Lecture 12: Waste!

OLPC; Identity; Proofs of Work; Environmental Impacts

CMSC 25910

Winter 2026

The University of Chicago

THE UNIVERSITY OF CHICAGO

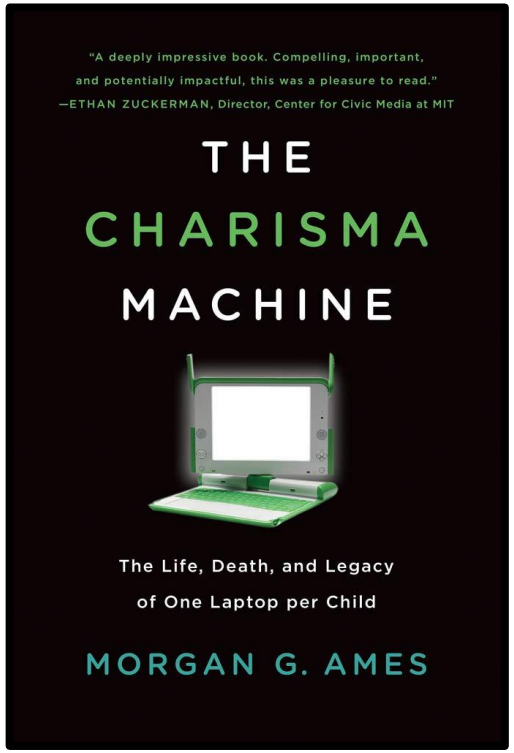
Good Intentions, But Ultimately a Waste?

One Laptop Per Child (OLPC)

- Project centered in the MIT Media Lab ~2005
  - Funding came from companies like AMD, eBay, Google, Marvell, etc.
- Goal: Transform education around the world in part by distributing electronic devices around the world

Failure of One Laptop Per Child (OLPC)

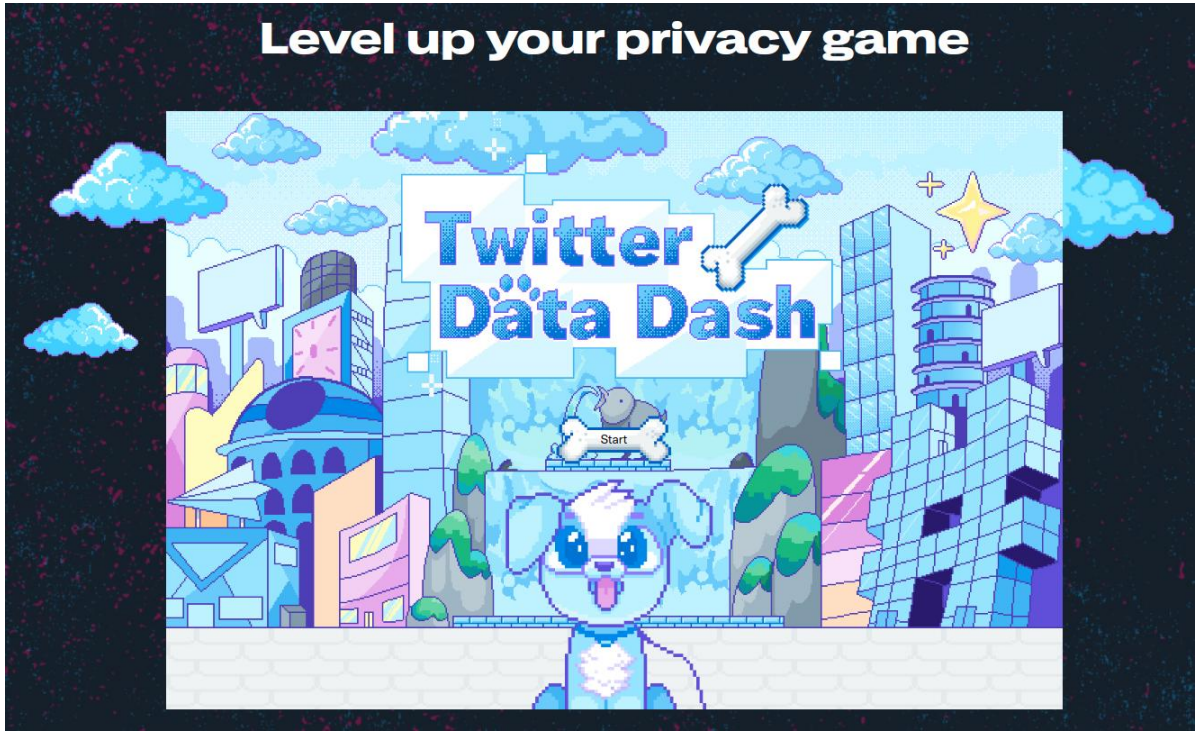
- US-centric worldview; expensive; focus on computers (to the detriment of other concerns); minimal availability of software; problems with maintainability; minimal training/infrastructure; over-adherence to FOSS; negative environmental impacts; bugs



Gamification of Privacy Policies: A Potential Waste?

Twitter Data Dash

- Twitter released an online game to discuss some of its privacy concepts to users
  - https://twitterdatadash.com/



https://gizmodo.com/twitter-privacy-policy-video-game-data-dash-1848912387

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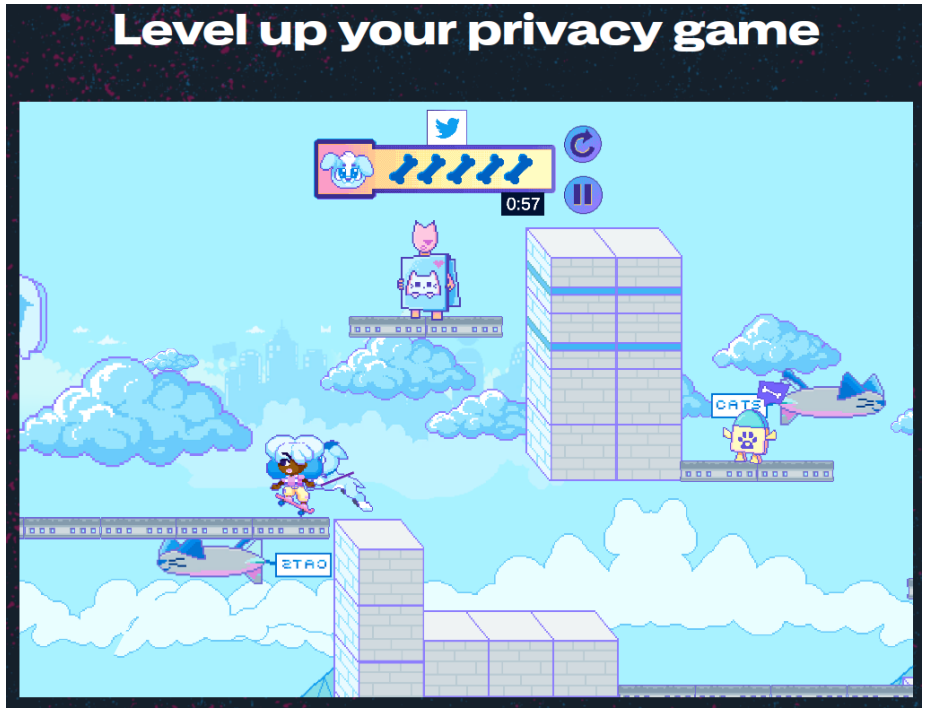
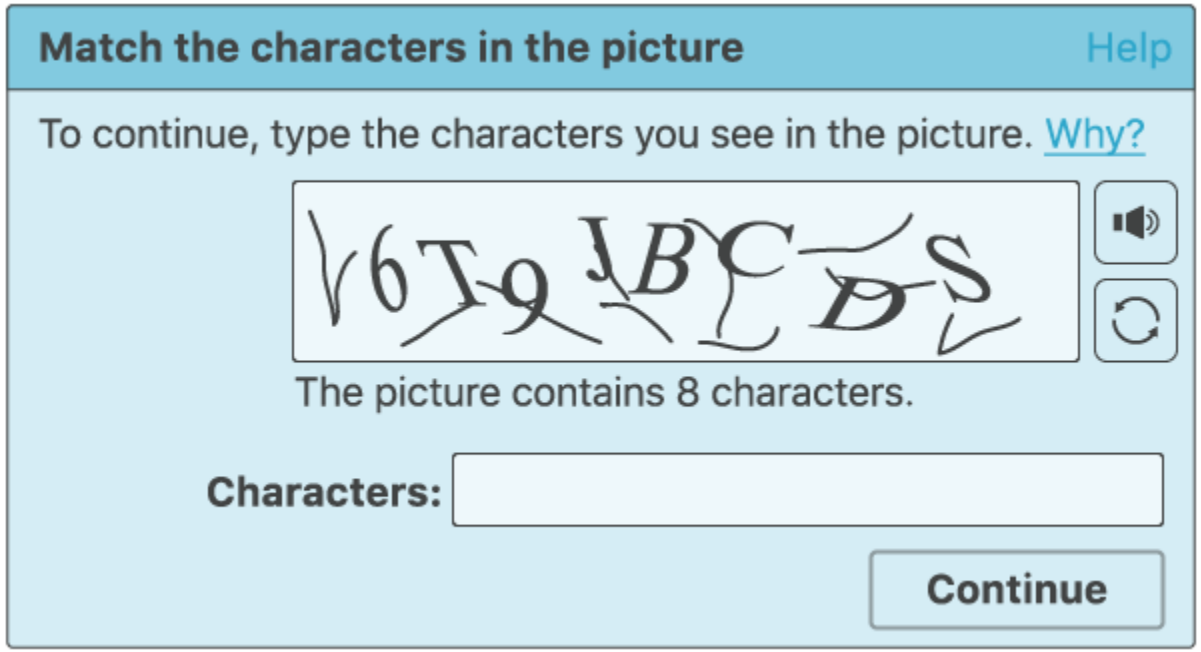


https://gizmodo.com/twitter-privacy-policy-video-game-data-dash-1848912387

Proving You Are Human

CAPTCHA

- **C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part (Luis von Ahn et al.)



reCAPTCHA

- Book digitization
  - NY Times, Google Books
- “One of the wavy words quite likely came from a digitized image from an old, musty text…the scanning programs made a lot of mistakes.”

https://www.nytimes.com/2011/03/29/science/29recaptcha.html and https://freakspot.net/en/como-explota-Google-con-CAPTCHAs/

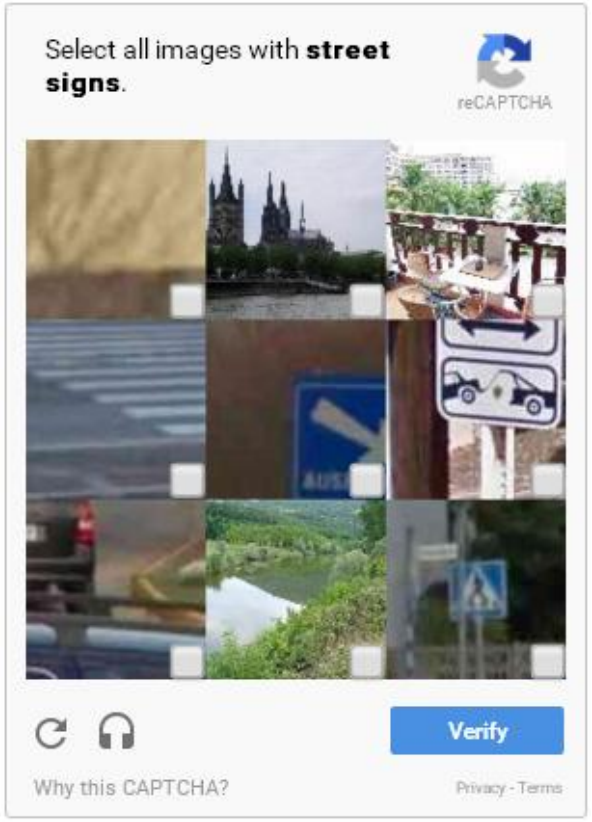
reCAPTCHA

- “ReCaptcha flags as “suspicious” any word that is deciphered differently by the two programs or that does not appear in an English dictionary… Then each suspicious word is turned into a Captcha. It is crucial to understand that the Captcha is a distorted version of the word as printed in the original photographic image. It is not made from the O.C.R.’s imagined translation, which is often unintelligible. The unknown word is then paired with a second Captcha word whose correct translation is already known. This is the “control.”

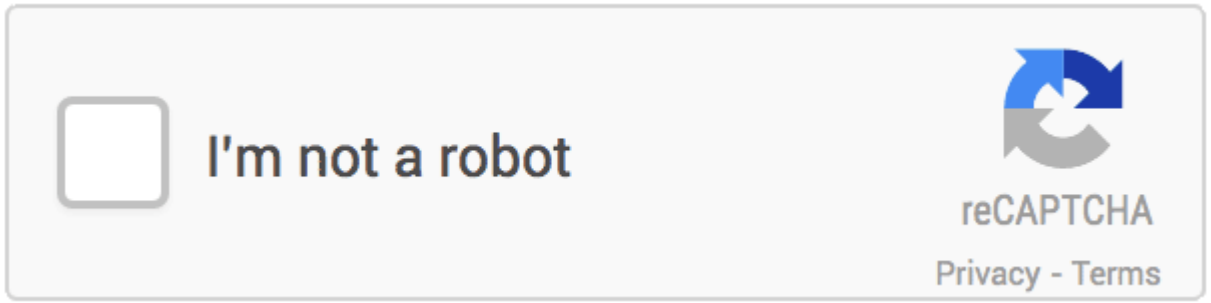
https://www.nytimes.com/2011/03/29/science/29recaptcha.html

reCAPTCHA

- Google Maps (and presumably self-driving cars):



- “Checking a box”



- Are CAPTCHAs accessible?

Images taken from https://freakspot.net/en/como-explota-Google-con-CAPTCHAs/
See also https://www.npr.org/sections/money/2019/04/24/716854013/episode-908-i-am-not-a-robot

Duolingo

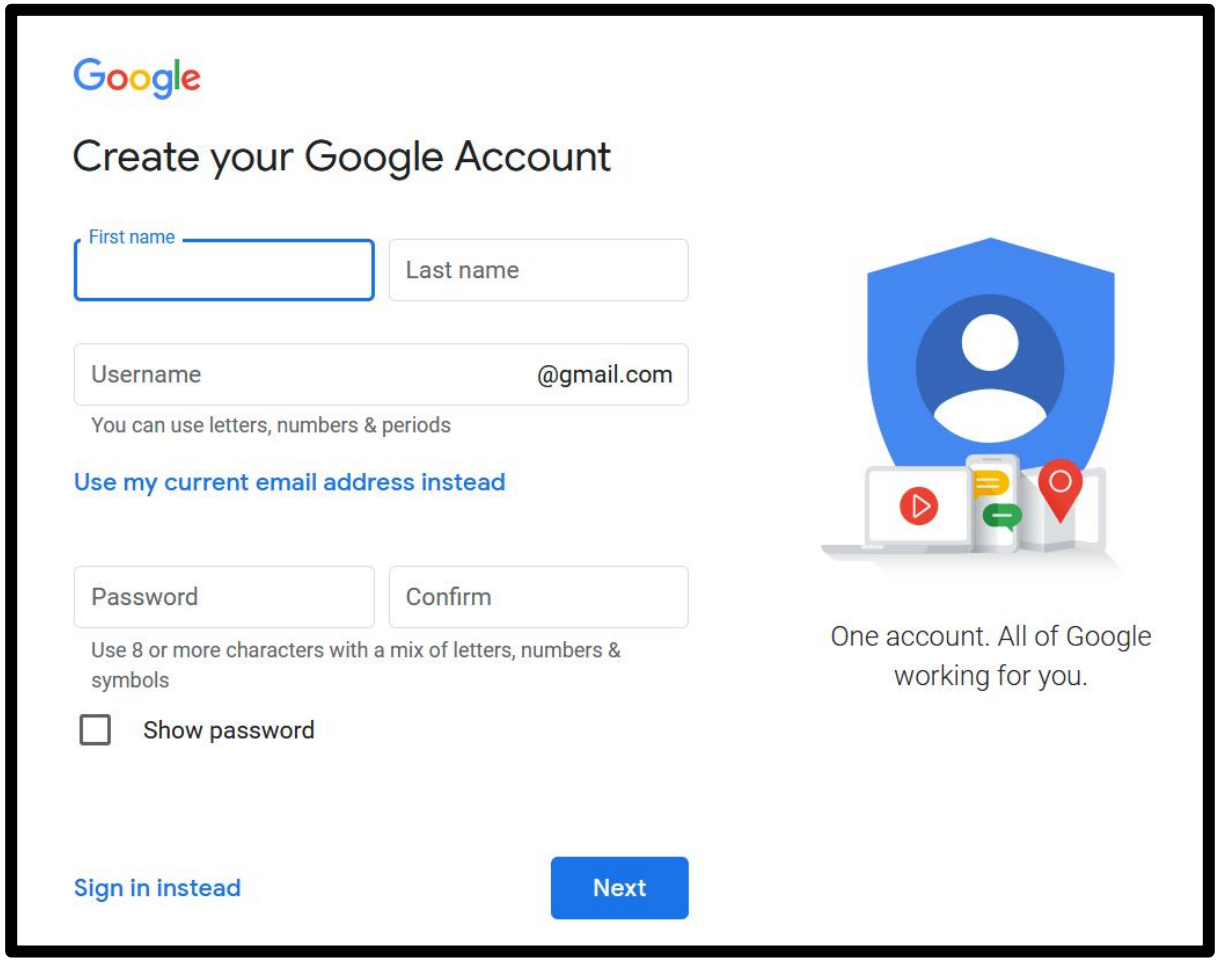
- Original (and perhaps future?) idea: use power of humans learning a language to create translations

duolingo

https://www.npr.org/2020/05/22/860884062/recaptcha-and-duolingo-luis-von-ahn
https://digital.hbs.edu/platform-digit/submission/duolingo-using-the-wisdom-of-crowds-to-translate-language/
See also https://www.npr.org/sections/money/2019/04/24/716854013/episode-908-i-am-not-a-robot

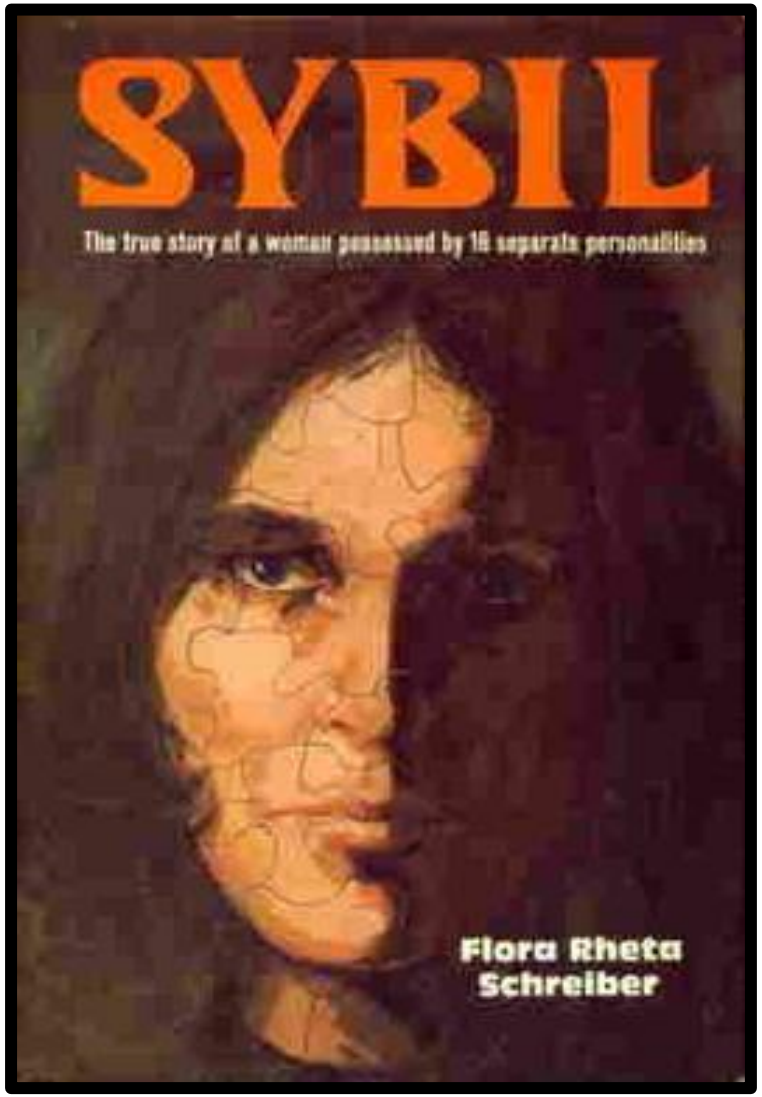
Identity: Preventing Multiple Accounts from One Person

Identity (in systems)



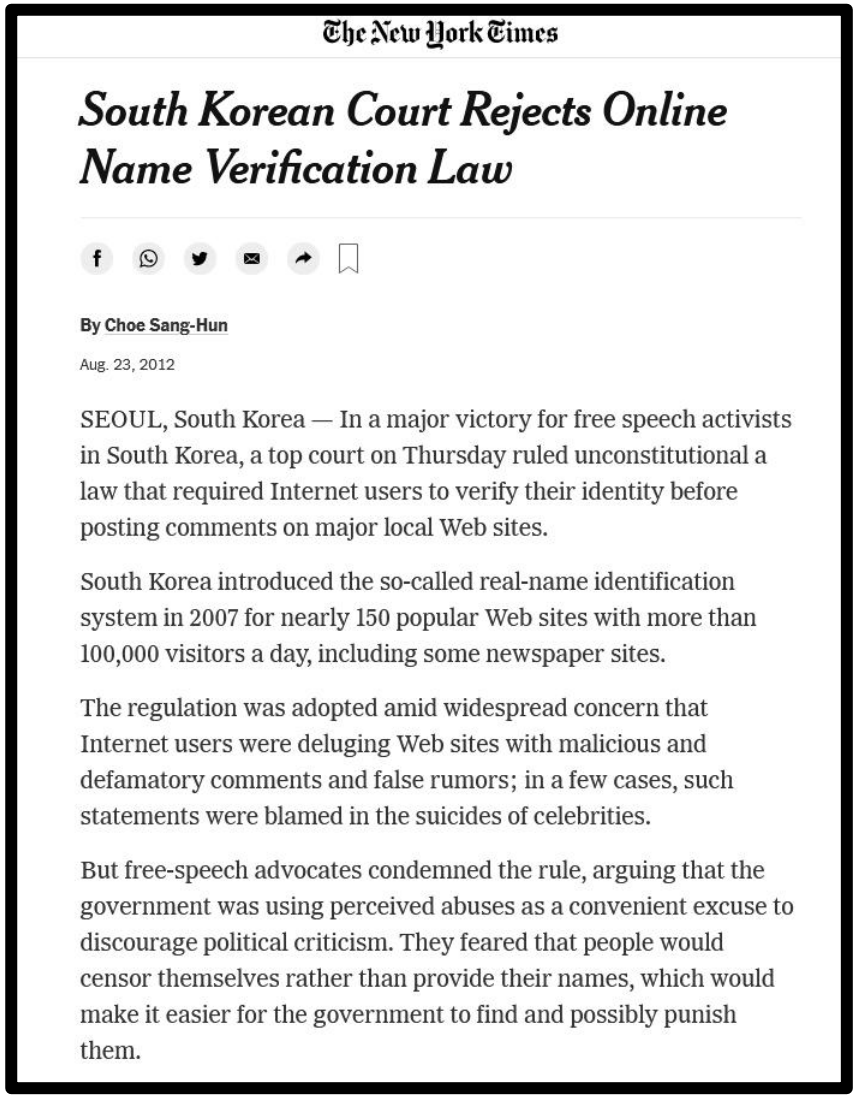
Sybil Attacks

- One individual creates many pseudonymous identities
- For instance, one individual creates many accounts
- Namesake: Sybil (pseudonym of a person who had a dissociative identity disorder)
- Also called: sock puppets (false identities)
- Why is this a problem for computer systems?



Binding Accounts to Real Identities

- IP address
- Mailing address
- National identity card
- Telephone number
  - What precise protocol?



The New York Times

South Korean Court Rejects Online Name Verification Law

By Choe Sang-Hun

Aug. 23, 2012

SEOUL, South Korea — In a major victory for free speech activists in South Korea, a top court on Thursday ruled unconstitutional a law that required Internet users to verify their identity before posting comments on major local Web sites.

South Korea introduced the so-called real-name identification system in 2007 for nearly 150 popular Web sites with more than 100,000 visitors a day, including some newspaper sites.

The regulation was adopted amid widespread concern that Internet users were deluging Web sites with malicious and defamatory comments and false rumors; in a few cases, such statements were blamed in the suicides of celebrities.

But free-speech advocates condemned the rule, arguing that the government was using perceived abuses as a convenient excuse to discourage political criticism. They feared that people would censor themselves rather than provide their names, which would make it easier for the government to find and possibly punish them.

Cybersecurity Law of the People's Republic of China (Effective June 1, 2017)

Article 24: Network operators handling network access and domain name registration services for users, handling stationary or mobile phone network access, or providing users with information publication or instant messaging services, shall require users to provide real identity information when signing agreements with users or confirming the provision of services. Where users do not provide real identity information, network operators must not provide them with relevant services.

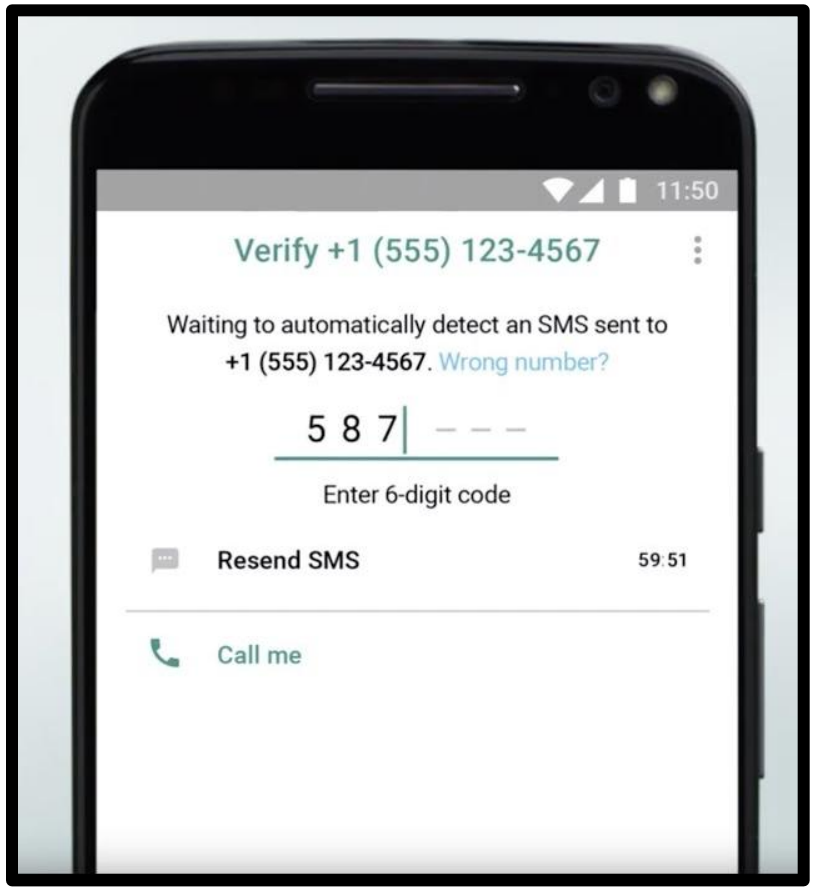
https://www.newamerica.org/cybersecurity-initiative/digichina/blog/translation-cybersecurity-law-peoples-republic-china/

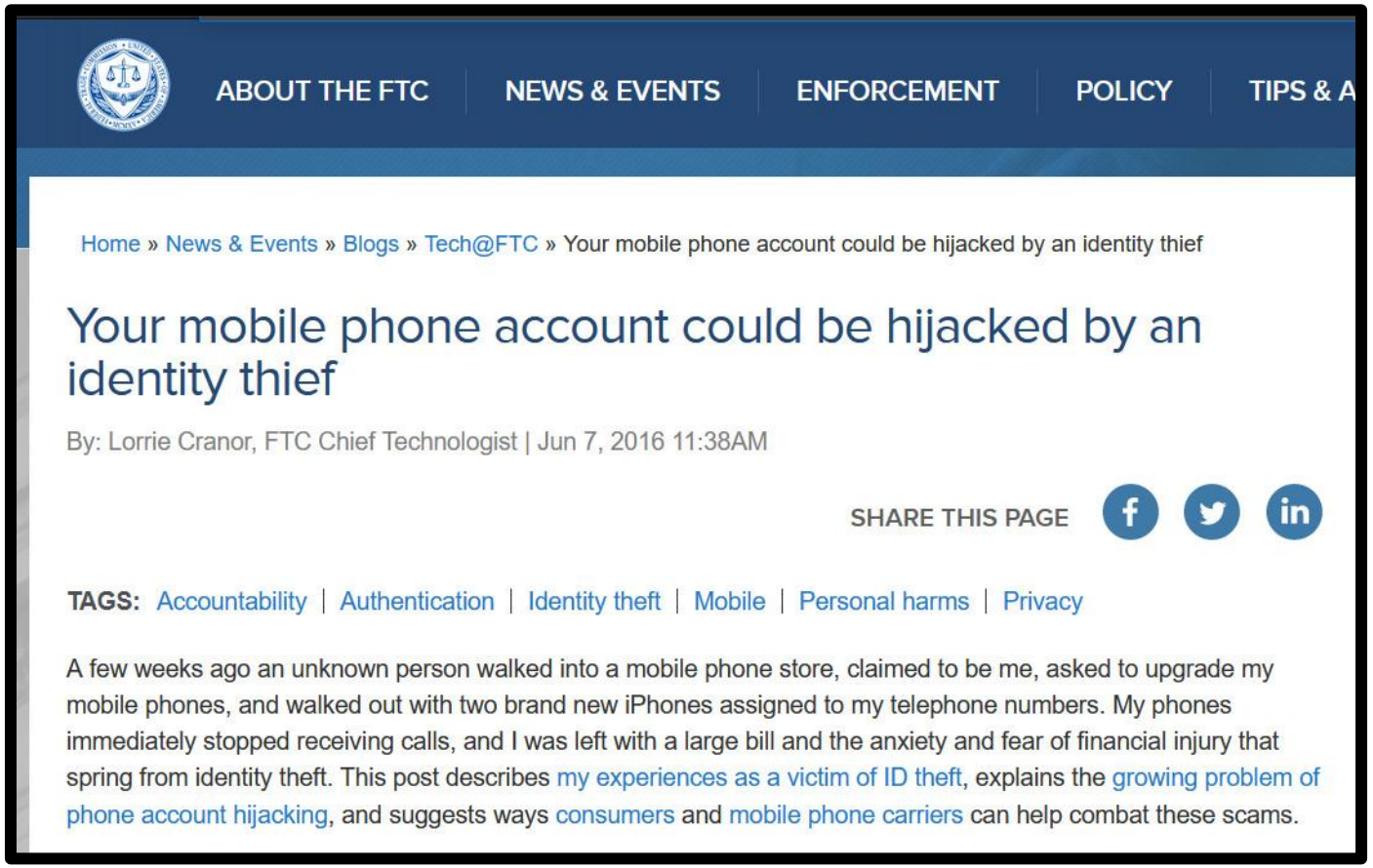
National ID Cards

- Some national ID cards include a microprocessor
  - Online authentication becomes possible

https://www.thalesgroup.com/en/markets/digital-identity-and-security/government/identity/2016-national-id-card-trends

Vulnerabilities of SMS Codes





https://www.youtube.com/watch?v=AWemFbRf95g
https://www.ftc.gov/news-events/blogs/techftc/2016/06/your-mobile-phone-account-could-be-hijacked-identity-thief

Age-Verification Laws

Gizmodo

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TECH POLICY

Colorado Legislators Want Device-Level Age Restrictions for Minors. Here's What That Means

Lawmakers are following in California's foot steps. Could this spark a nationwide trend?

BY ECE YILDIRIM PUBLISHED FEBRUARY 23, 2026

READING TIME 3 MINUTES

READ LATER COMMENTS (6)

© Nerza

As a growing list of countries around the world crack down on social media's adverse effects on minors, states have begun taking matters into their own hands.

Many states, including Texas, Virginia, and Utah, have begun restricting minors from accessing platforms with harmful content like porn.

Spectrum's Invincible WiFi Ensures You're Always Connected—No Matter What

https://gizmodo.com/colorado-legislators-want-device-level-age-restrictions-for-minors-heres-what-that-means-2000725313

Age-Verification Laws

- “Differing from other legislation, both the Colorado bill and the California law require operating system providers like Apple, Google, and Microsoft to verify user age instead of leaving that duty to the apps. Here’s how it works. Your operating system will require you to verify your age when you first set up your device, creating a digital signal that puts you into a certain age bracket. Then, any time you try to download an app with restricted content, it will use that digital age signal to determine if you are allowed to access it. That’s unless ‘a developer has clear and convincing information that a user’s age is different than the age indicated by an age signal,’ the bill says.”

https://gizmodo.com/colorado-legislators-want-device-level-age-restrictions-for-minors-heres-what-that-means-2000725313

Age-Verification Laws

- “Colorado's SB26-051, introduced last month, would require operating systems to register the owner’s age, which third-party apps can then leverage to determine if the user is an adult. The bill calls for the device owner to register their birthdate or age, but for the purposes of creating an “age bracket,” which can then be shared to an app developer through an API to learn their age range, according to BiometricUpdate.com…. But it looks like it’s easy to bypass the age check proposed by SB26-051. The legislation itself doesn’t mention any state ID check to verify the owner’s age. In addition, the bill doesn’t seem to cover websites, only apps and app stores.”

https://www.pcmag.com/news/colorado-lawmakers-push-for-age-verification-at-the-operating-system-level

Age-Verification Laws

Discord Voluntarily Pushes Mandatory Age Verification Despite Recent Data Breach

BY RINDALA ALAJAJI AND SAMANTHA BALDWIN | FEBRUARY 12, 2026

https://www.eff.org/deeplinks/2026/02/discord-voluntarily-pushes-mandatory-age-verification-despite-recent-data-breach

Age-Verification Laws

- “Beginning in early March, users who are either (a) estimated by Discord to be under 18, or (b) Discord doesn't have enough information on, may find themselves locked into a ‘teen-appropriate experience.’ That means content filters, age gates, restrictions on direct messages and friend requests, and the inability to speak in “Stage channels,” which are the large-audience audio spaces that power many community events. Discord says most adults may be sorted automatically through a new ‘age inference’ system that relies on account tenure, device and activity data, and broader platform patterns. Those whose age isn’t estimated due to lack of information or who are estimated to not be adults will be asked to scan their face or upload a government ID through a third-party vendor if they want to avoid the default teen account restrictions.”

https://www.eff.org/deeplinks/2026/02/discord-voluntarily-pushes-mandatory-age-verification-despite-recent-data-breach

Age-Verification Laws

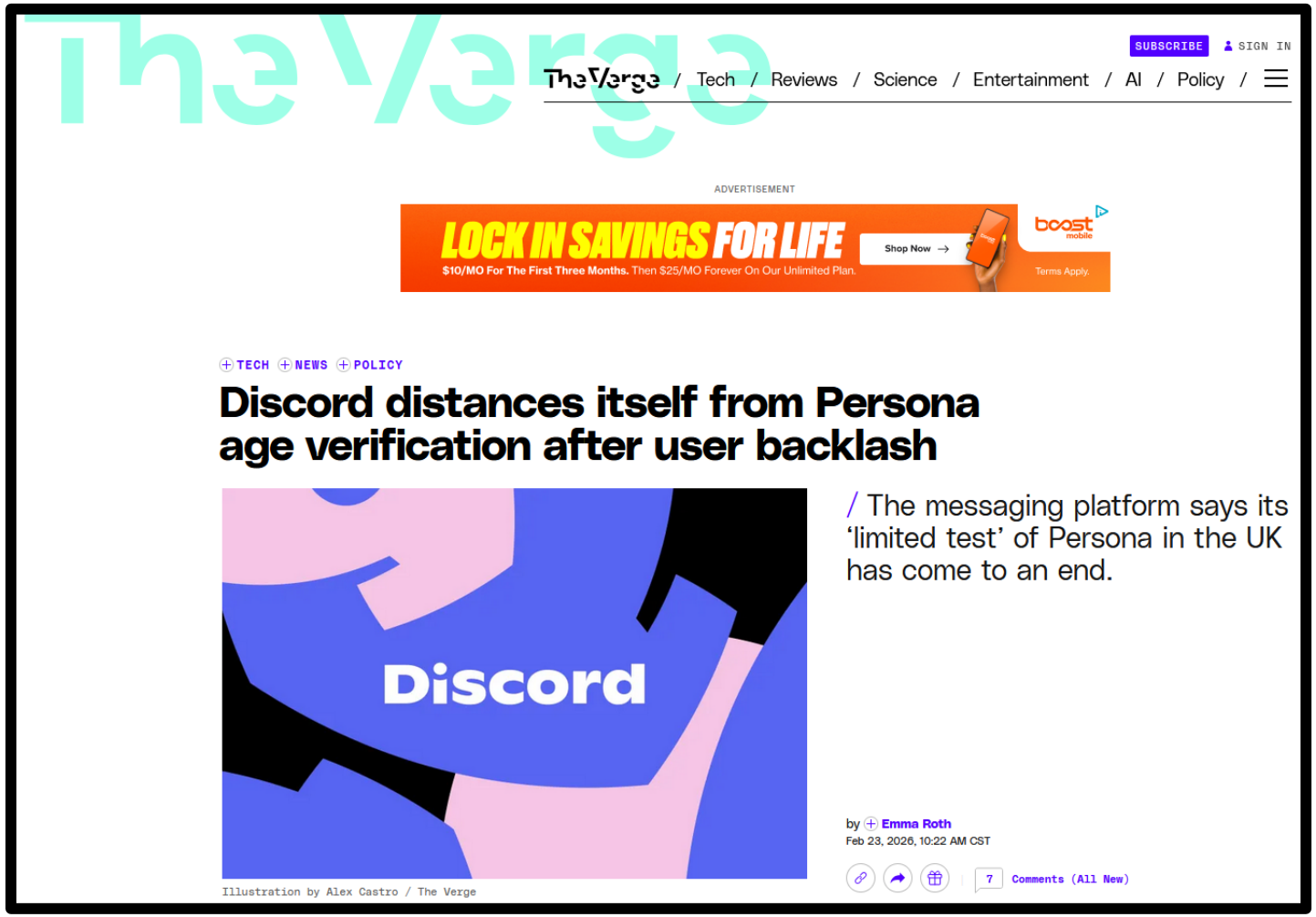
“That’s why we created our guide, ‘So You’ve Hit an Age Gate. Now What?’ It walks through practical steps to minimize risk, such as:

- Submit the least amount of sensitive data possible.
- Ask: What data is collected? Who can access it? How long is it retained?
- Look for evidence of independent, security-focused audits.
- Be cautious about background details in selfies or ID photos.

There is unfortunately no perfect option, only tradeoffs. And every user will have their own unique set of safety concerns to consider.”

https://www.eff.org/deeplinks/2026/02/discord-voluntarily-pushes-mandatory-age-verification-despite-recent-data-breach

Age-Verification Laws



https://www.theverge.com/tech/878369/discord-persona-age-verification
Also consider reading https://www.igorslab.de/en/persona-discord-and-openai-when-age-verification-suddenly-smells-like-fincen/

Proof of Work

Prerequisite: Hashing Revisited

- Similar inputs result in very different outputs
- md5(“blase”) = 12B872ADB2588C668D706D847FC1DA7E
- md5(“blasé”) = 29AFE9B75D98D3C4ECFCB34FDFC422A2

Need for Proofs of Work

- Example (problematic) system: You upload some data to a computer system and it trains a neural network with that data
- Example (problematic) system: You upload the product of two large prime numbers to a system and it factorizes it
- What’s the problem?

Need for Proofs of Work

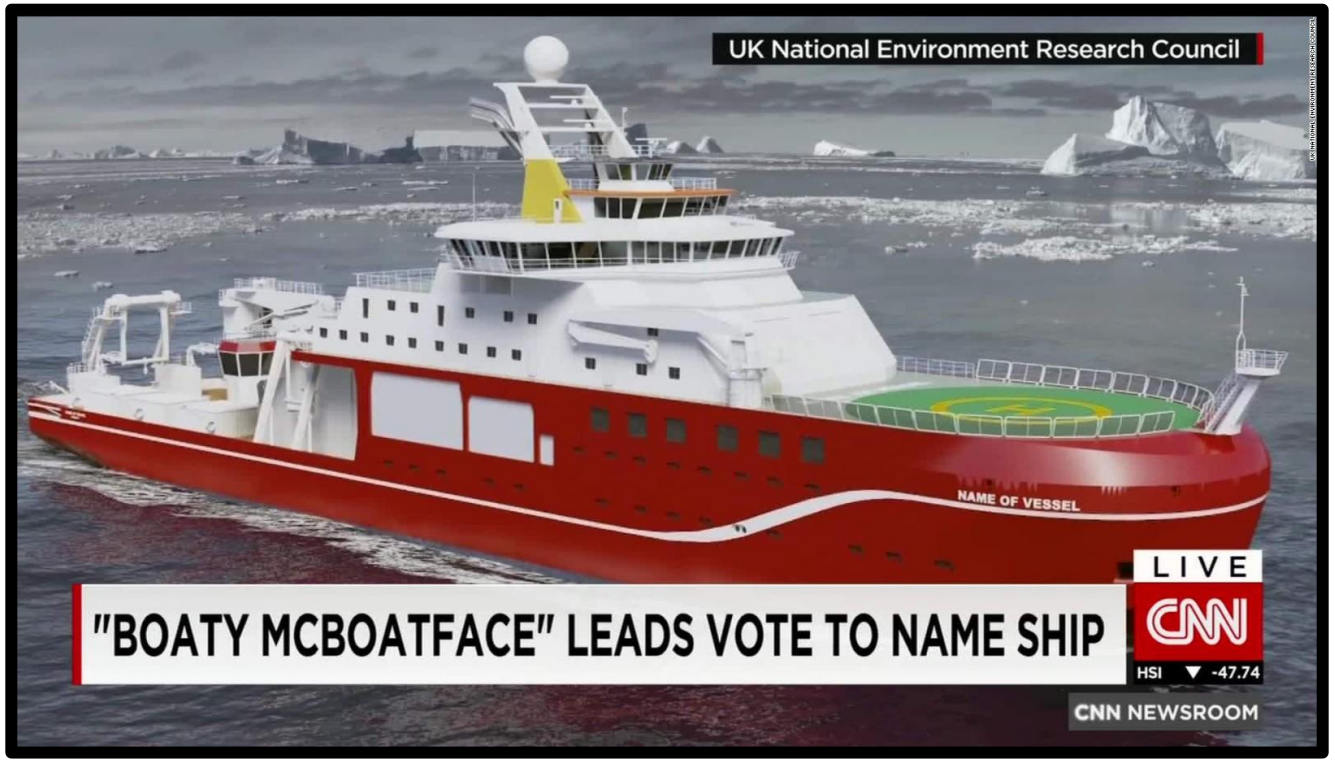
- Example (problematic) system: You upload some data to a computer system and it trains a neural network with that data
- Example (problematic) system: You upload the product of two large prime numbers to a system and it factorizes it
- What's the problem? **Denial of Service (DoS) attacks**

Need for Proofs of Work

- Example (problematic) system: Everyone can vote on who wins the CS 25910 Memelord award
- What's the problem?

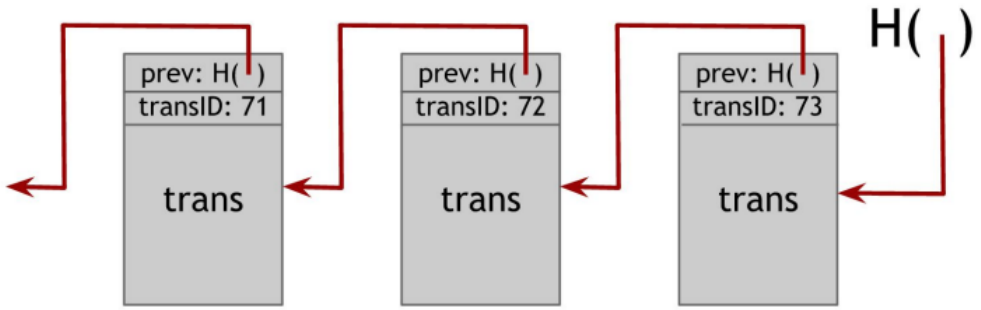
Need for Proofs of Work

- Example (problematic) system: Everyone can vote on who wins the CS 25910 Memelord award
- What's the problem? **Does one person = one vote?**



Blockchain

- Blocks of transactions are linked together into a chain
- Hashes connect the blocks
- *Emergent consensus*: The hash chain representing the most cumulative work is considered valid
- Blocks (in Bitcoin) are mined every 10 minutes



Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Blockchain

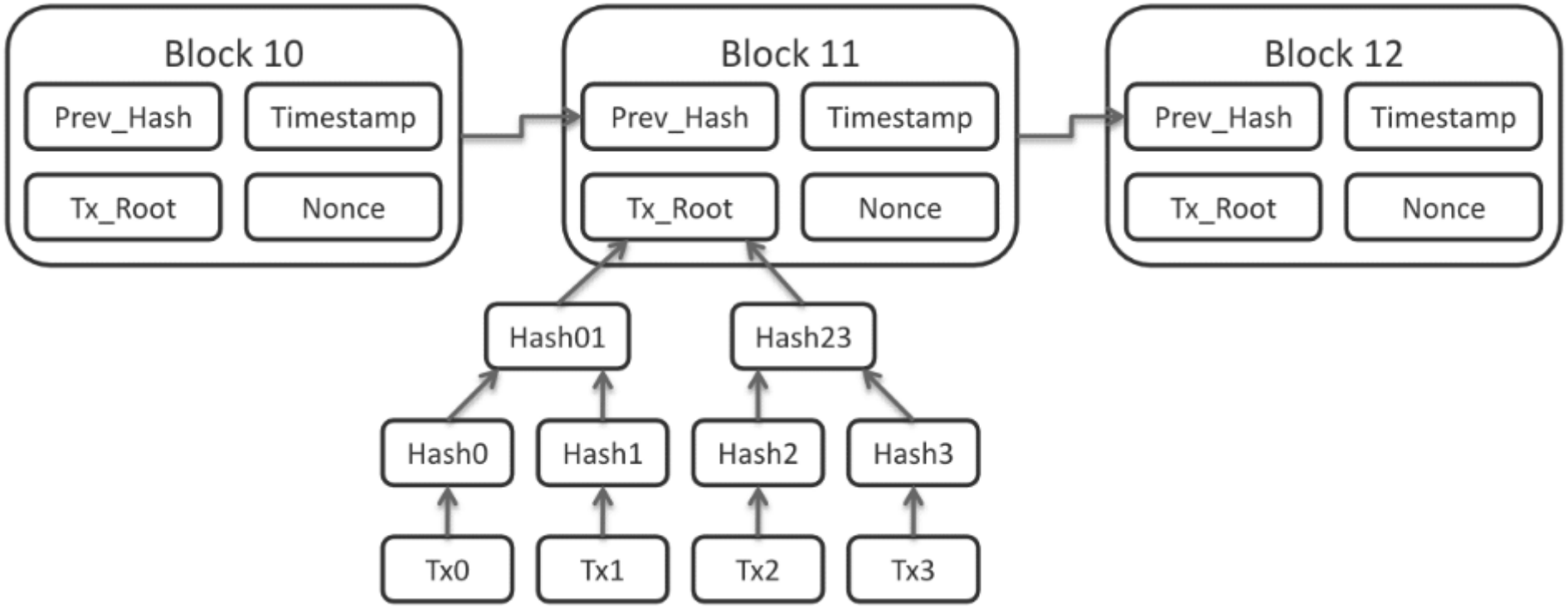


Image taken from https://coincentral.com/what-is-a-nonce-proof-of-work

Blockchain as Used in Bitcoin

- Transactions include transfers of the cryptocurrency
- Sign transactions with a secret (private) key
- Broadcast transactions throughout the network
- Transactions are assembled into the ledger

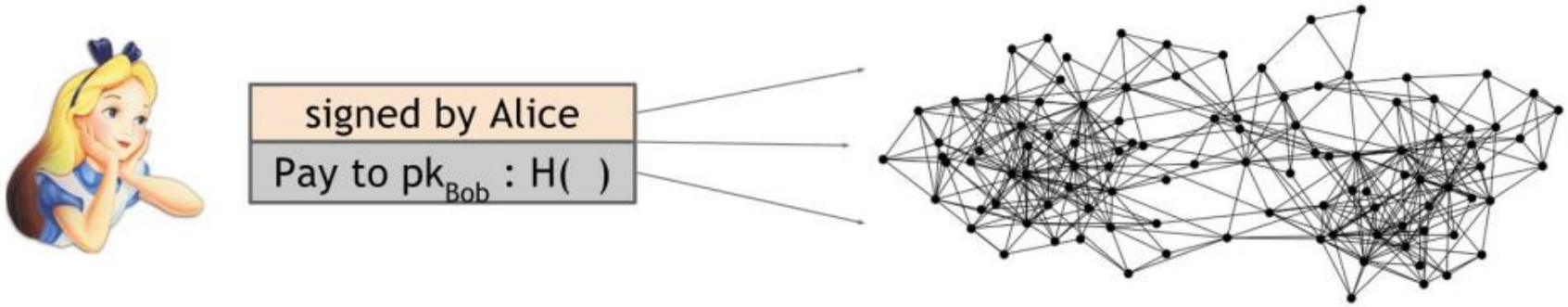


Figure 2.1 Broadcasting a transaction In order to pay Bob, Alice broadcasts the transaction to the entire Bitcoin peer-to-peer network.

Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Blockchain as a Distributed Ledger

- Conceptual (but impractical) idea: ledger of accounts

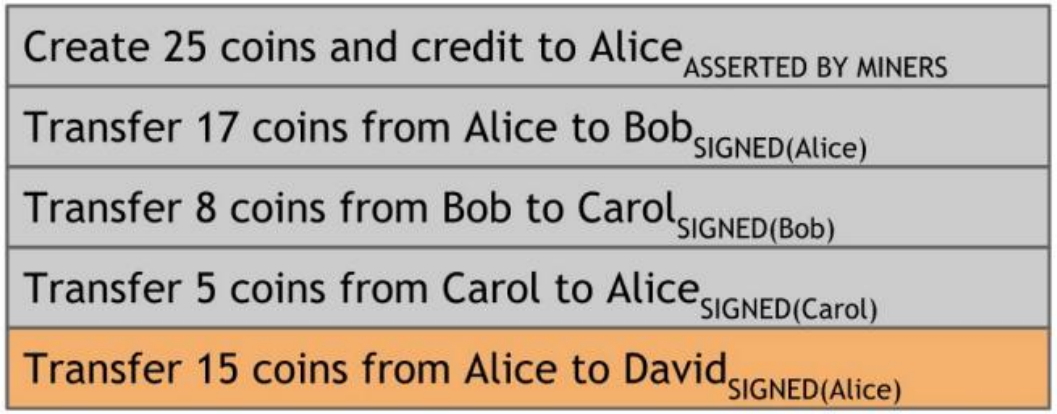


Figure 3.1 an account-based ledger

Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Blockchain as a Distributed Ledger

- More practical (and what is actually done): ledger of transaction; future transactions connected to a previous one

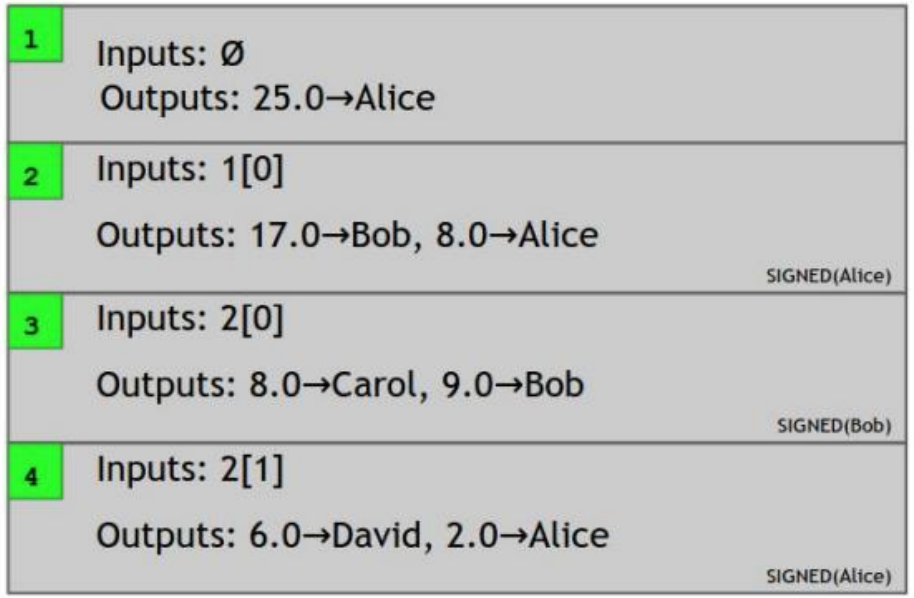


Figure 3.2 a transaction-based ledger, which is very close to Bitcoin

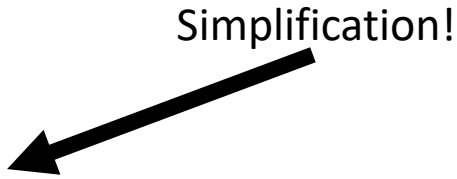
Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Distributed Consensus in Bitcoin

Bitcoin consensus algorithm (simplified)

This algorithm is simplified in that it assumes the ability to select a random node in a manner that is not vulnerable to Sybil attacks.

1. New transactions are broadcast to all nodes
2. Each node collects new transactions into a block
3. In each round a random node gets to broadcast its block
4. Other nodes accept the block only if all transactions in it are valid (unspent, valid signatures)
5. Nodes express their acceptance of the block by including its hash in the next block they create



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Distributed Consensus in Bitcoin

- We are going to be hashing blocks, which include:
  - A pointer to the previous block and a hash of its contents (*prev_hash*)
  - The transactions captured in this block of the ledger (*tx*…)
  - A nonce, which you'll guess (over and over and over)
- Try to find a nonce that solves the following:

$$H(nonce \,||\, prev\_hash \,||\, tx \,||\, tx \,||\, \ldots \,||\, tx) < target$$

- Note that you include a transaction paying yourself, so your block (and thus the relevant nonce) is specific to you

Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html and https://www.vox.com/2015/11/3/18053556/how-does-the-bitcoin-network-process-transactions

Iterating on a Nonce

Example 8-10. SHA256 output of a script for generating many hashes by iterating on a nonce

```
$ python hash_example.py

I am Satoshi Nakamoto0 => a80a81401765c8eddee25df36728d732...
I am Satoshi Nakamoto1 => f7bc9a6304a4647bb41241a677b5345f...
I am Satoshi Nakamoto2 => ea758a8134b115298a1583ffb80ae629...
I am Satoshi Nakamoto3 => bfa9779618ff072c903d773de30c99bd...
I am Satoshi Nakamoto4 => bce8564de9a83c18c31944a66bde992f...
I am Satoshi Nakamoto5 => eb362c3cf3479be0a97a20163589038e...
I am Satoshi Nakamoto6 => 4a2fd48e3be420d0d28e202360cfbaba...
I am Satoshi Nakamoto7 => 790b5a1349a5f2b909bf74d0d166b17a...
I am Satoshi Nakamoto8 => 702c45e5b15aa54b625d68dd947f1597...
I am Satoshi Nakamoto9 => 7007cf7dd40f5e933cd89fff5b791ff0...
I am Satoshi Nakamoto10 => c2f38c81992f4614206a21537bd634a...
I am Satoshi Nakamoto11 => 7045da6ed8a914690f087690e1e8d66...
I am Satoshi Nakamoto12 => 60f01db30c1a0d4cbce2b4b22e88b9b...
I am Satoshi Nakamoto13 => 0ebc56d59a34f5082aaef3d66b37a66...
I am Satoshi Nakamoto14 => 27ead1ca85da66981fd9da01a8c6816...
I am Satoshi Nakamoto15 => 394809fb809c5f83ce97ab554a2812c...
I am Satoshi Nakamoto16 => 8fa4992219df33f50834465d3047429...
I am Satoshi Nakamoto17 => dca9b8b4f8d8e1521fa4eaa46f4f0cd...
I am Satoshi Nakamoto18 => 9989a401b2a3a318b01e9ca9a22b0f3...
I am Satoshi Nakamoto19 => cda56022ecb5b67b2bc93a2d764e75f...
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Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Clarifications About the Overall Process

- Validate blocks (e.g., no invalid transactions)
- Select the chain with the most proof of work

Text and images taken from https://d28rh4a8wq0iu5.cloudfront.net/bitcointech/readings/princeton_bitcoin_book.pdf and https://www.oreilly.com/library/view/mastering-bitcoin/9781491902639/ch08.html

Proof of Stake

Proof of Stake (PoS)

- An alternative approach to proof of work
  - See, e.g., https://ethereum.org/en/developers/docs/consensus-mechanisms/pos/
- Prospective validator offers some of their own coins in the system to be permitted to validate a block
  - e.g., Ethereum requires that 32 ETH be staked
  - Multiple validators have to agree on the block for it to be accepted
  - Lose your staked coins if you attest to a malicious block
- Fear: what if some entity controls 51% of the cryptocurrency
- Typically selected randomly from among staked users

Environmental Impacts

Electronic Waste

Bloomberg CityLab

The Toxic Effects of Electronic Waste in Accra, Ghana

Sorting through used electronics is a livelihood for many in the Agbogbloshie area, but toxic e-waste poses serious health risks.

Peter Yeung
May 29, 2019, 2:20 PM CDT

Abdrahaman Daouda came to Accra from Niger two years ago. He collects used water sachets and scrap metal, and hopes to buy his own taxi one day. But when it rains at Agbogbloshie, he finds it difficult to breathe. *Peter Yeung*

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Heavy, acidic gusts of smoke billow across the Agbogbloshie dump, a wasteland dotted with burning mounds of trash in Ghana's capital, Accra.

Up to 10,000 workers wade through tons of discarded goods as part of an enormous, informal recycling process, in what has become one of the world's largest destinations for used electronic goods.

CNN World Africa Americas Asia Australia China Europe India Middle East United Kingdom LIVE TV Edition

MARKETPLACE AFRICA

The rising e-waste crisis is being reckoned with in Rwanda, one gadget at a time

By Daniel Renjifo, CNN
Updated 1:21 PM ET, Fri February 26, 2021

How Rwanda is leading e-waste recycling efforts in Africa

How Flutterwave's unicorn status could sprout more innovation in African fintech

How international demand for Nigerian cotton is suiting well for small farmers

How big data is fostering expansion for this South African logistics enterprise

How ghost are coming South Afric

(CNN) — For Eric Nshimiyimanain, who owns two small electronic repair shops in Kigali, Rwanda, the startup chime of an old Windows laptop is the sound of a business opportunity.

He refurbishes broken PCs, laptops, phones and secondhand gadgets classified as electronic waste, or "e-waste" that would otherwise end up as trash in Nduba, Rwanda's only open-air dump in the outskirts of the capital.

https://www.bloomberg.com/news/articles/2019-05-29/the-rich-world-s-electronic-waste-dumped-in-ghana
https://www.smithsonianmag.com/science-nature/burning-truth-behind-e-waste-dump-africa-180957597/
https://www.cnn.com/2021/02/26/africa/marketplace-africa-ewaste-electronics-recycle-rwanda-spc-intl/index.html

Electronic Waste

ecoEDA: Recycling E-waste During Electronics Design

Jasmine Lu
University of Chicago
jasminelu@uchicago.edu

Beza Desta
University of Chicago
bezad@uchicago.edu

K. D. Wu
University of Chicago
wuhua@uchicago.edu

Romain Nith
University of Chicago
rnith@uchicago.edu

Joyce Passananti
University of Chicago
joycep@uchicago.edu

Pedro Lopes
University of Chicago
pedrolopes@uchicago.edu

Figure 1: We propose ecoEDA, an interactive electronics design tool that enables electronic components to be reused in new projects rather than simply ending up as e-waste. Our tool enables various pathways for electronics designers to prioritize recycling during the design process such as exploring reusable components via suggestions or importing printed circuit board projects into a library of recyclable components. Through use of our tool, components in typical e-waste can be given a second life in new project designs.

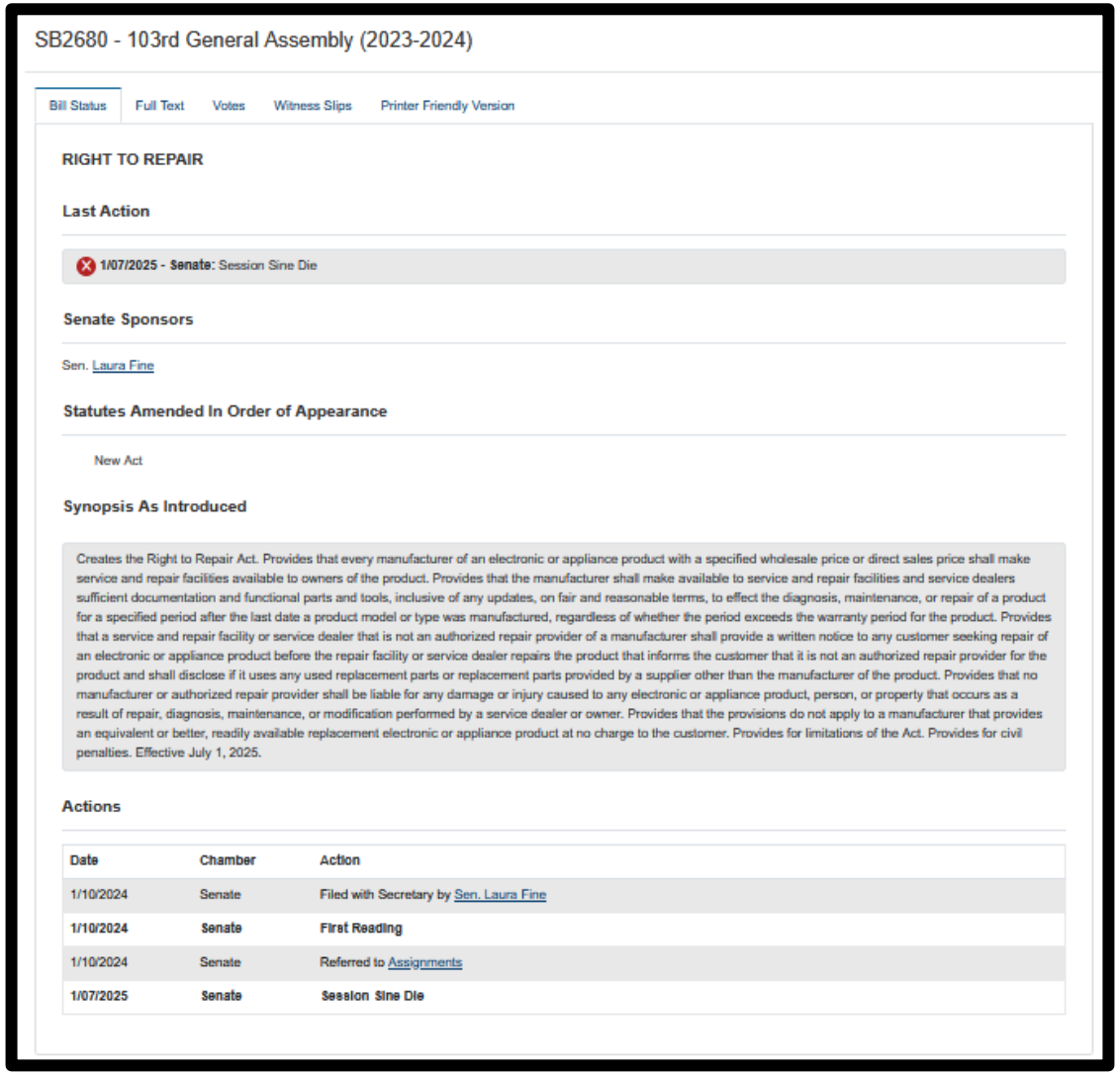
Jasmine Lu, Beza Desta, K.D. Wu, Romain Nith, Joyce Passananti, Pedro Lopes. ecoEDA: Recycling E-waste During Electronics Design. In *Proc. UIST*, 2023. https://lab.plopes.org/published/2023-UIST-ecoEDA.pdf

Right to Repair

- Problem: Manufacturers are making it harder for end users (or even specialized third-party firms) to repair or replace parts of their electronic devices
- Impacts of not being able to repair devices: Higher costs to consumers, environmental waste, unnecessary “upgrades”

Jasmine Lu, Beza Desta, K.D. Wu, Romain Nith, Joyce Passananti, Pedro Lopes. ecoEDA: Recycling E-waste During Electronics Design. In *Proc. UIST*, 2023. https://lab.plopes.org/published/2023-UIST-ecoEDA.pdf

Attempts at Right to Repair in Illinois



SB2680 - 103rd General Assembly (2023-2024)

Bill Status | Full Text | Votes | Witness Slips | Printer Friendly Version

RIGHT TO REPAIR

Last Action

1/07/2025 - **Senate:** Session Sine Die

Senate Sponsors

Sen. Laura Fine

Statutes Amended In Order of Appearance

New Act

Synopsis As Introduced

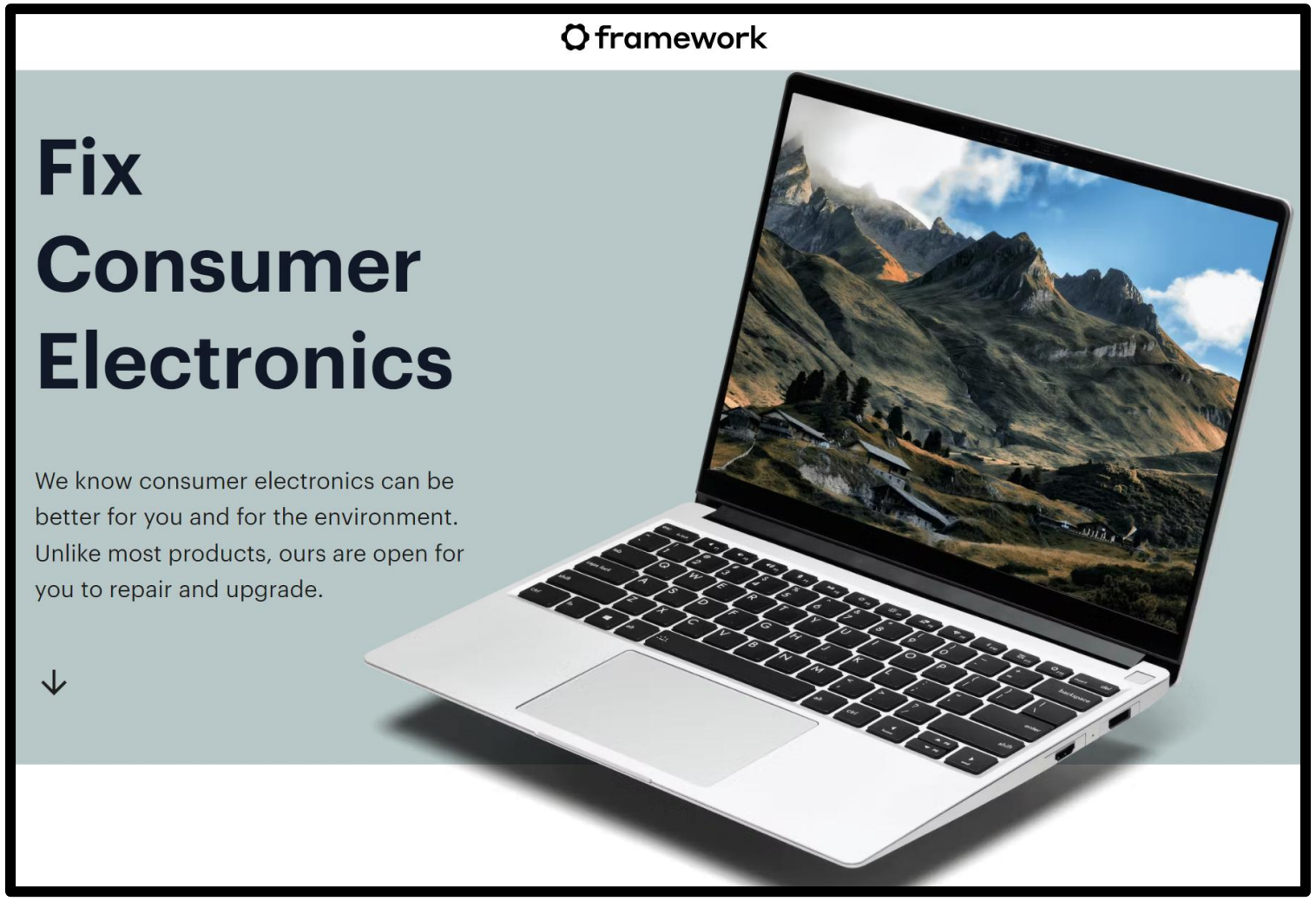
Creates the Right to Repair Act. Provides that every manufacturer of an electronic or appliance product with a specified wholesale price or direct sales price shall make service and repair facilities available to owners of the product. Provides that the manufacturer shall make available to service and repair facilities and service dealers sufficient documentation and functional parts and tools, inclusive of any updates, on fair and reasonable terms, to effect the diagnosis, maintenance, or repair of a product for a specified period after the last date a product model or type was manufactured, regardless of whether the period exceeds the warranty period for the product. Provides that a service and repair facility or service dealer that is not an authorized repair provider of a manufacturer shall provide a written notice to any customer seeking repair of an electronic or appliance product before the repair facility or service dealer repairs the product that informs the customer that it is not an authorized repair provider for the product and shall disclose if it uses any used replacement parts or replacement parts provided by a supplier other than the manufacturer of the product. Provides that no manufacturer or authorized repair provider shall be liable for any damage or injury caused to any electronic or appliance product, person, or property that occurs as a result of repair, diagnosis, maintenance, or modification performed by a service dealer or owner. Provides that the provisions do not apply to a manufacturer that provides an equivalent or better, readily available replacement electronic or appliance product at no charge to the customer. Provides for limitations of the Act. Provides for civil penalties. Effective July 1, 2025.

Actions

Date	Chamber	Action
1/10/2024	Senate	Filed with Secretary by Sen. Laura Fine
1/10/2024	Senate	First Reading
1/10/2024	Senate	Referred to Assignments
1/07/2025	Senate	Session Sine Die

https://www.ilga.gov/legislation/BillStatus.asp?DocNum=2680&GAID=17&DocTypeID=SB&SessionID=112&GA=103

Right to Repair Example: Framework



https://frame.work/about

Right to Repair Example: Framework

Diurnal Patterns of Energy Usage

COMMUNICATIONS OF THE ACM

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Home / Magazine Archive / February 2021 (Vol. 64, No. 2) / Driving the Cloud to True Zero Carbon / Full Text

EDITOR'S LETTER

Driving the Cloud to True Zero Carbon

By Andrew A. Chien

Communications of the ACM, February 2021, Vol. 64 No. 2, Page 5
10.1145/3445037

Comments

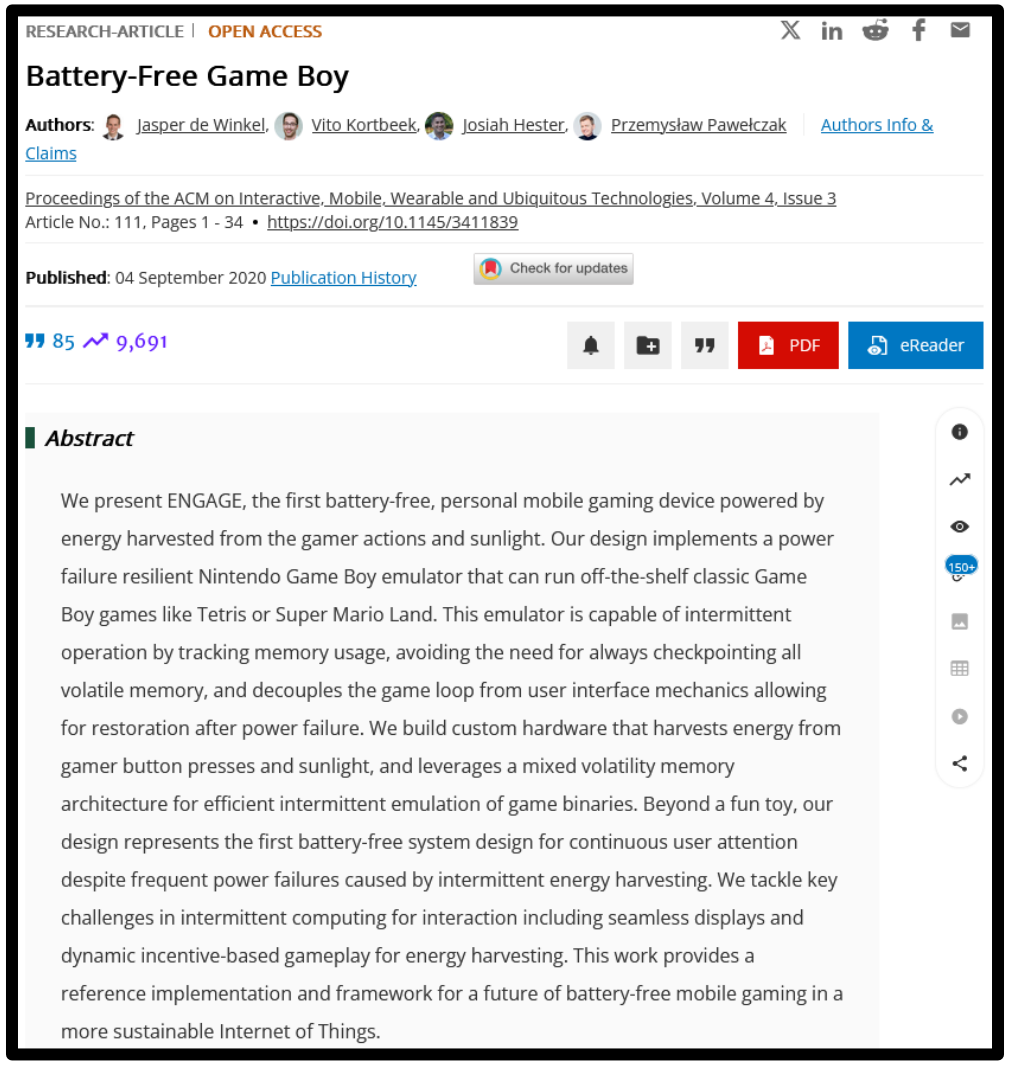
VIEW AS: SHARE:

The right vision is to operate the cloud with zero-carbon emission from power (scope 2). Not just offsetting through renewable energy purchases. Not just 24x7 matching. True zero carbon in electric power consumed, and with no increase as the cloud continues to grow. That's the right vision for our proud computing technology community to lead the fight against climate change, and to see increasing use of computing as a positive force to slow climate change.[a,b]

Why must we act? The power grid is decarbonizing, but progress is slow. Aggressive states (for example, California and New York) have zero-carbon goals 20 or more years in the future, 2045 and 2040. Nationally, the U.S. produced 19% of its electric power from renewable resources (2020), and with "datacenter alley" reporting 12% renewables[c] (Northern Virginia). This trails the world's 26% renewables today, and U.S.

https://cacm.acm.org/magazines/2021/2/250064-driving-the-cloud-to-true-zero-carbon/fulltext

Alternative Approaches to Energy Usage



RESEARCH-ARTICLE | OPEN ACCESS

Battery-Free Game Boy

Authors: Jasper de Winkel, Vito Kortbeek, Josiah Hester, Przemysław Pawełczak | Authors Info & Claims

Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, Volume 4, Issue 3
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Published: 04 September 2020 Publication History

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PDF eReader

Abstract

We present ENGAGE, the first battery-free, personal mobile gaming device powered by energy harvested from the gamer actions and sunlight. Our design implements a power failure resilient Nintendo Game Boy emulator that can run off-the-shelf classic Game Boy games like Tetris or Super Mario Land. This emulator is capable of intermittent operation by tracking memory usage, avoiding the need for always checkpointing all volatile memory, and decouples the game loop from user interface mechanics allowing for restoration after power failure. We build custom hardware that harvests energy from gamer button presses and sunlight, and leverages a mixed volatility memory architecture for efficient intermittent emulation of game binaries. Beyond a fun toy, our design represents the first battery-free system design for continuous user attention despite frequent power failures caused by intermittent energy harvesting. We tackle key challenges in intermittent computing for interaction including seamless displays and dynamic incentive-based gameplay for energy harvesting. This work provides a reference implementation and framework for a future of battery-free mobile gaming in a more sustainable Internet of Things.

https://dl.acm.org/doi/10.1145/3411839