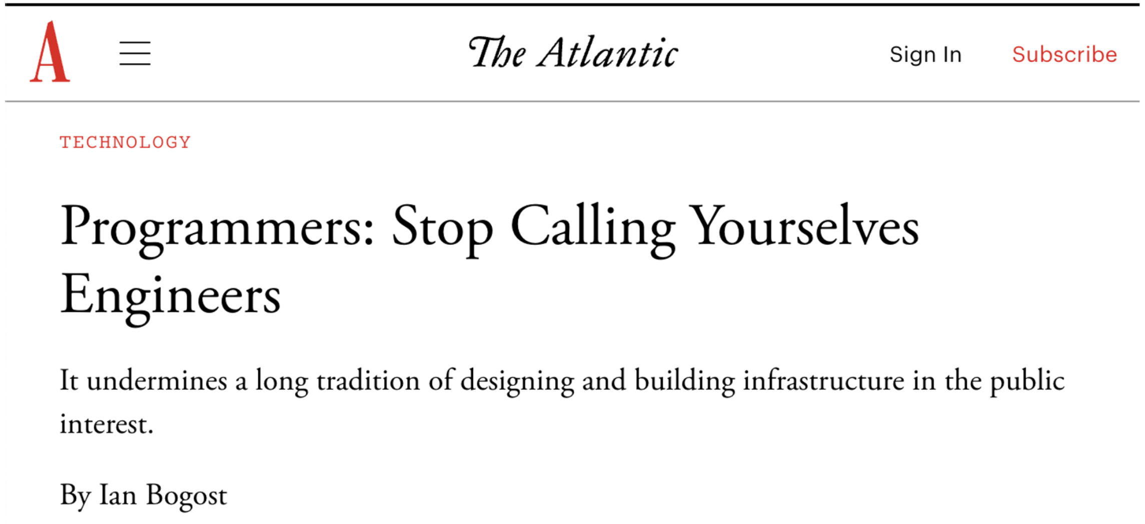
- Motivation: Importance of trust in OS
- What is trust?
- How does trust emerge?
- Example: Trusting Linux

Plan For Today

- **Motivation: Importance of trust in OS**
- What is trust?
- How does trust emerge?
- Example: Trusting Linux

Learning Goals

Understand how trust emerges and manifests with operating systems in given contexts



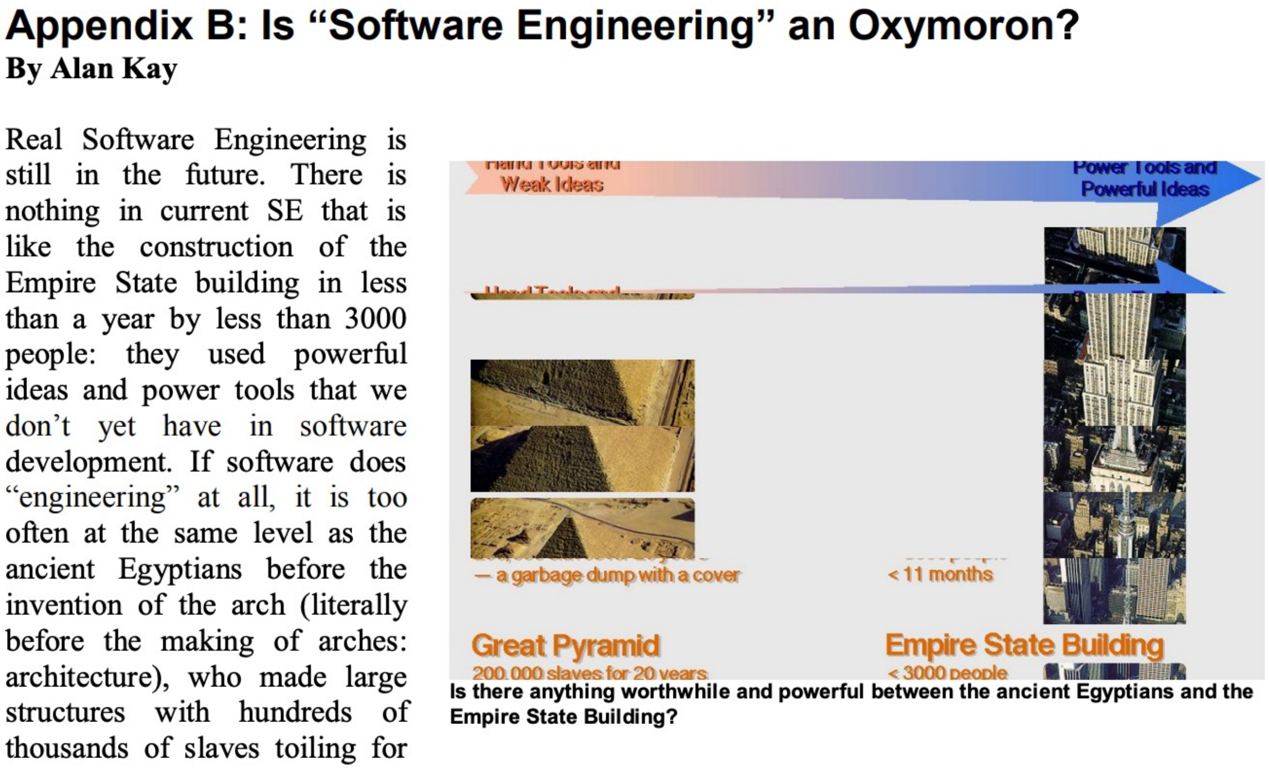
The Atlantic Sign In Subscribe

TECHNOLOGY

Programmers: Stop Calling Yourselves Engineers

It undermines a long tradition of designing and building infrastructure in the public interest.

By Ian Bogost



Appendix B: Is "Software Engineering" an Oxymoron?

By Alan Kay

Real Software Engineering is still in the future. There is nothing in current SE that is like the construction of the Empire State building in less than a year by less than 3000 people: they used powerful ideas and power tools that we don't yet have in software development. If software does "engineering" at all, it is too often at the same level as the ancient Egyptians before the invention of the arch (literally before the making of arches: architecture), who made large structures with hundreds of thousands of slaves toiling for

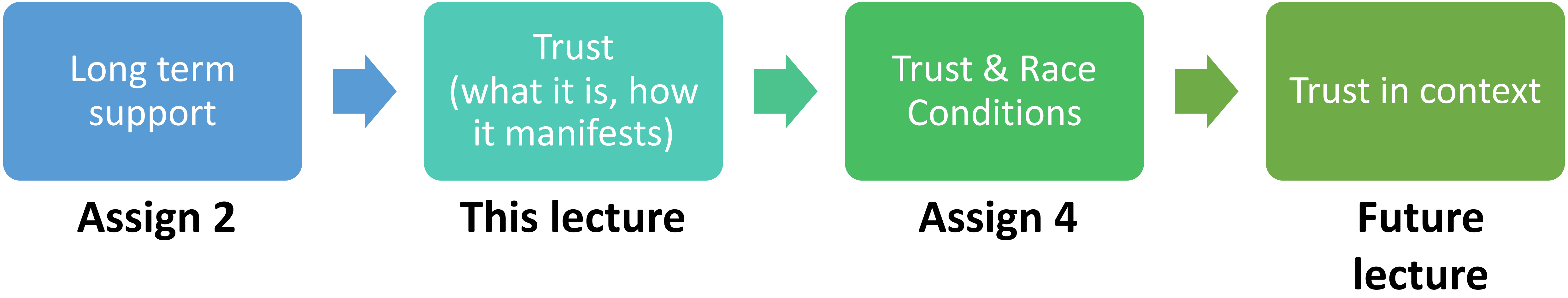
Hand Tools and Weak Ideas
Power Tools and Powerful Ideas
— a garbage dump with a cover
< 11 months
Great Pyramid
200,000 slaves for 20 years
Empire State Building
< 3000 people

Is there anything worthwhile and powerful between the ancient Egyptians and the Empire State Building?

https://www.theatlantic.com/technology/archive/2015/11/programmers-should-not-call-themselves-engineers/414271/

https://web.archive.org/web/20030407181600/www.opencroquet.org/downloads/Croquet0.1.pdf

CS111 Ethics Topic: Trust



Long term support

Assign 2

Trust
(what it is, how it manifests)

This lecture

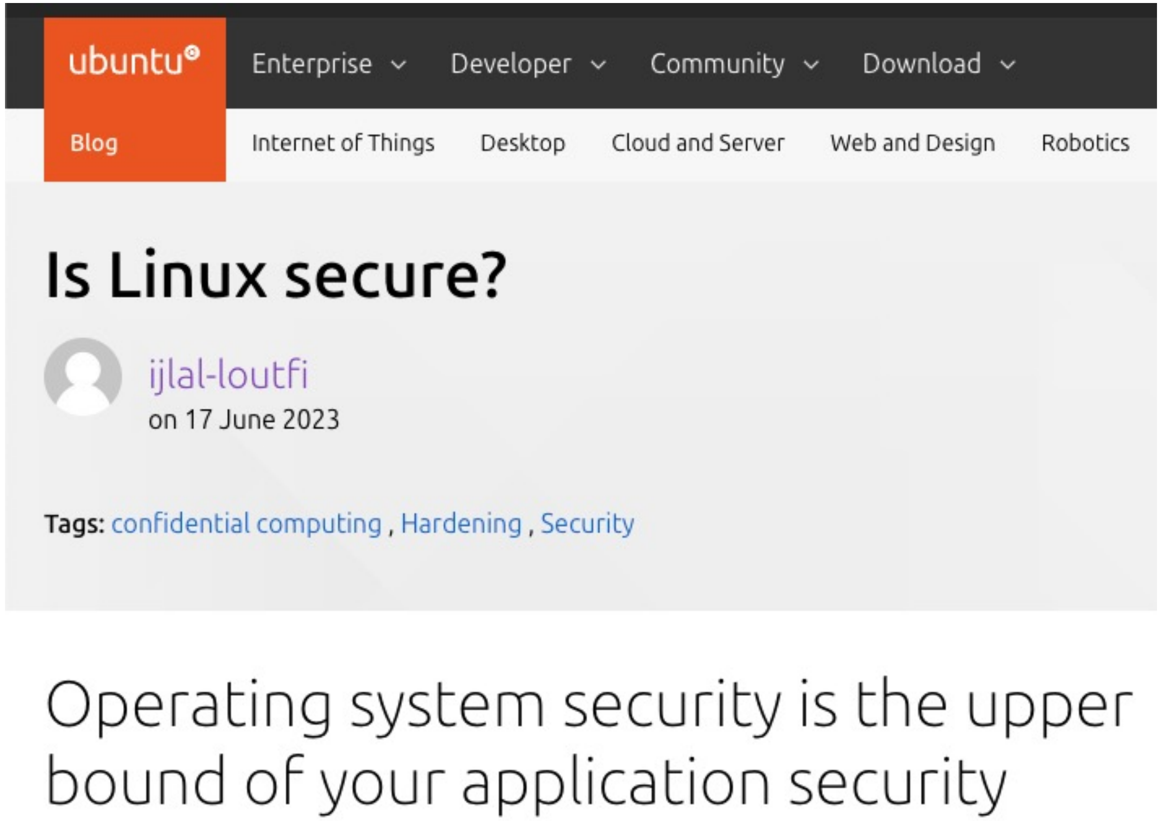
Trust & Race Conditions

Assign 4

Trust in context

Future lecture

How do we trust OS (open vs closed)?



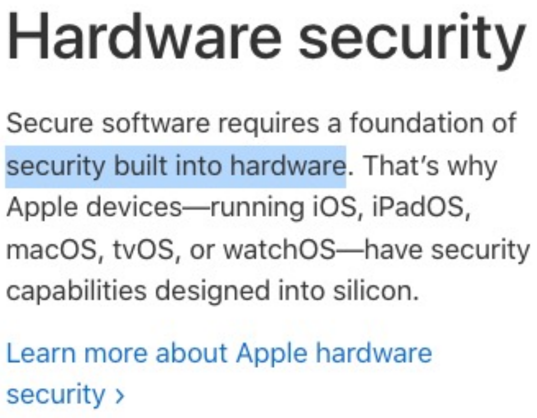
Is Linux secure?

ijlal-loutfi
on 17 June 2023

Tags: confidential computing , Hardening , Security

Operating system security is the upper bound of your application security

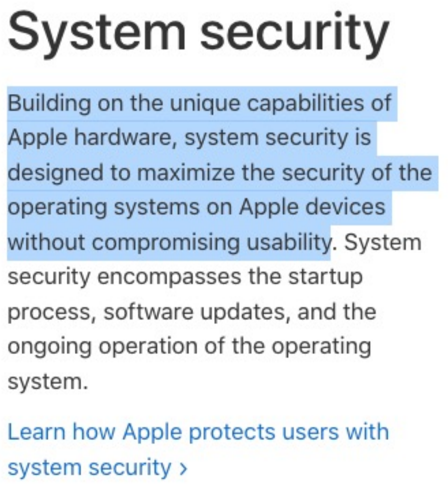
"The Linux kernel and its entire ecosystem of operating system distributions are built around the values of openness, transparency, agility and trustworthiness. These values are what lay the foundation for modern



Hardware security

Secure software requires a foundation of security built into hardware. That's why Apple devices—running iOS, iPadOS, macOS, tvOS, or watchOS—have security capabilities designed into silicon.

Learn more about Apple hardware security ›



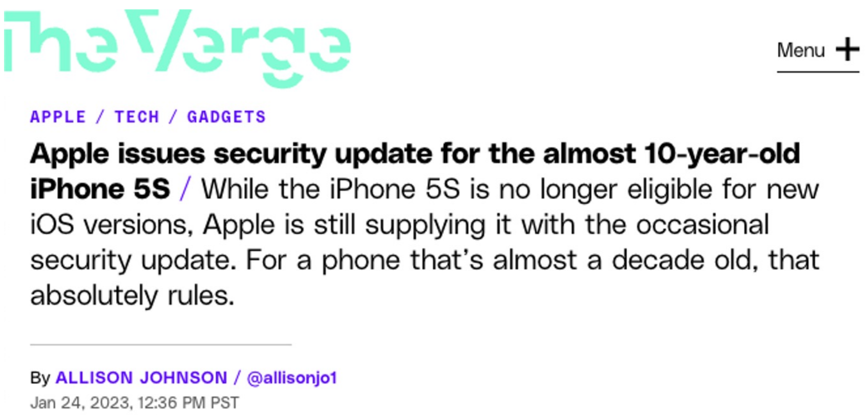
System security

Building on the unique capabilities of Apple hardware, system security is designed to maximize the security of the operating systems on Apple devices without compromising usability. System security encompasses the startup process, software updates, and the ongoing operation of the operating system.

Learn how Apple protects users with system security ›

Trust in OS for Standardization

- OS provides efficiency through standardization
- Users rely on technology built on OS
- App developers build off of OS
- Systems programmers make decisions that ripple far and long



The Verge

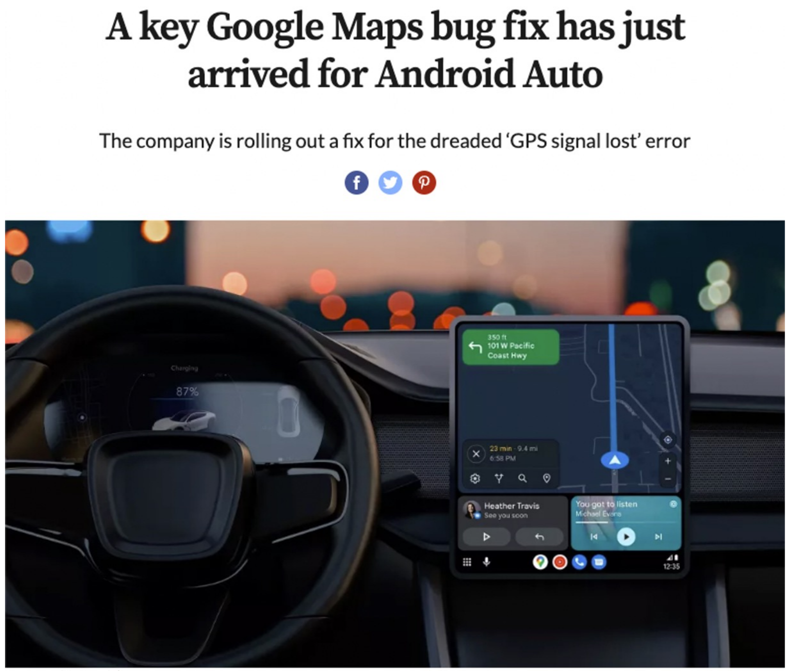
Menu +

APPLE / TECH / GADGETS

Apple issues security update for the almost 10-year-old iPhone 5S / While the iPhone 5S is no longer eligible for new iOS versions, Apple is still supplying it with the occasional security update. For a phone that's almost a decade old, that absolutely rules.

By ALLISON JOHNSON / @allisonjo1

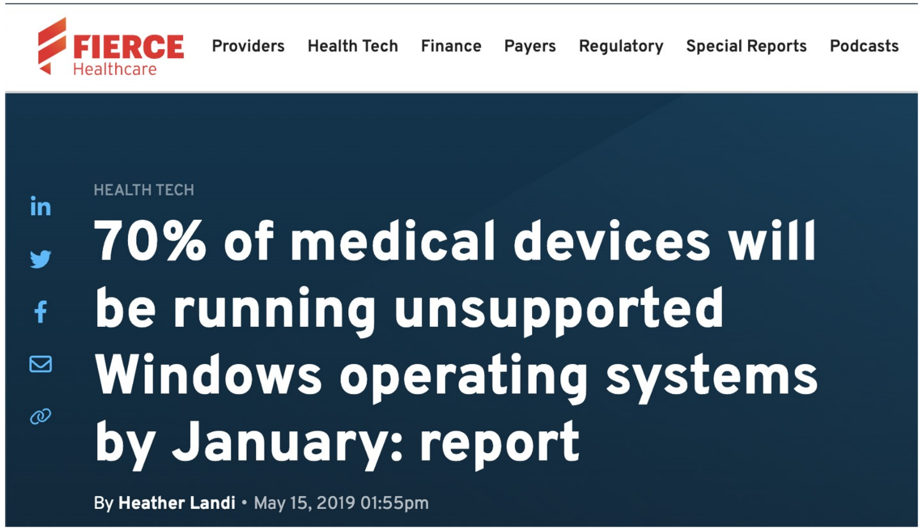
Jan 24, 2023, 12:36 PM PST



A key Google Maps bug fix has just arrived for Android Auto

The company is rolling out a fix for the dreaded 'GPS signal lost' error

mage credit: Google)



FIERCE Healthcare

Providers Health Tech Finance Payers Regulatory Special Reports Podcasts

HEALTH TECH

70% of medical devices will be running unsupported Windows operating systems by January: report

By Heather Landi • May 15, 2019 01:55pm

Plan For Today

- Motivation: Importance of trust in OS
  - OS is public infrastructure of software
- **What is trust?**
- How does trust emerge?
- Example: Trusting Linux

Trust as an unquestioning attitude

- Trust is to stop questioning the dependability of a thing
- Efficiency/safety tradeoff:
  - Trust lowers the barriers of monitoring and questioning (more efficient)
- Involves
  - Intentions
  - Dependence
  - Vulnerability/Risk
- Example: what/who did you trust to get to class today?

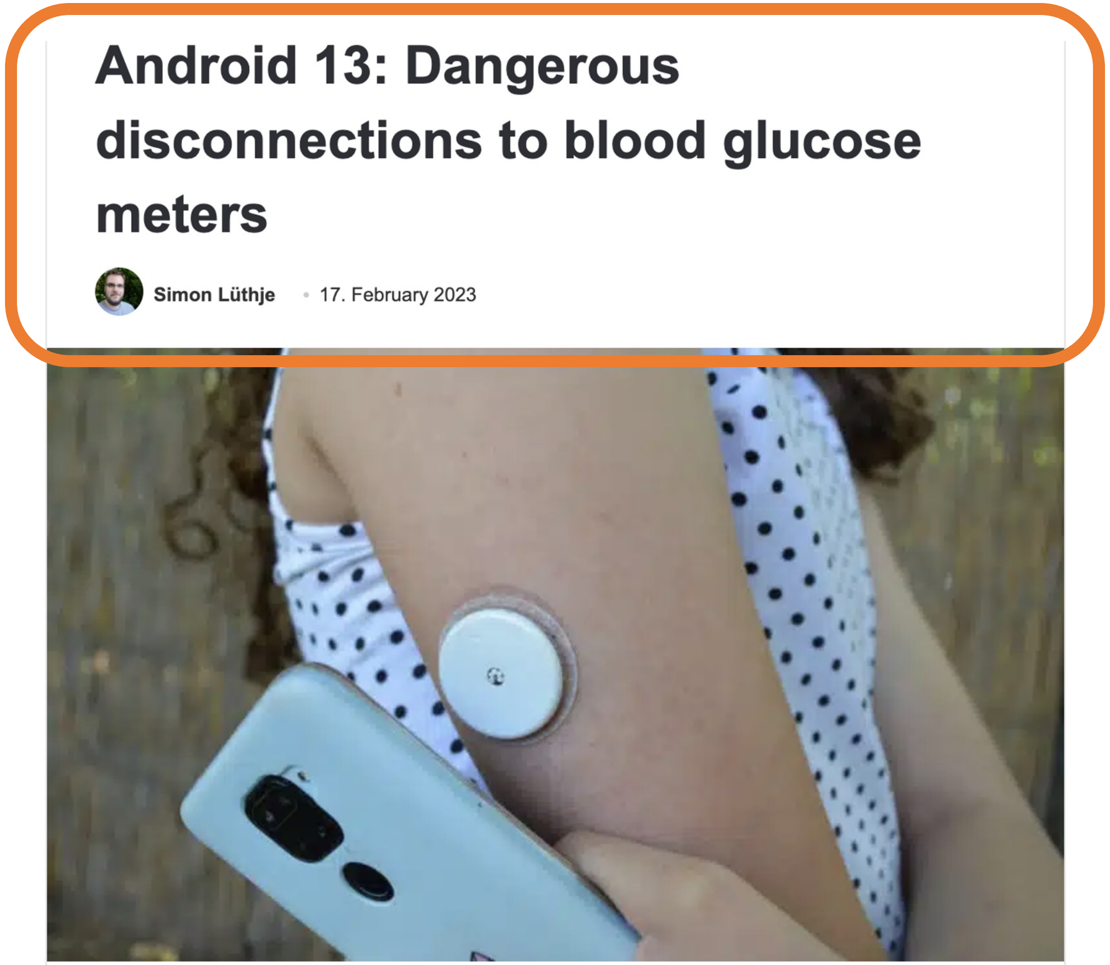
Trusting software is extending agency

- *agency*: our capacity to take actions that align with our goals
- “when we trust, we try to make something a part of our agency... To unquestioningly trust something is to let it in—to attempt to bring it inside one’s practical functioning.”
- Example: glucose monitoring

CT Nguyen: *Trust as an unquestioning attitude*

Risk: Agential Gullibility

- Trusting more than warranted
- Difficult to b/c software changes, hard to inspect
- Example: glucose monitoring issues w/ Android update



Android 13: Dangerous disconnections to blood glucose meters

Simon Lüthje · 17. February 2023

Takeaway: Trust is powerful, necessary, risky

If I trust people or things (e.g. SW), I …

- Integrate it with my own functioning
- Work more efficiently with them (stop questioning)
- Feel betrayed when they fail us

=> Trust (by extending agency) with great care!

Self-assessment on trust

Think back to the person/thing/service you trusted…

How does trusting them extend your agency/functioning?

How might/did you exhibit *agential gullibility*? (trust more than is warranted)

What would be/was the result of your trust being violated?

Self-assessment on trust

Think back to the person/thing/service you trusted… TurboTax Tax Preparation Software

How does trusting them extend your agency/functioning?

> Able to complete taxes more efficiently and had more confidence I did it correctly.

How might/did you exhibit *agential gullibility*? (trust more than is warranted)

> Tricked into paying for service even though it was legally supposed to be free.

What would be/was the result of your trust being violated?

> Feeling of betrayal. Stopped using software.

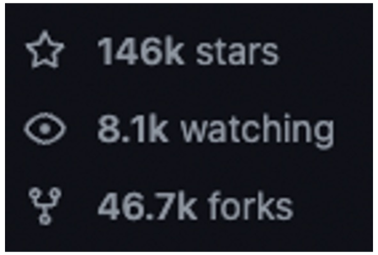
Learn more: https://www.propublica.org/article/inside-turbotax-20-year-fight-to-stop-americans-from-filing-their-taxes-for-free

Plan For Today

- Motivation: Importance of trust in OS
  - OS is public infrastructure of software
- What is trust?
  - Extending agency to software through unquestioning attitude
- **How does trust emerge?**
- Example: Trusting Linux

Three paths to trust

1. Assumption: trust absent any cluses to warrant it
   a. E.g. using unknown third party library b/c deadline nearing
2. Inference: reputation is based on past performance, characteristics, institutions
   a. Some weaker (e.g. trust in brands or affiliation)
   b. Some stronger (e.g. past performance)
   c. Trust in prior versions of software



☆ 146k stars

8.1k watching

46.7k forks

3. Substitution: structural arrangements that partly replace need for trust
   a. Often involves separation of code, responsibilities
   b. E.g. user permissions of file system, keeping personal info off work accounts, devices

Paul B. de Laat: *How can contributors to open-source communities be trusted? On the assumption, inference, and substitution of trust*

Self-assessment on how trust manifests

Identify one person/thing/service that you trust by…

Assumption (trust absent clues to warrant it)

Inference (trust from evidence of past performance, characteristics, institutions)

Substitution (structural arrangement to partly decrease the need for trust)

Self-assessment on how trust manifests

Identify one person/thing/service that you trust by…

Assumption (trust absent clues to warrant it)

> Anyone warning me about imminent danger (e.g. “look out for the car!”)

Inference (trust from evidence of past performance, characteristics, institutions)

> Password management service (inferred trust based on online reviews, review of privacy policy)

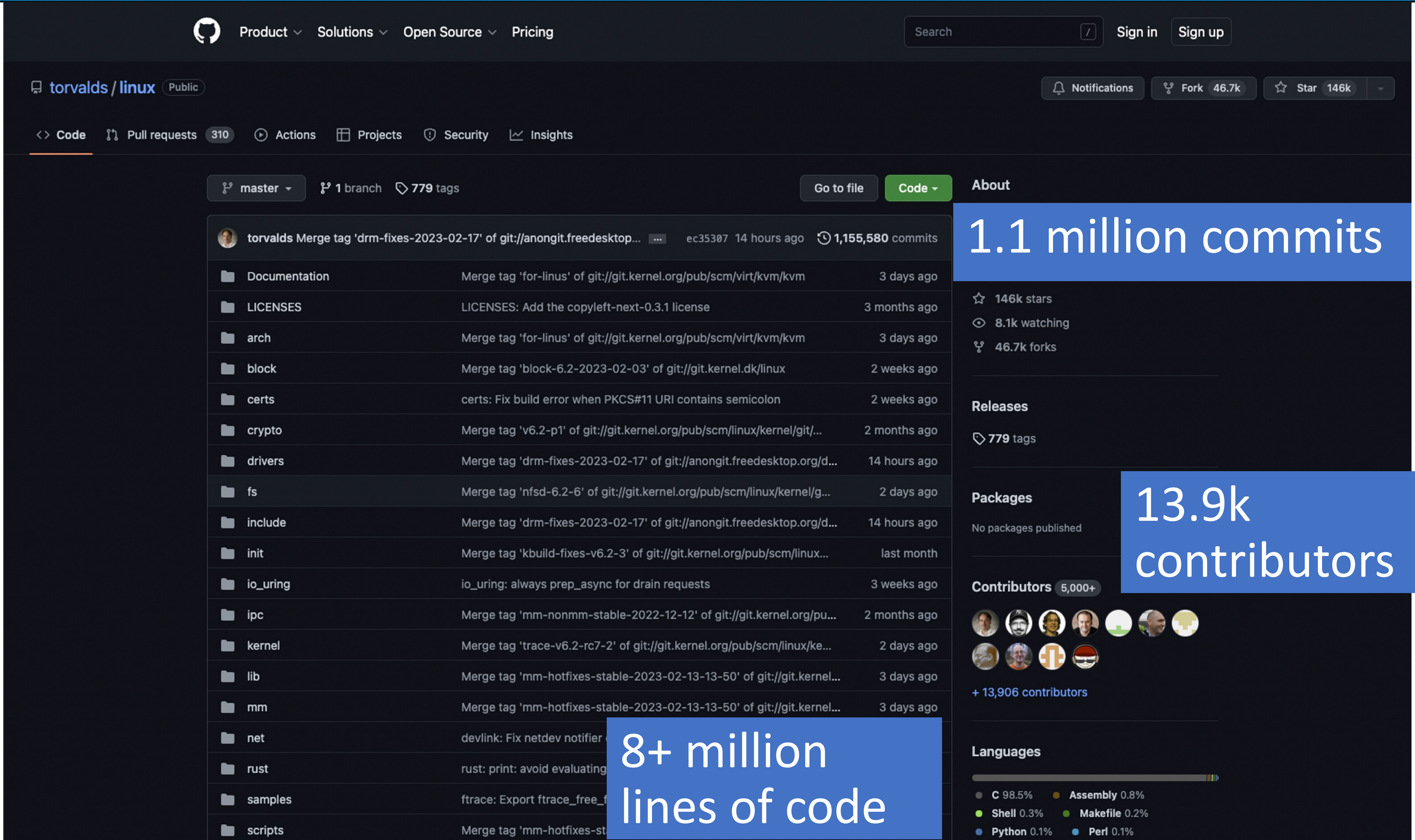
Substitution (structural arrangement to partly decrease the need for trust)

> Keep some important passwords stored locally and not on app

Plan For Today

- Motivation: Importance of trust in OS
  - Trust amongst tech users, app developers, and OS developers is intertwined
- What is trust?
  - Extending agency to software
- How does trust emerge?
  - Assumption, inference, substitution
- **Example: Trusting Linux**

Linux is hard to trust



torvalds / linux Public

torvalds Merge tag 'drm-fixes-2023-02-17' of git://anongit.freedesktop... ec35307 14 hours ago 1,155,580 commits

Documentation	Merge tag 'for-linus' of git://git.kernel.org/pub/scm/virt/kvm/kvm	3 days ago
LICENSES	LICENSES: Add the copyleft-next-0.3.1 license	3 months ago
arch	Merge tag 'for-linus' of git://git.kernel.org/pub/scm/virt/kvm/kvm	3 days ago
block	Merge tag 'block-6.2-2023-02-03' of git://git.kernel.dk/linux	2 weeks ago
certs	certs: Fix build error when PKCS#11 URI contains semicolon	2 weeks ago
crypto	Merge tag 'v6.2-p1' of git://git.kernel.org/pub/scm/linux/kernel/git/...	2 months ago
drivers	Merge tag 'drm-fixes-2023-02-17' of git://anongit.freedesktop.org/d...	14 hours ago
fs	Merge tag 'nfsd-6.2-6' of git://git.kernel.org/pub/scm/linux/kernel/g...	2 days ago
include	Merge tag 'drm-fixes-2023-02-17' of git://anongit.freedesktop.org/d...	14 hours ago
init	Merge tag 'kbuild-fixes-v6.2-3' of git://git.kernel.org/pub/scm/linux...	last month
io_uring	io_uring: always prep_async for drain requests	3 weeks ago
ipc	Merge tag 'mm-nonmm-stable-2022-12-12' of git://git.kernel.org/pu...	2 months ago
kernel	Merge tag 'trace-v6.2-rc7-2' of git://git.kernel.org/pub/scm/linux/ke...	2 days ago
lib	Merge tag 'mm-hotfixes-stable-2023-02-13-13-50' of git://git.kernel...	3 days ago
mm	Merge tag 'mm-hotfixes-stable-2023-02-13-13-50' of git://git.kernel...	3 days ago
net	devlink: Fix netdev notifier	
rust	rust: print: avoid evaluating	
samples	ftrace: Export ftrace_free_f	
scripts	Merge tag 'mm-hotfixes-st	

About

146k stars
8.1k watching
46.7k forks

Releases

779 tags

Packages

No packages published

Contributors 5,000+

+ 13,906 contributors

Languages

C 98.5% Assembly 0.8%
Shell 0.3% Makefile 0.2%
Python 0.1% Perl 0.1%

1.1 million commits

13.9k contributors

8+ million lines of code

Users Trusting Linux

- Why: People use Linux-based tools to extend their agency
    - Android smartphones
    - 13.6% of servers
    - Almost all supercomputers
- How trust emerges?
    - Assumption
        - “never thought about it”
        - ”no other option”
    - Inference
        - open source
        - previous use
    - Substitution
        - Redundant security protocols (e.g. strong password, isolate/encrypt sensitive files)

App Developers Trusting Linux

- Why: Standardization and tools of OS enable efficiency
  - High cost to build and maintain new OS
  - Familiar => lowers learning time developers
- How trust emerges?
  - Assumption: rare given affordances to infer trust
  - Inference
    - Used by other app developers (lots of stars on GitHub)
    - trust Linus Torvalds
  - Substitution
    - code is open source (read it, fork it)
    - Add “redundant” checks in code (ex: spurious wakeup)

☆ 146k stars

8.1k watching

46.7k forks

Systems Programmers Trusting Linux

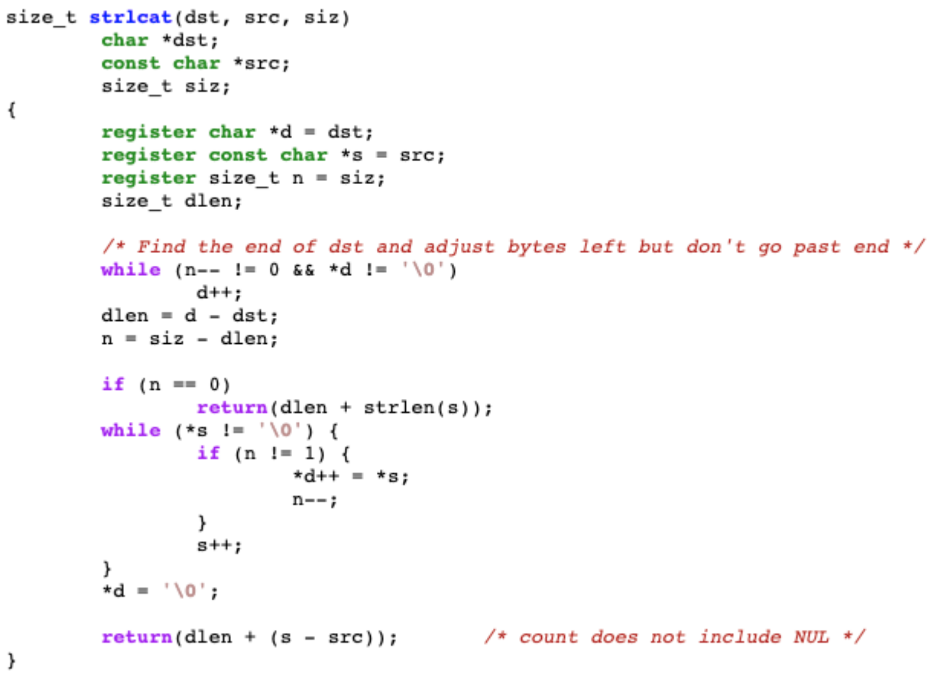
- Why: No single person can build & maintain an OS. Need to extend agency to others to support.
- How trust emerges?
  - Assumption: rarely happens
  - Inference
    - Known in community
    - Quality of previous code submissions
  - Substitution
    - Formalization: tools and procedures to streamline cooperation
    - Division of roles
    - Decision making: Linus has final authority

> *"I don't like the idea of having developers do their own updates in my kernel source tree. (...)*
> *"there really aren't that many people that I trust enough to give write permissions to the kernel tree."*
> *– Linus Torvalds*

Abstractions as way to substitute trust

strlcat: size bound string copying & concatenation

Since 1998 (few changes since)



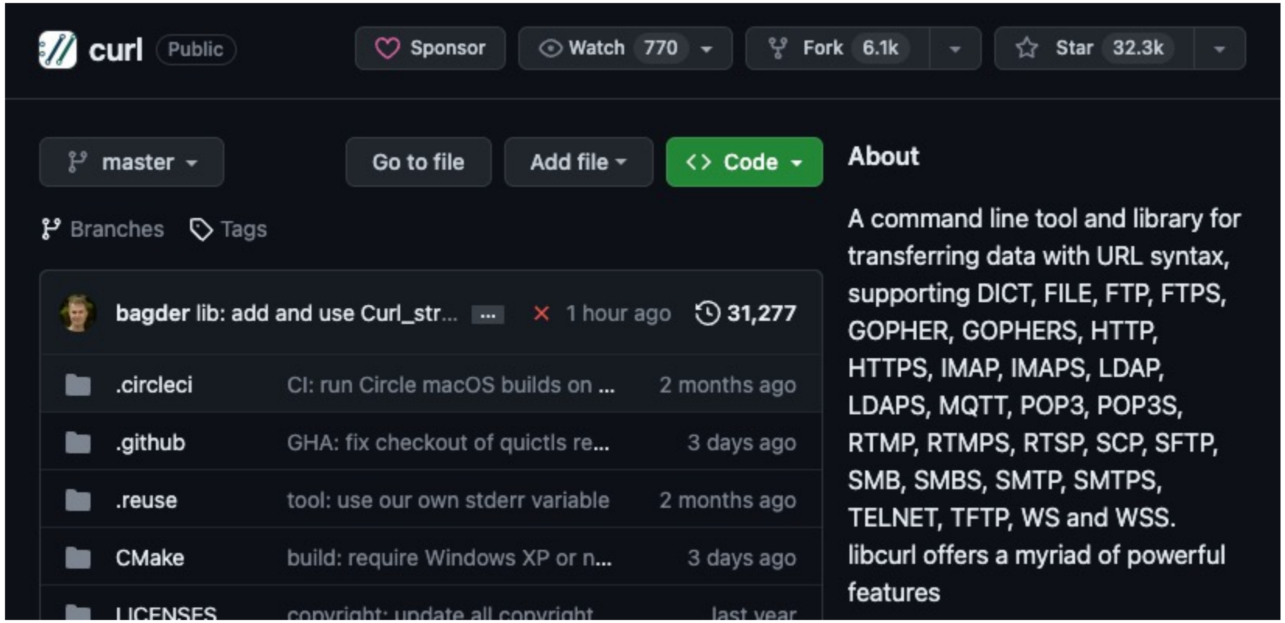
```
size_t strlcat(dst, src, siz)
        char *dst;
        const char *src;
        size_t siz;
{
        register char *d = dst;
        register const char *s = src;
        register size_t n = siz;
        size_t dlen;

        /* Find the end of dst and adjust bytes left but don't go past end */
        while (n-- != 0 && *d != '\0')
                d++;
        dlen = d - dst;
        n = siz - dlen;

        if (n == 0)
                return(dlen + strlen(s));
        while (*s != '\0') {
                if (n != 1) {
                        *d++ = *s;
                        n--;
                }
                s++;
        }
        *d = '\0';

        return(dlen + (s - src));       /* count does not include NUL */
}
```

curl: tool for transferring data from or to a server using URLs. (used by 20 bil.)

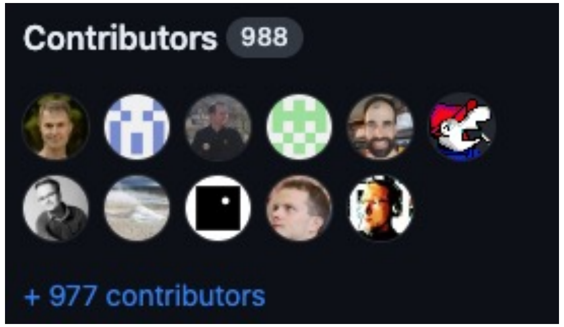


bagder lib: add and use Curl_str... ✕ 1 hour ago 31,277

.circleci	CI: run Circle macOS builds on ...	2 months ago
.github	GHA: fix checkout of quictls re...	3 days ago
.reuse	tool: use our own stderr variable	2 months ago
CMake	build: require Windows XP or n...	3 days ago
LICENSES	copyright: update all copyright	last year

About

A command line tool and library for transferring data with URL syntax, supporting DICT, FILE, FTP, FTPS, GOPHER, GOPHERS, HTTP, HTTPS, IMAP, IMAPS, LDAP, LDAPS, MQTT, POP3, POP3S, RTMP, RTMPS, RTSP, SCP, SFTP, SMB, SMBS, SMTP, SMTPS, TELNET, TFTP, WS and WSS. libcurl offers a myriad of powerful features



Contributors 988

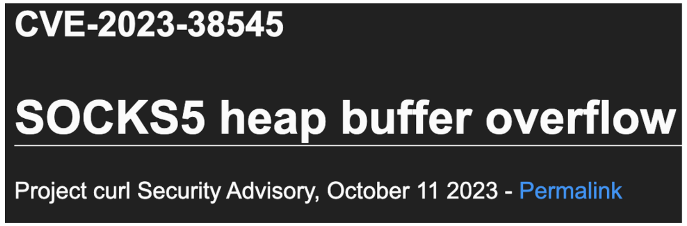
+ 977 contributors

Trust is getting harder b/c code complexity beyond comprehension of single person.
(example of substitution: SOLID, Barbara Liskov)

Old does not (necessarily) mean trustworthy!

- SOCKS5: enables anonymous network communication (e.g. when using Tor to access internet, VPNs)
- Hostname can only be 255 bytes
- Bug introduced where long hostname (e.g. https://aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa/) overflows buffer that stores

- Bug existed for 3.6 yrs
- Resolution: patch made (throw error), test case added
- Robust substitution: rewriting in memory-safe language (Rust)



CVE-2023-38545

SOCKS5 heap buffer overflow

Project curl Security Advisory, October 11 2023 - Permalink

https://daniel.haxx.se/blog/2023/10/11/how-i-made-a-heap-overflow-in-curl/#comments

> ““Every human make mistake but spotting the mistake, acknowledging it and explaining it to a wide audience takes a very good human… this makes Curl even more trustable than before.”
>
> - commenter on dev blogpost

Recap

1. Trust amongst tech users, app developers, and system programmers is intertwined
2. Trust is about extending agency, enabling "unquestioning attitude"
3. Trust emerges through assumption, inference, substitution
4. Linux kernel to used broadly and large, so users, app developers, system programmers must trust through inference and substitution
5. Can design ways to (partially) substitute need to trust

Ethics takeaway: Trust is often required, powerful, and dangerous. Key design challenge is how we design structures that enable us to substitute trust.

Benjamin Xie, Ph.D.

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assign4

Assignment 4 consists of an ethics exploration + implementing 2 *monitor pattern classes* for 2 multithreaded programs.

Unique Locks

- It is common to acquire a lock and hold onto it until the end of some scope (e.g. end of function, end of loop, etc.).
- There is a convenient variable type called ***unique_lock*** that when created can automatically lock a mutex, and when destroyed (e.g. when it goes out of scope) can automatically unlock a mutex.
- Particularly useful if you have many paths to exit a function and you must unlock in all paths.

leave_eastbound

We lock at the beginning of this function and unlock at the end.

```
void Bridge::leave_eastbound(size_t id) {
    bridge_lock.lock();
    n_crossing_eastbound--;
    if (n_crossing_eastbound == 0) {
        none_crossing_eastbound.notify_all();
    }
    print(id, "crossed", true);
    bridge_lock.unlock();
}
```

leave_eastbound

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void Bridge::leave_eastbound(size_t id) {
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```

Auto-locks permitsLock here

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    }
    print(id, "crossed", true);
}
```

Auto-unlocks permitsLock here (goes out of scope)

arrive_eastbound

```
void Bridge::arrive_eastbound(size_t id) {
    bridge_lock.lock();
    print(id, "arrived", true);
    while (n_crossing_westbound > 0) {
        none_crossing_westbound.wait(bridge_lock);
    }
    n_crossing_eastbound++;
    print(id, "crossing", true);
    bridge_lock.unlock();
}
```

arrive_eastbound

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void Bridge::arrive_eastbound(size_t id) {
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    }
    n_crossing_eastbound++;
    print(id, "crossing", true);
}
```

Use it with CV instead of original lock (it has wrapper methods for manually locking/unlocking!)

arrive_eastbound

```
void Bridge::arrive_eastbound(size_t id) {
    unique_lock<mutex> lock(bridge_lock);
    print(id, "arrived", true);
    while (n_crossing_westbound > 0) {
        none_crossing_westbound.wait(lock);
    }
    n_crossing_eastbound++;
    print(id, "crossing", true);
}
```

Auto-unlocks permitsLock here (goes out of scope)

Assign4 Data Structures

- Data structures can be used to store condition variables or state
- Structs also helpful to bundle state together and make multiple instances of structs
- **Key note: condition variables cannot be copied**. E.g. cannot create a condition variable and push onto vector. Consider how pointers might help!

Recap

- Trust and Operating Systems
- assign4

Lecture 16 takeaway: Trust is often required, powerful, and dangerous. Key design challenge is how we design structures that enable us to substitute trust. For assign4, you'll explore these topics and use the monitor pattern to write multithreaded programs.

Next time: how does the OS run and switch between threads?

```
cp -r /afs/ir/class/cs111/lecture-code/lect16 .
```