Online Tracking, What Can Be Done About it, and Who’s Doing it

Pete Snyder
Senior Privacy Researcher, Director of Privacy
pes@brave.com

Hi, I’m Pete 👋

- **Grew up in Chicago**
  …actual Chicago

- **Law school -> freelance web stuff**
  Started: Anchorage, AK
  Ended: Judge Judy Show invitation

- University of Illinois at Chicago

Me at Brave

- **Research at Brave**
  …privacy, blocking, reliability

- **Co-Chair of PING**
  Privacy committee on W3C

- **Research <-> Engineering**
  Web compat, filter lists, etc.

- **Academic <-> Industry Collaborations**

Brave in a Slide

- **Privacy focused**
- **Alternative web funding model**
  Fix incentive problems
- **Research + Engineering**
- **Not just a browser**
  - search.brave.com
  - talk.brave.com
  - VPN
  - more coming…

Overview

- **Why Privacy Matters**
  A sloppy manifesto

- **Defining Tracking**
  Abstracting the problem

- **Tracking in Practice**
  Methods and defenses

- **Privacy Beyond Tracking**
  Other issues and concerns

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Why Does Tracking Exist?

2 CENTS PAY NO MORE!

Chicago Daily Tribune

THE WORLD'S GREATEST NEWSPAPER

FINAL

HUGE SWINDLE PLOT

Judge Orders Girl in 'Badger'

BALK INSURANCE COMPANY THEFT

Chicago Daily Tribune

THE WORLD'S GREATEST NEWSPAPER

FINAL

GOONS SMASH MEAT PLANT

Massed CIO Pickets Rout Police at So. St. Paul

YOUNGDAHL SIDESTEPS AID PLEAS

Defy Writ, Bar Workers

U.S. Heiress Killed in Plane Crash

PLAYING WITH THE SCISSORS AGAIN

TRUMAN ASKS 2½ BILLIONS MORE; EUROPEAN AID PLAN IS ASSAILED

Spending Called 'Utter Folly,' 'Waste'

HOUSE PASSES BILL TO COMPEL U.S. AIDS TO TALK

Air Force, Army, Navy to Get Shares

TAYLOR . . . big audition

Taylor's one-day mission

From JOHN ETHERIDGE

JAMES TAYLOR can prove he is up to being England's permanent one-day captain after getting chosen to lead the new generation.

The pint-sized batsman, 25, takes charge against Ireland on May 8 — the first 50-over match since the World Cup disaster.

Regular skipper Eoin Morgan misses the game to play in the IPL.

He had a nightmare World Cup and, if Taylor impresses, the selectors might switch. The most likely long-term prospect, though, is Joe Root.

Notts star Taylor said: "We must put the World Cup behind us — not ignore it but learn from it. This is a fresh start."

England's 11-man squad has five uncapped players: Kent keeper/batsman Sam Billings, Surrey all-rounder Zafar Ansari, Somerset seamer Lewis Gregory, Northants all-rounder David Willey and Hampshire batsman James Vince.

More players will be added after England pick their Third Test XI to face West Indies on Friday.

ENGLAND (to play Ireland): Hales, Roy, Taylor (capt), Vince, Ansari, Bairstow (wk), Billings (wk), Bresnan, Gregory, Willey, Finn.

Kid Dan's ton of fun

TEENAGER Dan Lawrence upstaged Kevin Pietersen by becoming one of county cricket's youngest century-makers.

The 17-year-old hit 161 in only his second first-class fixture as Essex racked up 610-8 against Surrey at The Oval.

Kent's Godfrey Bryan in 1920 and Dipak Patel for Worcestershire in 1976 are believed to have hit tons when younger than Lawrence, whose previous highest score was ten.

KP was eight not out as Surrey trailed by 175 runs in their second innings.

Lee: Oui will return

By JONNY FORDHAM

LEE DICKSON believes English rugby can wrestle back control from teams across the Chanel.

A French invasion takes place at Twickenham on Saturday as Clermont face Toulon in the European Champions Cup final.

Dickson's Premiership leaders Northampton were KO'd by Clermont. But the England scrum-half, 30, said: "We will be back.

"In the past we have beaten the big French teams — and Wasps nearly turned Toulon over."

Captaincy is wrong Root

IT WOULD BE A ROAD TO RUIN

SMOKIN' JOE . . . Root is red-hot

Graeme Swann

OUR COLUMNISTS ARE THE TALK OF SPORT

JOE ROOT has become a world-class batsman, averaging more than 100 in Test cricket in the past year.

But to make him England captain any time in the next five years would be a disaster. I think it would ruin him as a batsman.

Like a few players before him, Joe has been handed the mantle of FEC – Future England Captain.

Everyone expects it to happen and I've little doubt he will lead England at some point. But I hope and pray it doesn't happen for at least five years, by which time he will be only 29.

In fact, I'm not sure Joe will ever be a good captain because it just doesn't suit his character.

Joe has a natural cheeky chappy personality – he's a joker, a jester, a wind-up merchant and a general breath of fresh air around the dressing room.

To be captain, he would need to change and become more mature and perhaps even feign gravitas. That simply is not Joe.

Of course, there is no vacancy at the moment anyway because Alastair Cook is doing a fine job now he is back concentrating on Test cricket. Cooky won't still be captain in five years' time but please don't give the job to Joe.

Just let Joe Root bat at No5 and score hundred after hundred. He can be England's Steve Waugh. So don't think about moving him up the order, either.

I love the way Joe handles himself on the field. He has this angelic face and looks as though butter wouldn't melt in his mouth. He's at his best when chatting away, taking the mickey and behaving like your annoying little brother.

He doesn't really sledge. It would be like being sledged by a baby because of the way he looks. Nobody could take him seriously.

Joe is great at smiling to take the heat out of situations. There's nothing more annoying for a steaming, sweating Neanderthal fast bowler than having some kid smiling and winking back at him.

But don't be fooled – Joe has a streak of steel, too. You don't score eight international centuries in the past 14 months without being a tough cookie.

The key to Rooty's success is he discovered the secret of Test cricket very early.

The ball is the same size, the pitch the same length, the bowlers the same as you've played against in county cricket. Joe realised the only big difference is how you think about the game with the pressure, the spotlight and TV coverage.

It is a mental thing, what goes on inside your head. And Joe's head is full of calmness, confidence and positive thoughts right now.

It was obvious right from the start that Joe had great talent and temperament.

He went on the tour to India in late 2012 as a back-up batsman and forced his way into the final Test in Nagpur.

He scored 73 and looked certain to make a debut century.

I was batting with him when he was out and accept some of the blame.

I kept trying to hit the spinners over the top, then Joe tried something similar and was caught and bowled.

Joe has certainly cashed in since and his last five Test centuries have been 180, 200 not out, 154 not out, 149 not out and 182 not out. Daddy hundreds, as Graham Gooch calls them. The best thing about Joe's batting is the energy he brings to the crease.

He walks in like an excited puppy, playing 100 shots before he's ten yards on to the outfield.

He has positive intent and urgency from the start and it normally perks up the rest of the team.

Every other batsman in the Second Test in Grenada struggled to score at a strike-rate of 50 runs per 100 balls but Joe rattled off 182 not out from 229 balls.

I tend to watch the way batsmen play spin bowling and Joe always looks to score runs against spin.

A lot of batsmen wait for a rank bad ball before attacking.

So Joe forces spinners to bowl more loose stuff, especially a wrist-spinner like Davendra Bishoo. He played Bishoo magnificently.

I'm calling Joe the new Geoffrey Boycott – the Yorkshireman who scores all the runs and runs everyone out. I even think some of the lads have started calling him Geoffrey.

He was involved in three run outs in Grenada but only one was his fault – the one when he barbecued Chris Jordan.

The Jimmy Anderson run out was hilarious because nobody has the right to pluck a ball from the air that's about 15 feet from the ground.

But Jason Holder did and dozy old Jimmy was way short of his ground.

Apparently, Holder's brother plays basketball in the States!

After the game, Rooty handed over a stump to Jimmy, pretending it was a white stick.

That's the sort of cheeky fun we like from Joe Root.

MAY THE SAUCE BE WITH YOU

ALL ROOTS lead to the cricket!

England batsman Joe Root met up with super sauce maker Levi Roots ahead of the Third Test against West Indies in Barbados on Friday. Let's hope it's a spicy affair.

BRIGHTON'S summer transfer policy may have to take a hit after chairman Tony Bloom's bet of misfortune.

The Seagulls supremo placed £13,000 on himself to finish the Brighton Marathon in no more than 3hr 45 min — only to cross the line four minutes and 38 seconds later.

VIEW TO A DILL

ANDREW DILLON

Cough not that Good

EVERTON is known as the school of science but they have been turning their hands to amateur dramatics too.

Reporters were gathered to interview Gareth Barry when the subject of team-mate Ross Barkley inevitably surfaced seeing as he is the **ONLY** interesting topic of conversation at Goodison Park.

As soon as Barkley's name was mentioned, the club's subtle press officer came out with an outrageously staged cough – as in 'be careful here mate, tricky subject coming up'.

But the carefully-managed plan to thwart the nasty hacks backfired when the entire group fell silent and he was presented with a packet of throat lozenges at the next press conference.

Ooh, suits you Shaun

SHAUN MURPHY'S garish suits have been dazzling fans, TV crews and players at snooker's world championship.

But spokesman for tournament sponsors Betfred, Mark 'Stuart' Pearson, told VTAD: "Every time we sponsor a horserace we give a prize for the best-dressed nag, taking into account coat, condition and colours. It's similar with Shaun."

Murphy will thus be given a cheque for the Royal Manchester Children's Hospital.

A 'Parker' can cut it

SOMETHING for the weekend, sir?

Traditional barber's shops would always offer extras to gentleman patrons to keep them safe while enjoying the company of others on a Saturday night.

The latest marketing trend is the 'pop-up' shop and this one in South West London offered customers the chance to have their hair cut in the style of Fulham captain Scott Parker.

Well, let's be honest. Those Fulham supporters have more chance of getting a s**g than seeing their team win on Saturday.

WORLD SNOOKER

BAD TABLE MANNERS . . . Ronnie puts his chalk down

CHALK OF SHAME

O'Sullivan in dust-up

By HARRY TALBOT

RONNIE O'SULLIVAN is caught in a World Snooker probe after breaking the rules in his quarter-final clash with Stuart Bingham.

The five-time world champ placed his chalk on the table to line up a shot but was **NOT** reprimanded by referee Terry Camilleri.

The official should have called a foul and awarded Bingham seven points, but the Rocket was allowed to continue his break and won the fifth frame to lead 3-2.

Rule 3 (d) ii states a seven-point penalty will be awarded if a player "uses any object to measure gaps or distance".

Former world champion Ken Doherty said: "You are not allowed to put chalk on the table because you are using it as a tool to measure the ball.

"That is exactly what Ronnie has done. Stuart Bingham was looking at him and should really be aware.

"If he had more knowledge of the rules, he would have jumped out of his chair.

"The referee is unaware, Ronnie is too but for me, that is a foul. You are not allowed to do that."

Former referee Michaela Tabb tweeted: "Chalkgate . . . Foul seven. I don't have Terry's opinion though, he may have seen it differently. Also the Crucible is the hardest venue to ref in."

It is the latest controversy surrounding 39-year-old O'Sullivan in this year's tournament.

He escaped a fine after briefly playing in his socks during his first-round win over Craig Steadman and came close to snapping his cue in fit of rage against Matthew Stevens in round two.

More recently O'Sullivan, 39, has taken a shine to boxing and even begun sparring.

And snooker's box-office star is well aware of the riches earned by those in the ring. He said: "Boxing is pay-per-view and if snooker was like that, I'd be able to command and dictate [illegible] more."

JUDD HEA-DING THROUGH

TRUMP . . . on a roll

JUDD TRUMP put China's No1 Ding Junhui to the sword as he moved to within a frame of the Crucible semi-finals.

The Juddernaut leads world No3 Ding 12-4 to take another massive stride towards his first world title.

After his best season that has seen titles in Australia and at the World Grand Prix in Llandudno, 25-year-old Trump rattled in breaks of 54, 82, 94, 108, 76, 10[illegible], 55, 127 and 111 to leave Ding in a daze.

NEIL ROBERTSON faces a fight to make the last four as he lost four frames on the spin to trail Barry Hawkins 5-[illegible].

In the final quarter-final, SHAUN MURPHY leads Anthony McGill 9-7 after winning the final three frames of last night's session.

Pep gets Klopped

From ANTONY KASTRINAKIS

JURGEN KLOPP wrecked Pep Guardiola's Treble bid as ten-man Borussia Dortmund beat Bayern Munich on penalties in the German Cup semi-finals.

Dortmund won the shootout 2-0 at the Allianz Arena, with the game ending 1-1 after extra-time.

Robert Lewandowski's opener against his old club was cancelled out by Pierre-Emerick Aubameyang's 75th-minute leveller for Dortmund.

Outgoing Dortmund boss Klopp, wanted by a host of Premier League clubs, saw Kevin Kampl sent off for a second booking late on.

£30m CUP DEAL

From Back Page

144-year history that full naming rights have been granted.

US drinks giant Budweiser – who paid £9m a year merely to be "in association with" the trophy FA Cup – ended their three-year partnership last year.

But the Emirates deal is a complete rebranding that will upset the purists.

Lawrie McMenemy, who guided Second Division Southampton to a famous Cup triumph over Manchester United in 1976, rapped: "It's the one and only, it's **THE** FA Cup and it would be a pity to see it lose that tradition, not just in our game but in the game worldwide. It was the biggest and the best. But football today is solely about money, money, money."

McMenemy *(above)* added: "I would have thought there was enough money circulating in football in TV rights to avoid this. Football is about history and tradition. Our Cup was different. No other country had anything to compare with it."

Football fans also took to Twitter last night, calling the deal "awful", "horrible" and "bulldozing over football".

With this year's competition not having a sponsor, FA commercial director Stuart Turner and his team have had to offer full naming rights to secure a new £30m-a-year deal.

Dubai-based Emirates – sponsors of current Cup holders Arsenal's stadium and kit – made their move after ending a £30m-a-year relationship with Villa.

An FA spokesman admitted: "We continue to have discussions with a number of parties about FA Cup partner opportunities."

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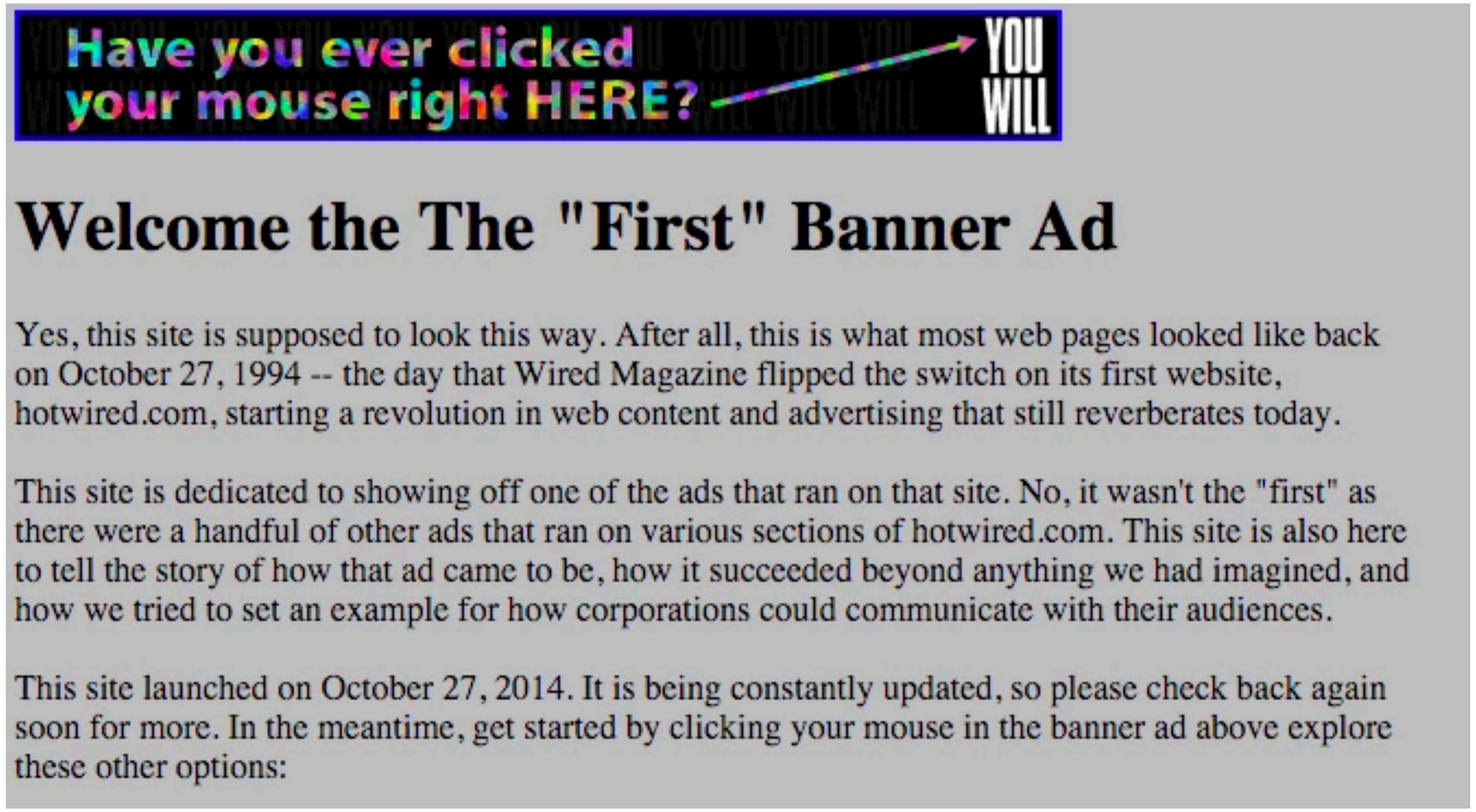

Welcome the The "First" Banner Ad

Yes, this site is supposed to look this way. After all, this is what most web pages looked like back on October 27, 1994 -- the day that Wired Magazine flipped the switch on its first website, hotwired.com, starting a revolution in web content and advertising that still reverberates today.

This site is dedicated to showing off one of the ads that ran on that site. No, it wasn't the "first" as there were a handful of other ads that ran on various sections of hotwired.com. This site is also here to tell the story of how that ad came to be, how it succeeded beyond anything we had imagined, and how we tried to set an example for how corporations could communicate with their audiences.

This site launched on October 27, 2014. It is being constantly updated, so please check back again soon for more. In the meantime, get started by clicking your mouse in the banner ad above explore these other options:

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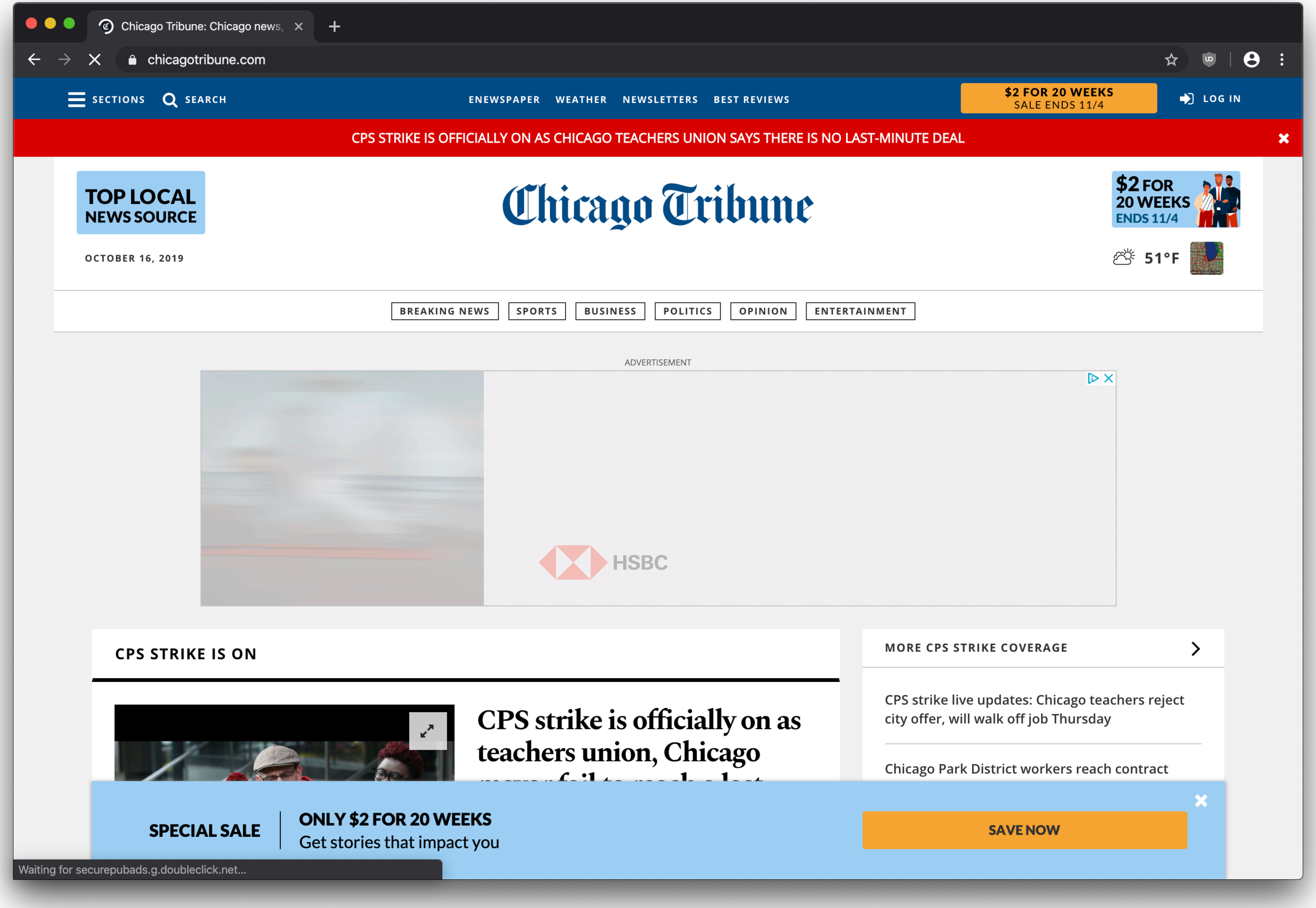

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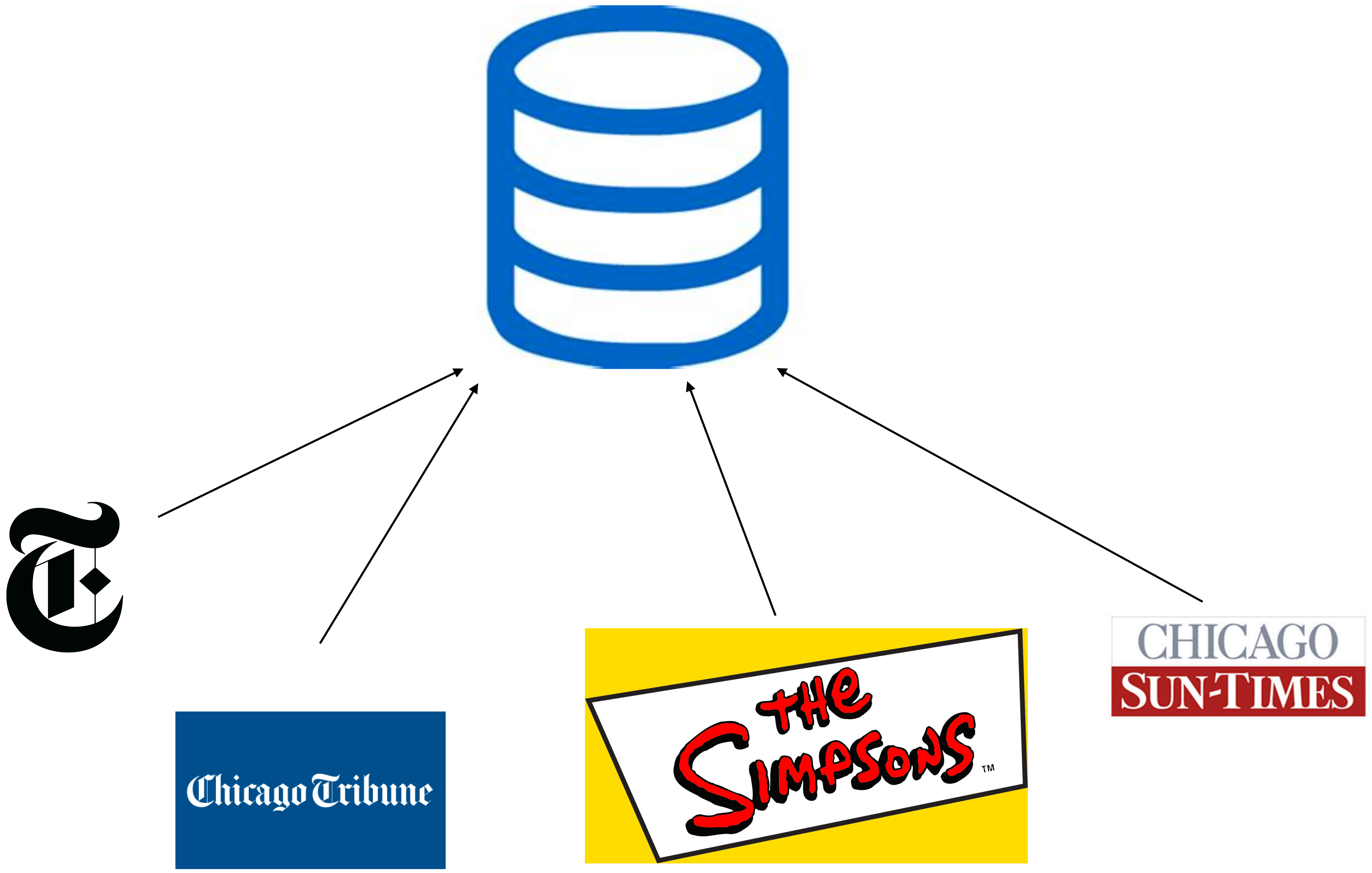
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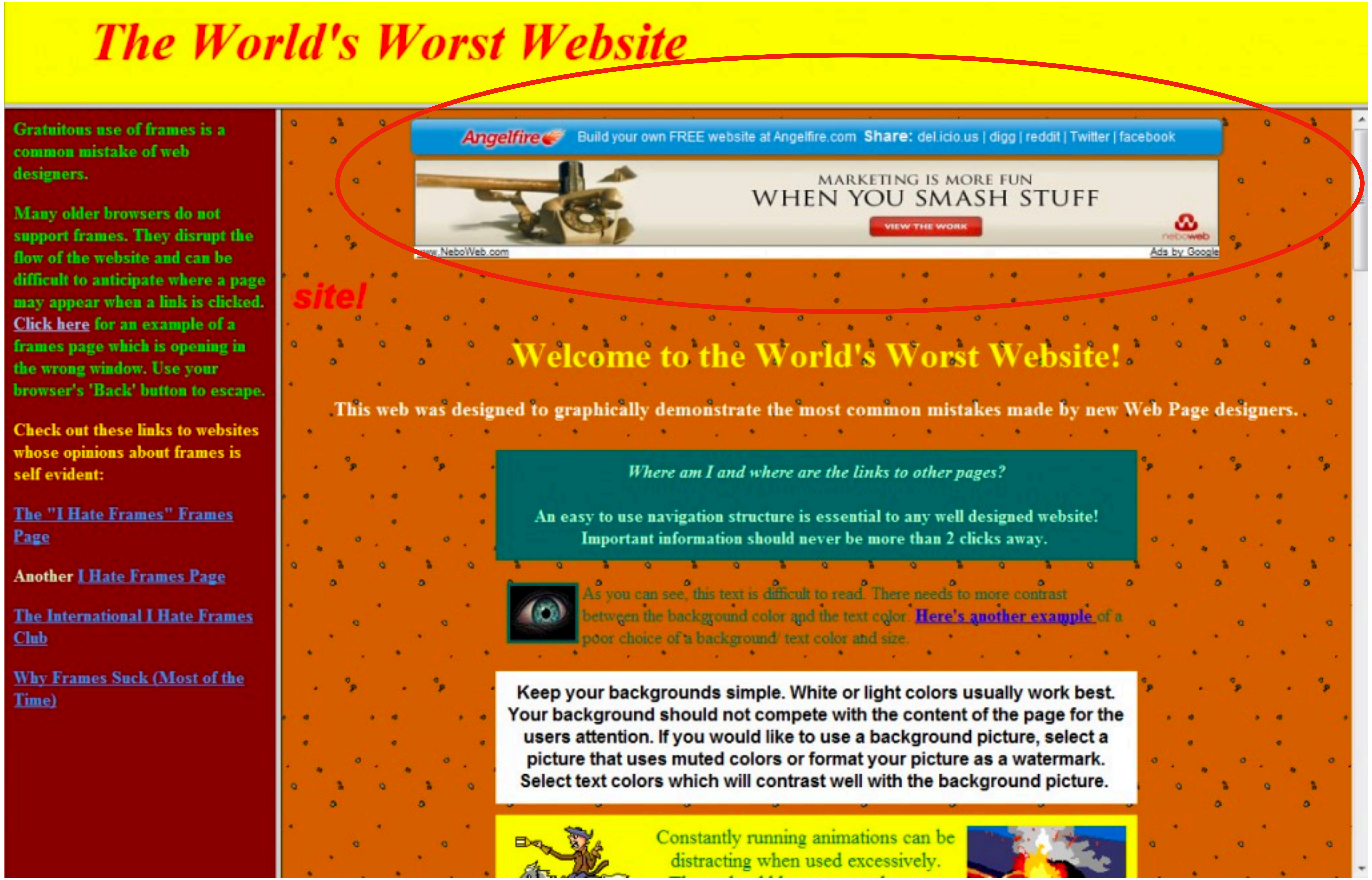


The World's Worst Website

Gratuitous use of frames is a common mistake of web designers.

Many older browsers do not support frames. They disrupt the flow of the website and can be difficult to anticipate where a page may appear when a link is clicked. Click here for an example of a frames page which is opening in the wrong window. Use your browser's 'Back' button to escape.

Check out these links to websites whose opinions about frames is self evident:

The "I Hate Frames" Frames Page

Another I Hate Frames Page

The International I Hate Frames Club

Why Frames Suck (Most of the Time)

Welcome to the World's Worst Website!

This web was designed to graphically demonstrate the most common mistakes made by new Web Page designers.

Where am I and where are the links to other pages?

An easy to use navigation structure is essential to any well designed website! Important information should never be more than 2 clicks away.

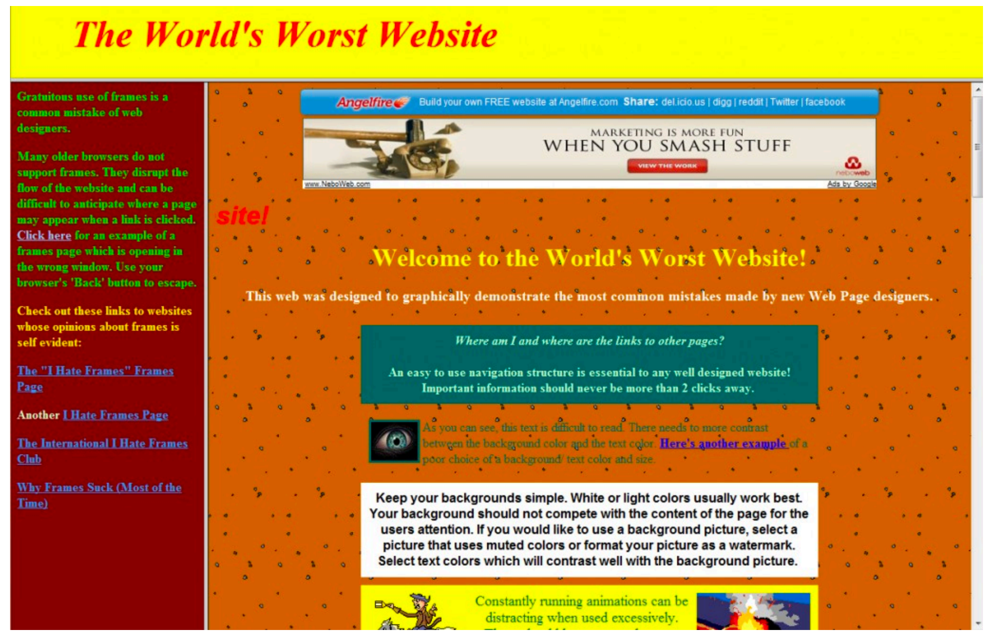
As you can see, this text is difficult to read. There needs to more contrast between the background color and the text color. Here's another example of a poor choice of a background/ text color and size.

Keep your backgrounds simple. White or light colors usually work best. Your background should not compete with the content of the page for the users attention. If you would like to use a background picture, select a picture that uses muted colors or format your picture as a watermark. Select text colors which will contrast well with the background picture.

Constantly running animations can be distracting when used excessively.

Chicago Tribune

CHICAGO SUN-TIMES



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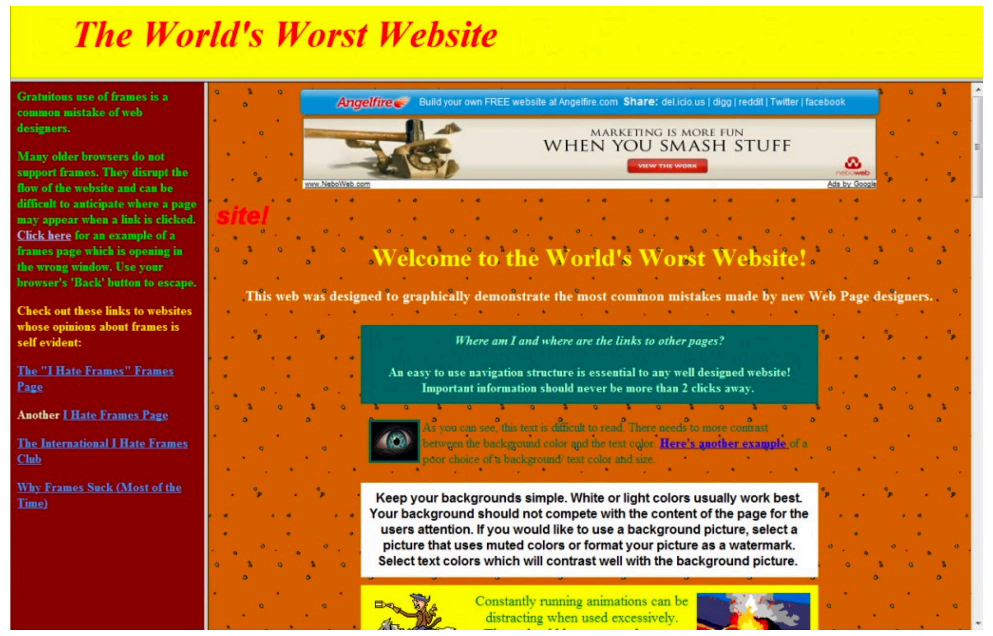

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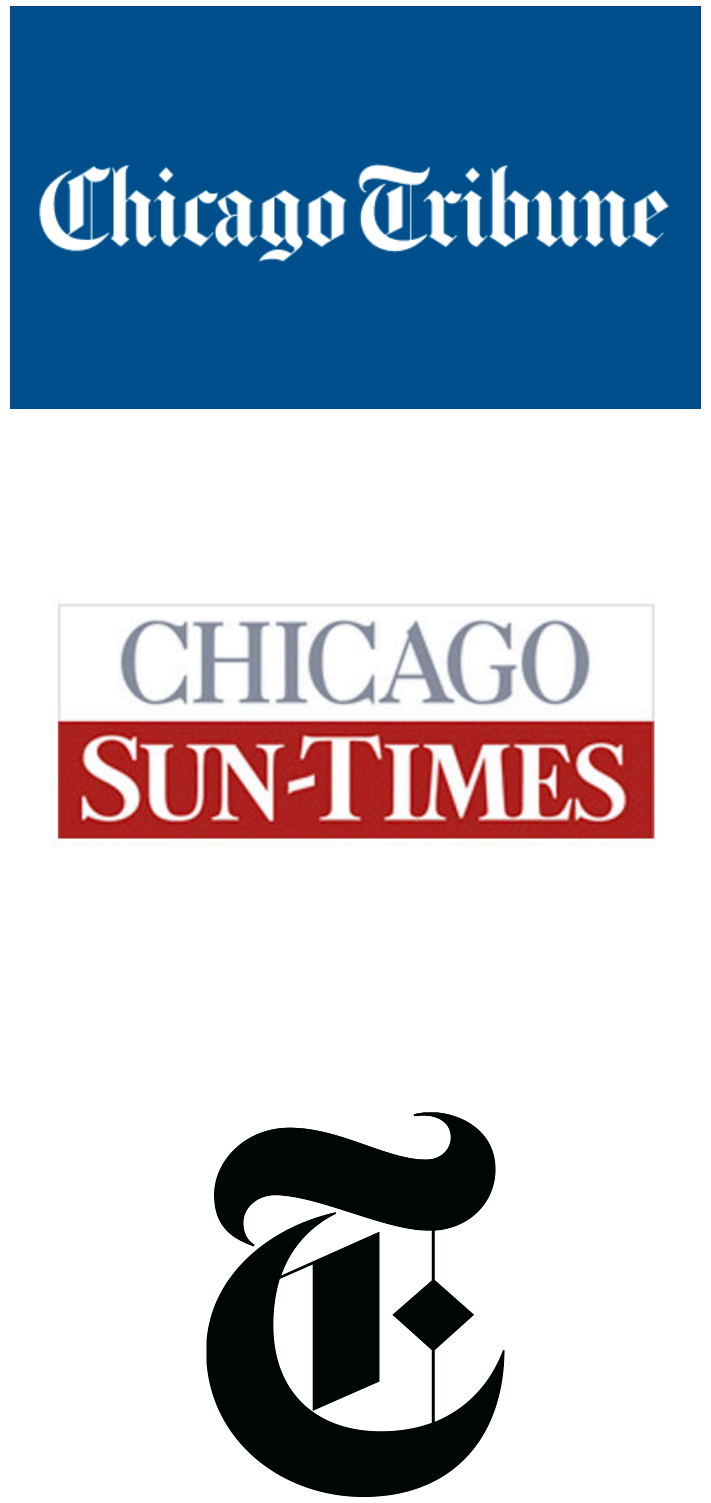

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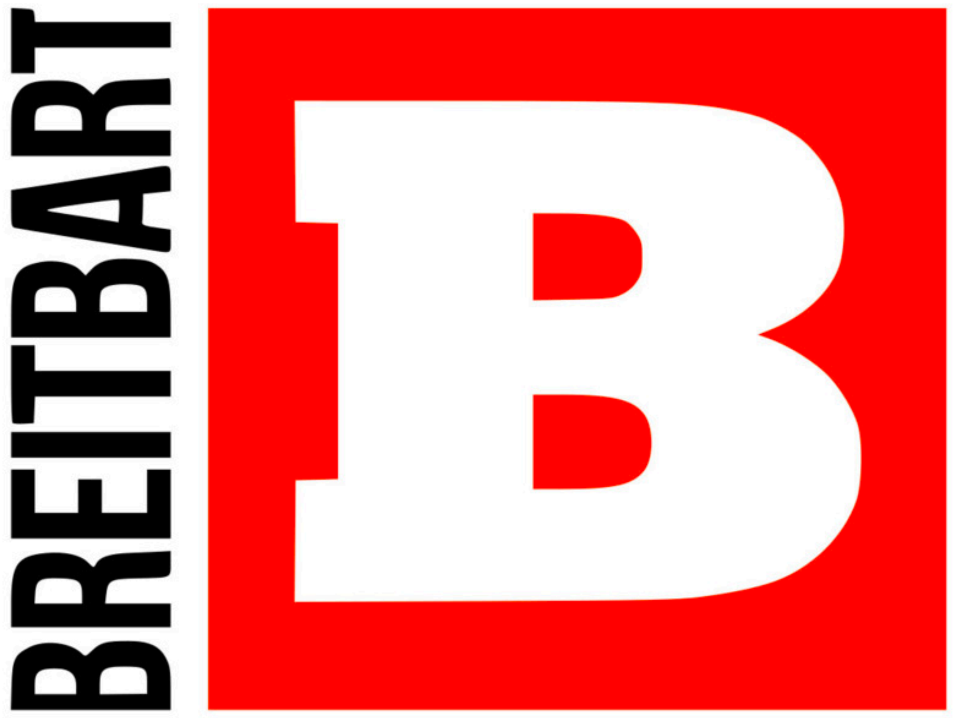

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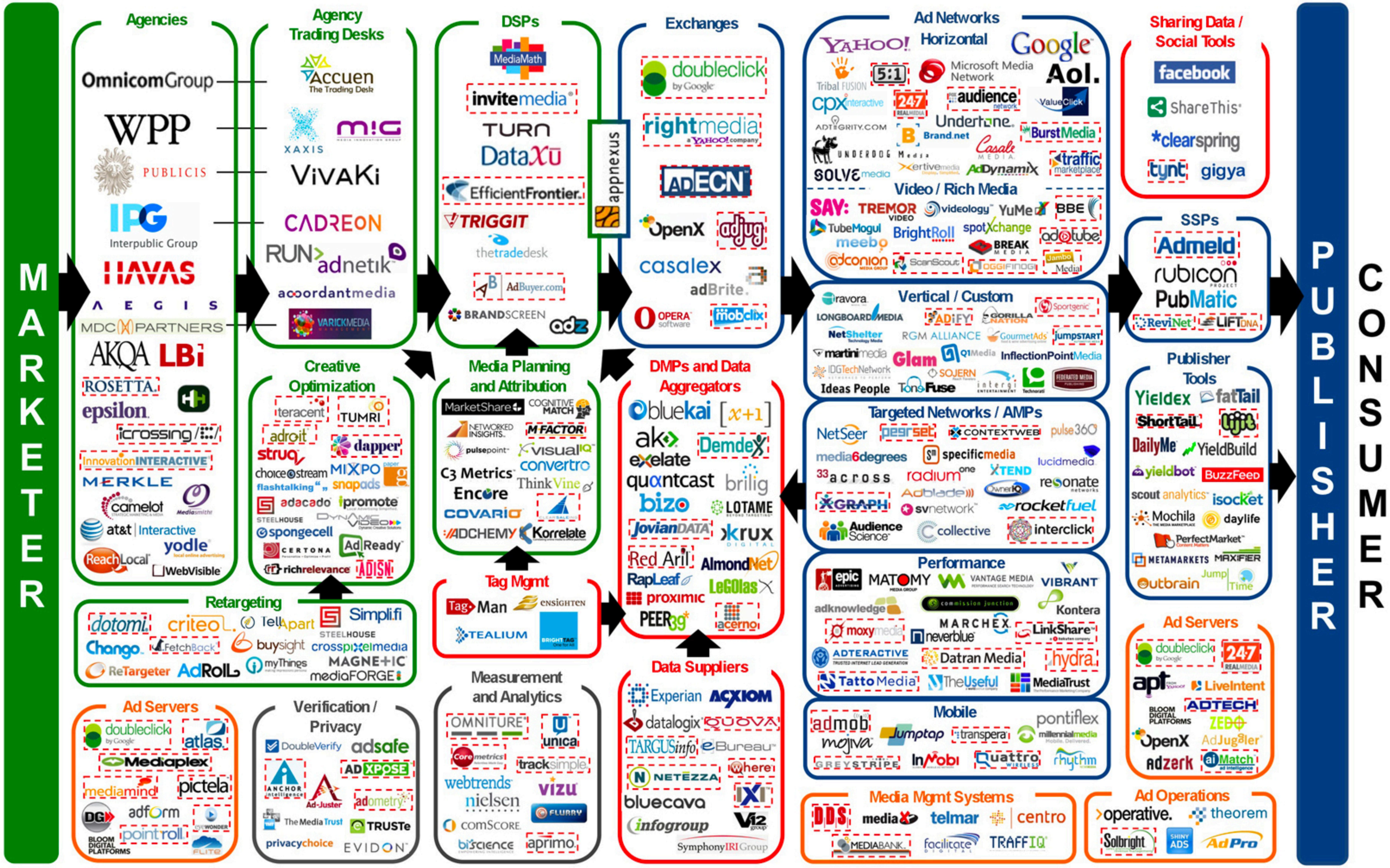

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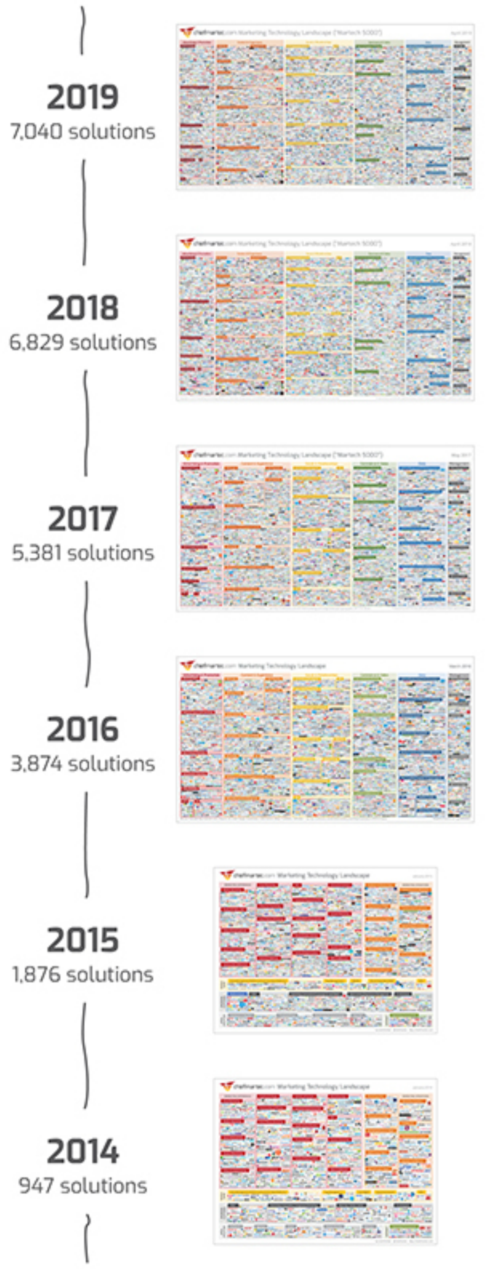

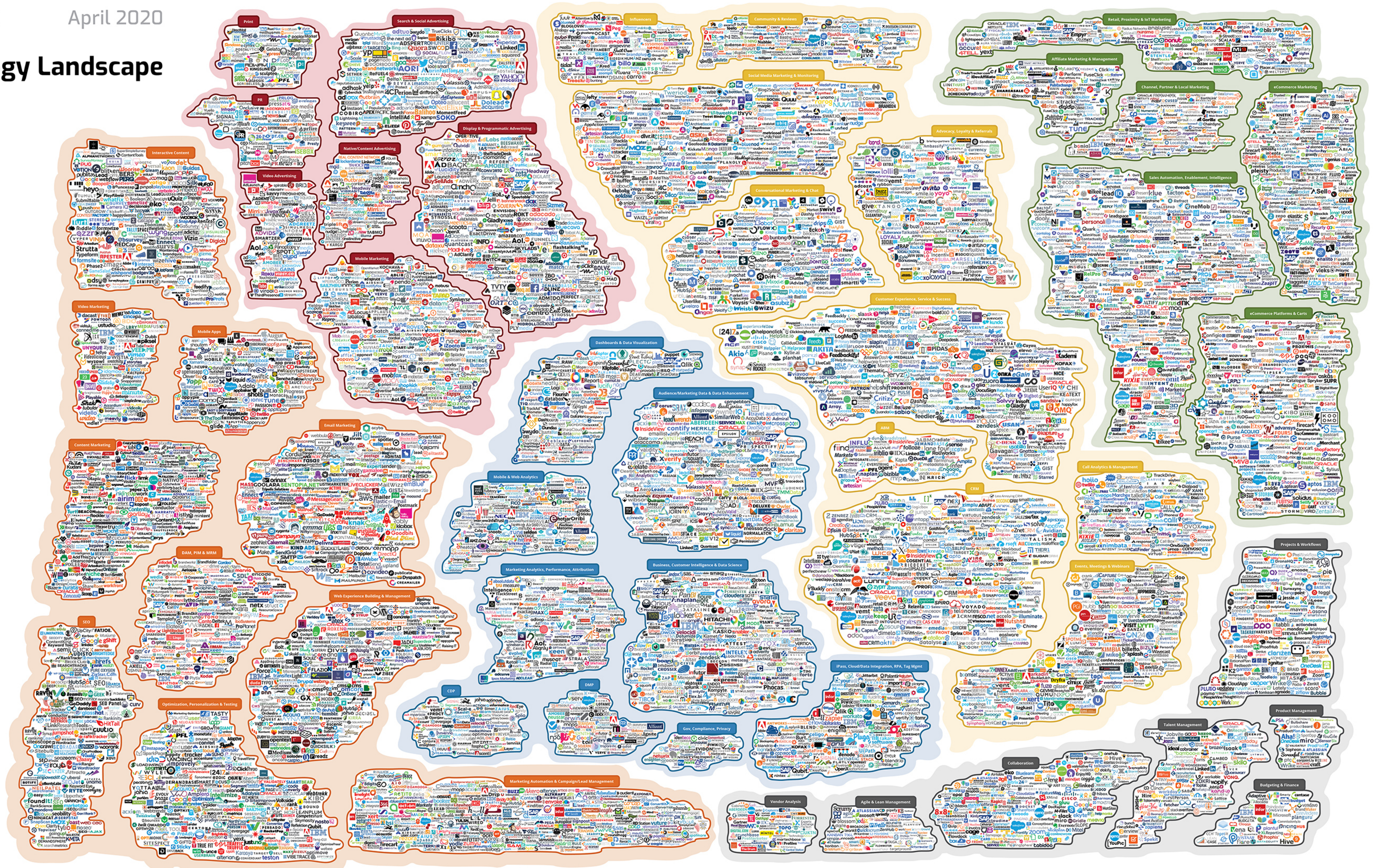

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Collaboration
Budgeting & Finance
Vendor Analysis
Agile & Lean Management

Produced by Scott Brinker (@chiefmartec) and Blue Green Brands (@bluegreenbrands).

Summarizing: Why Does Tracking Matter

- Incompatible with dignity

- Power and control

- Transfers wealth from value-creators to attention-attractors

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Definitions

- **Website:** eTLD+1 (determined by public suffix list)
  e.g., brave.com != mozilla.org
  e.g., talk.brave.com == search.brave.com
  e.g., ted.github.io != betty.github.io

- **Origin:** The full DNS host name serving a site

- **First-party:** Site of the top level document

- **Third-party:** any other site

Definitions (more)

- **DOM Storage:** Explicit storage APIs
  e.g., cookies, localStorage, IndexDB

- **Network State:** All other storage
  e.g., caches (v8, DNS, HTTP)
  e.g., Header instructions (HSTS, ALT-SRV, etc)

- **Online Tracking**
  Its trickier…

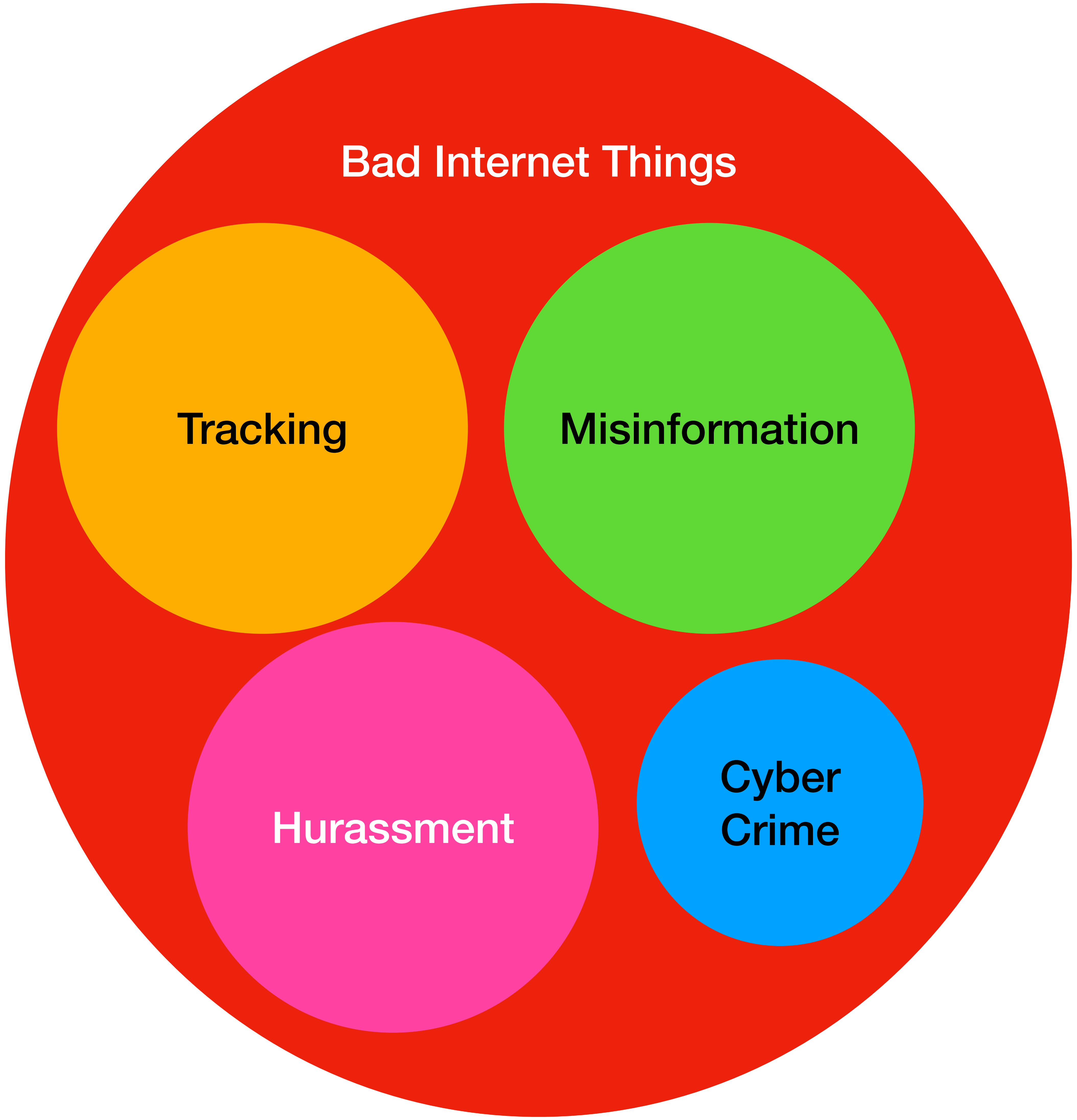
A Rough Definition of Tracking

- **Linking activities…**
  e.g., being “followed”

- **across boundaries…**
  e.g., temporal, geographic, conceptual

- **In a way not expected or desired.**
  e.g., ignorance or non-consent

Tracking in Context



Bad Internet Things

Tracking

Misinformation

Hurassment

Cyber Crime

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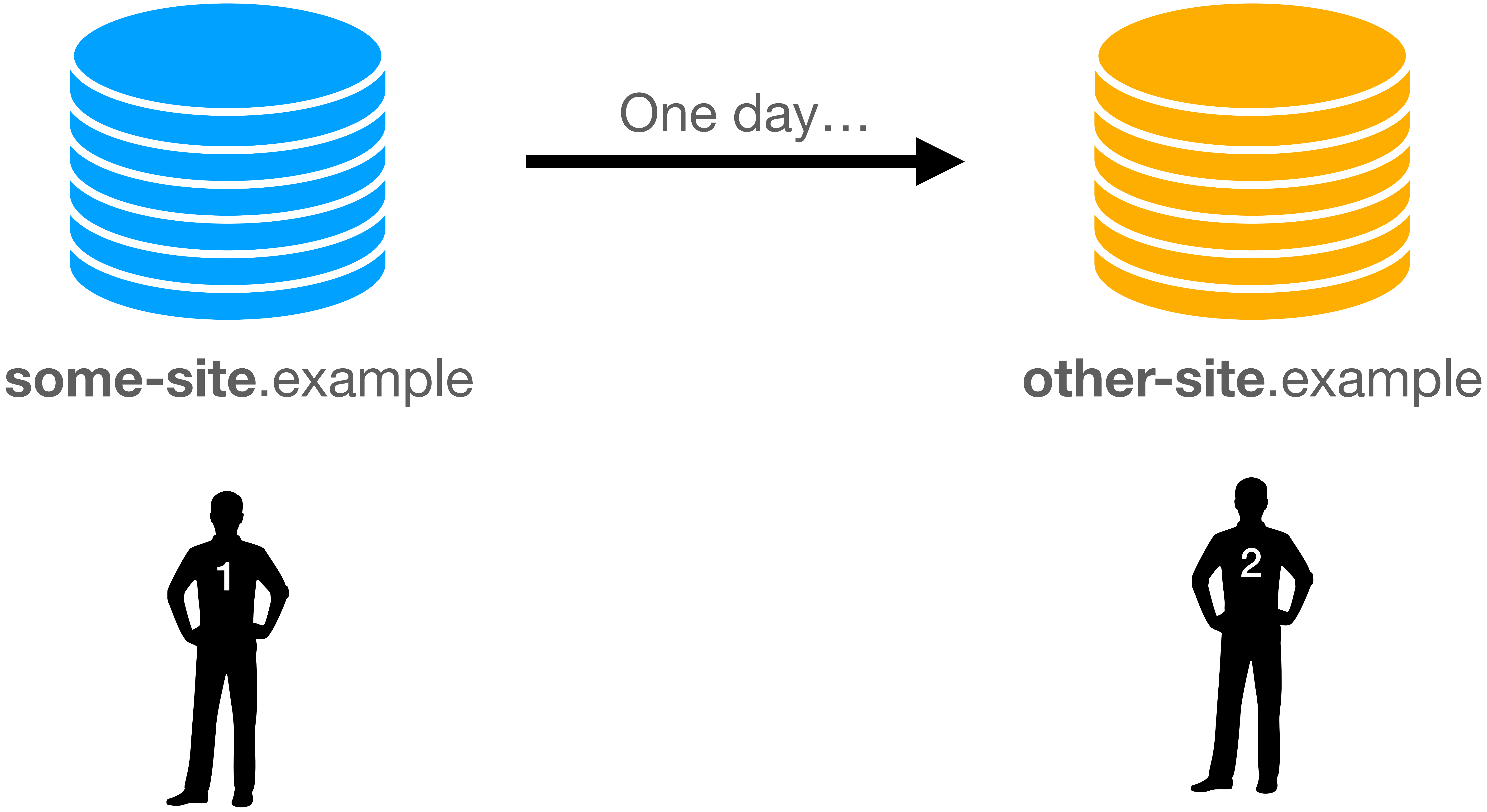
  e.g., ignorance or non-consent

Question One

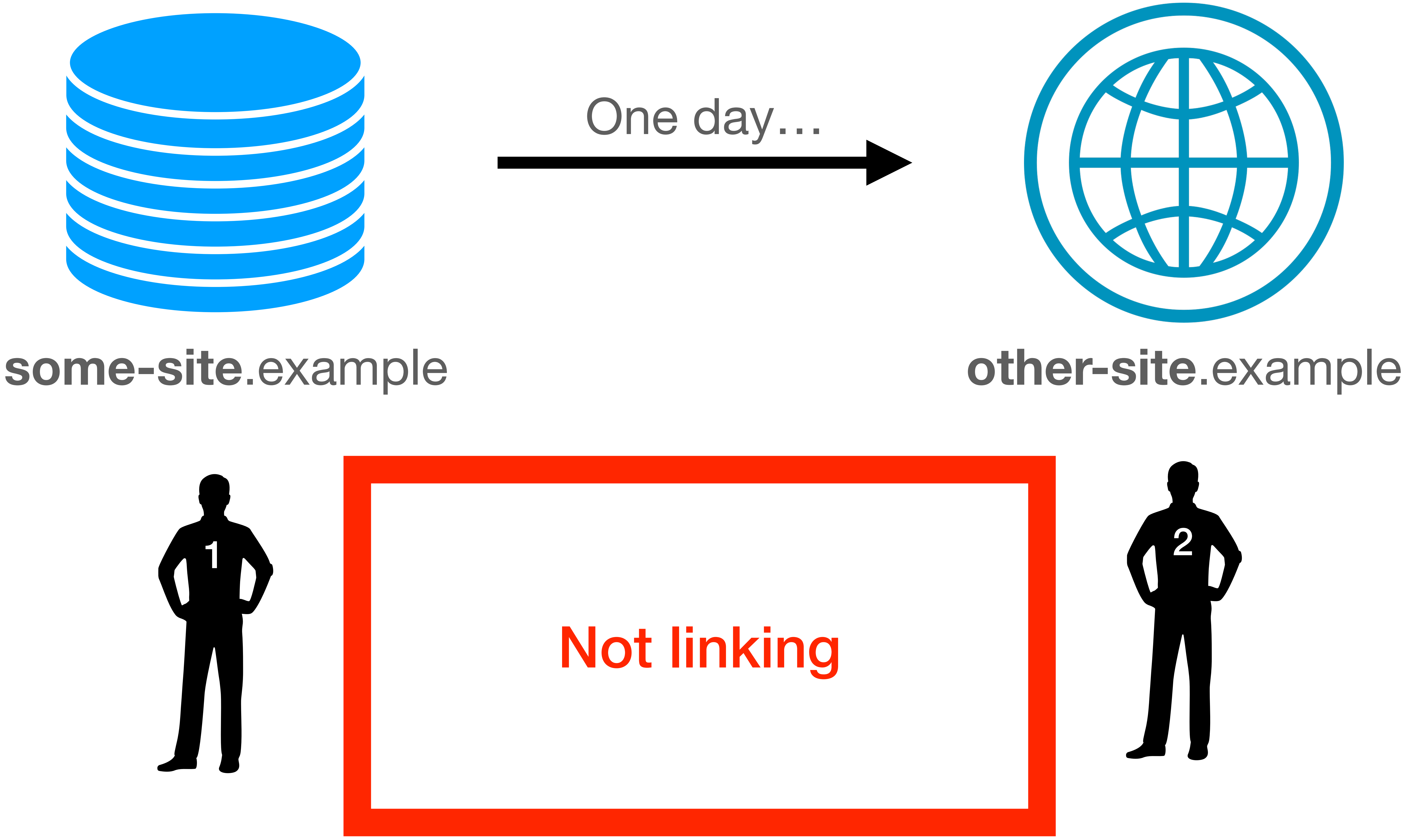


some-site.example

One day…

other-site.example

Question One



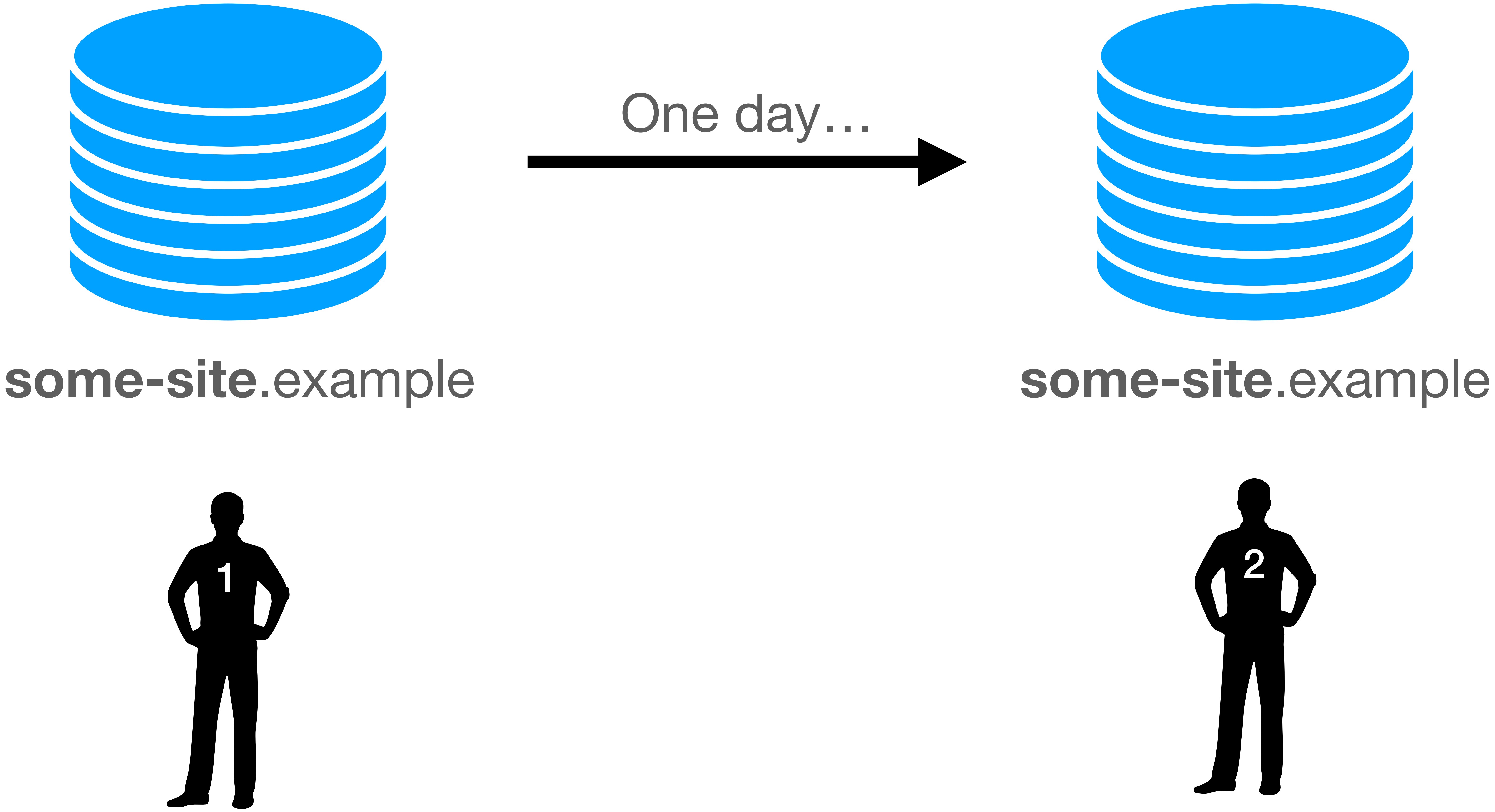
One day…

some-site.example

other-site.example

Not linking

Question Two

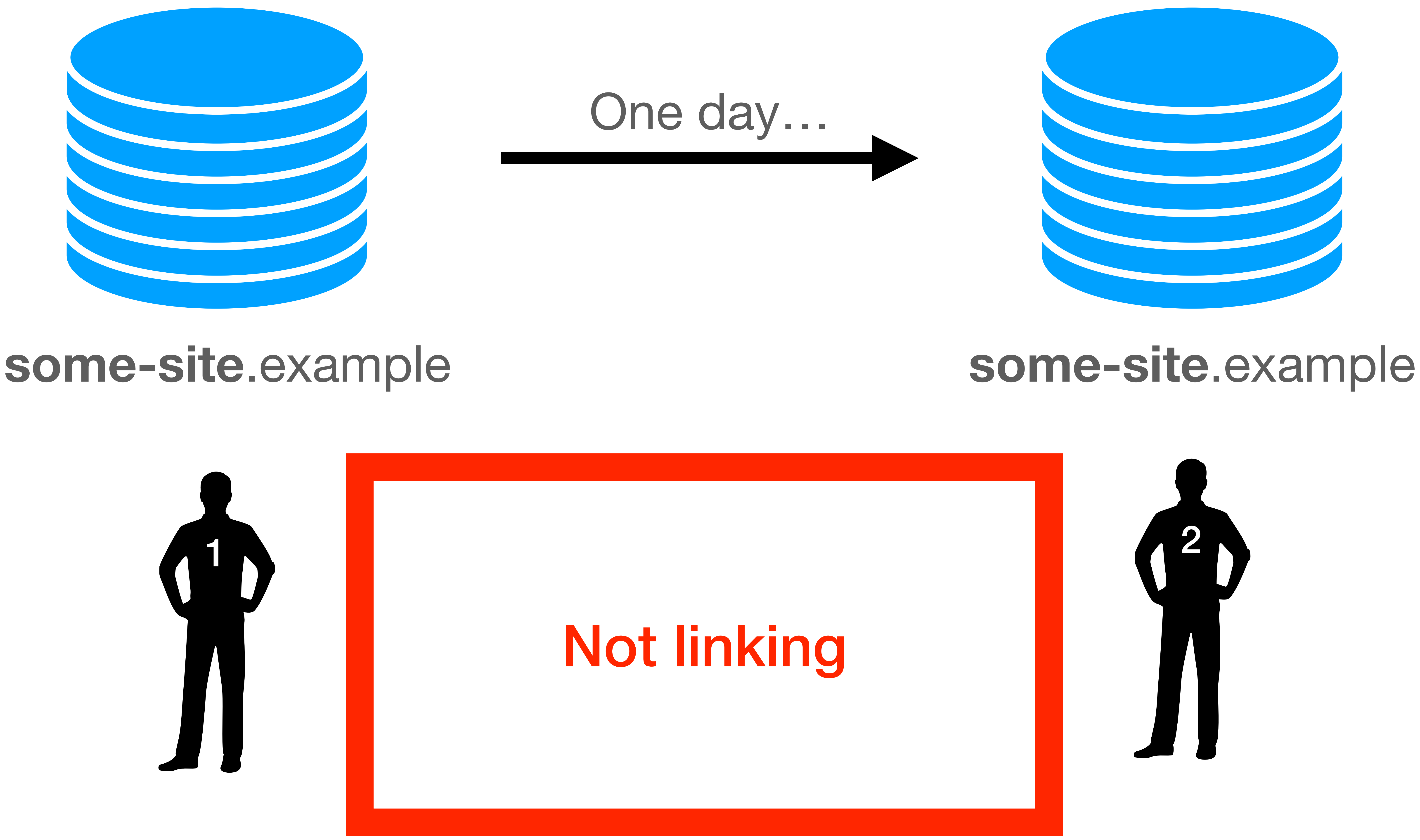


One day…

some-site.example

some-site.example

Question Two



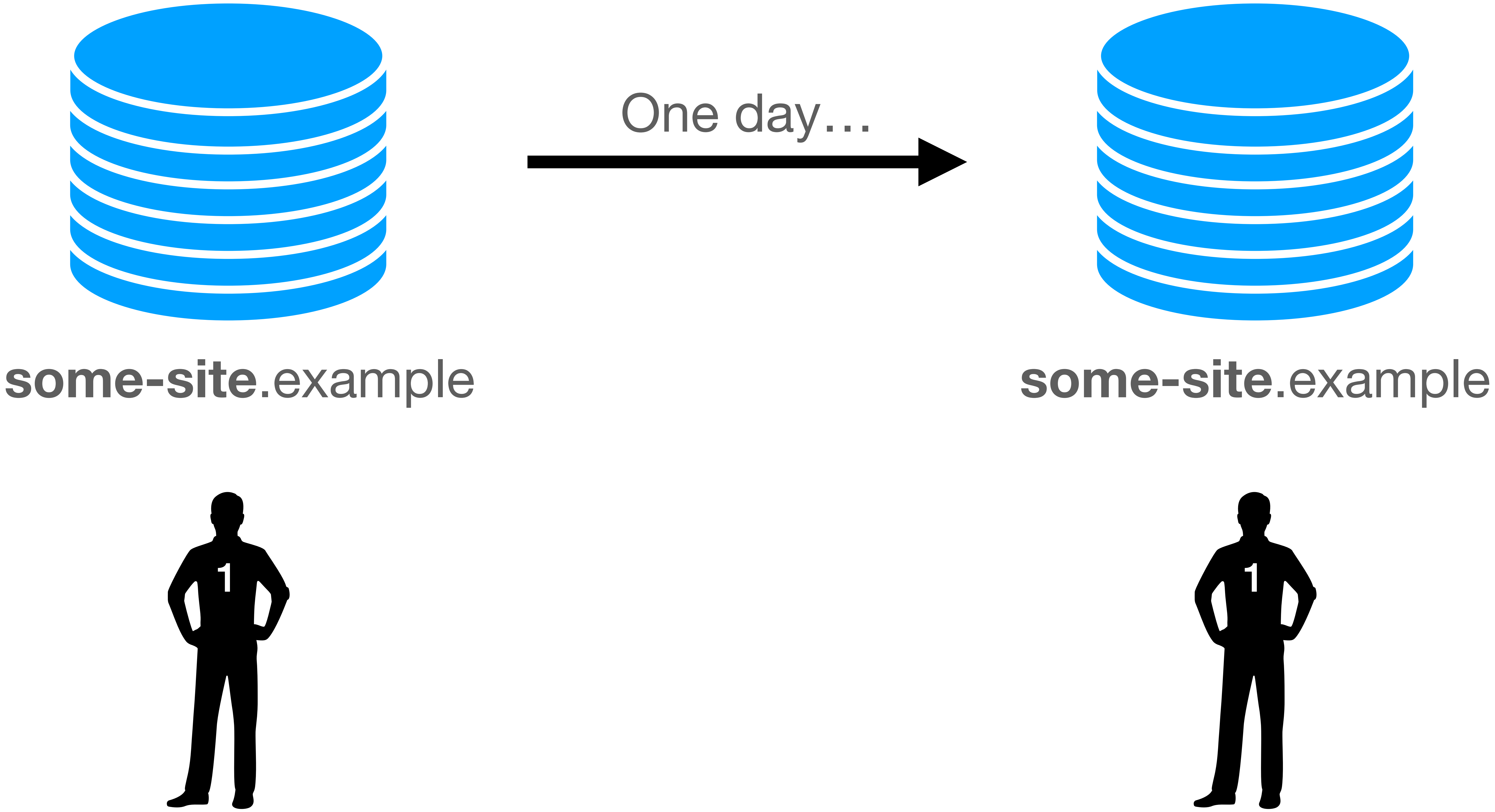
One day…

some-site.example

some-site.example

Not linking

Question Three

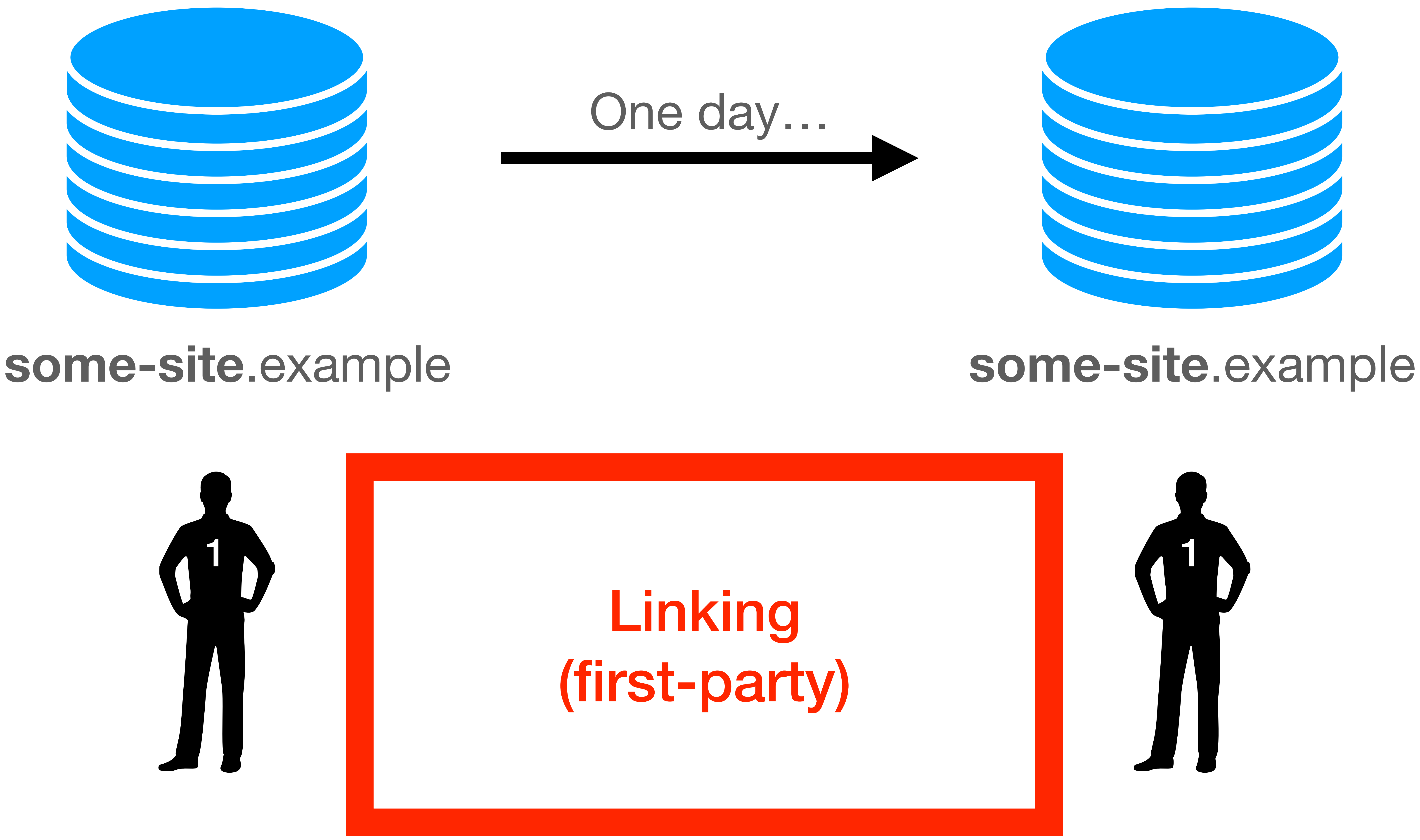


One day…

some-site.example

some-site.example

Question Three



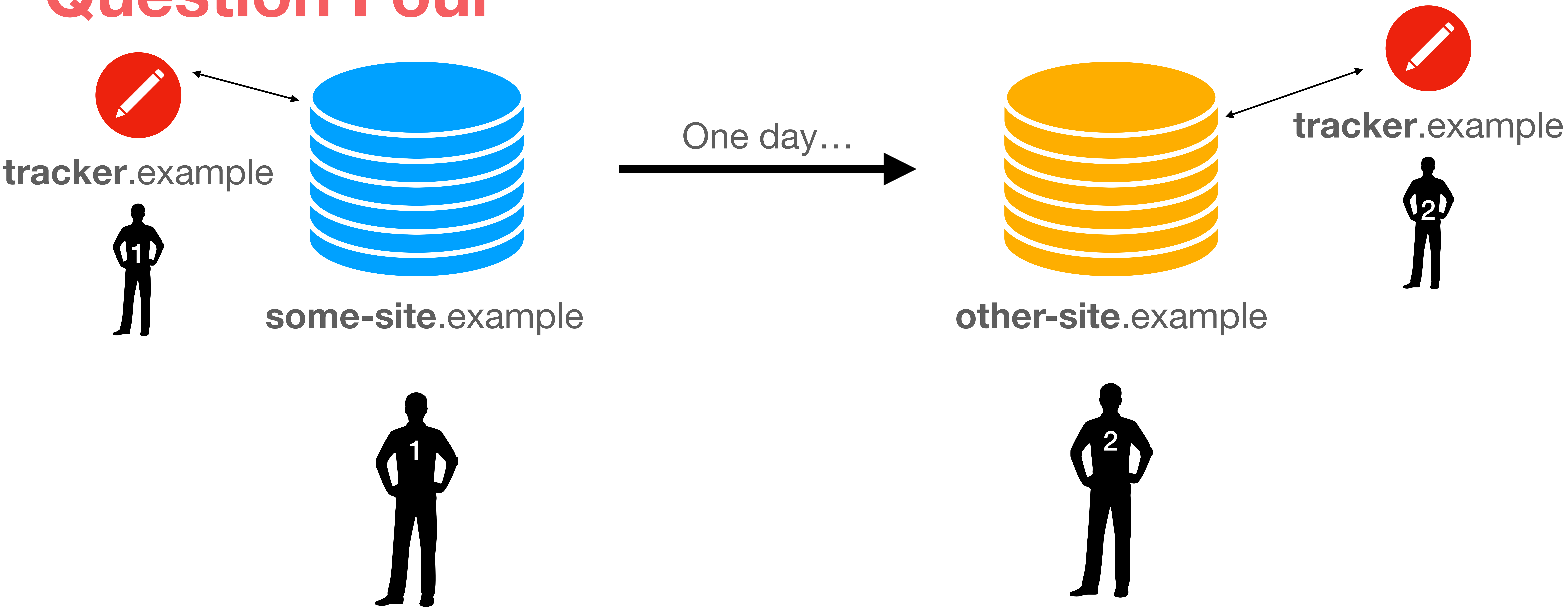
One day…

some-site.example

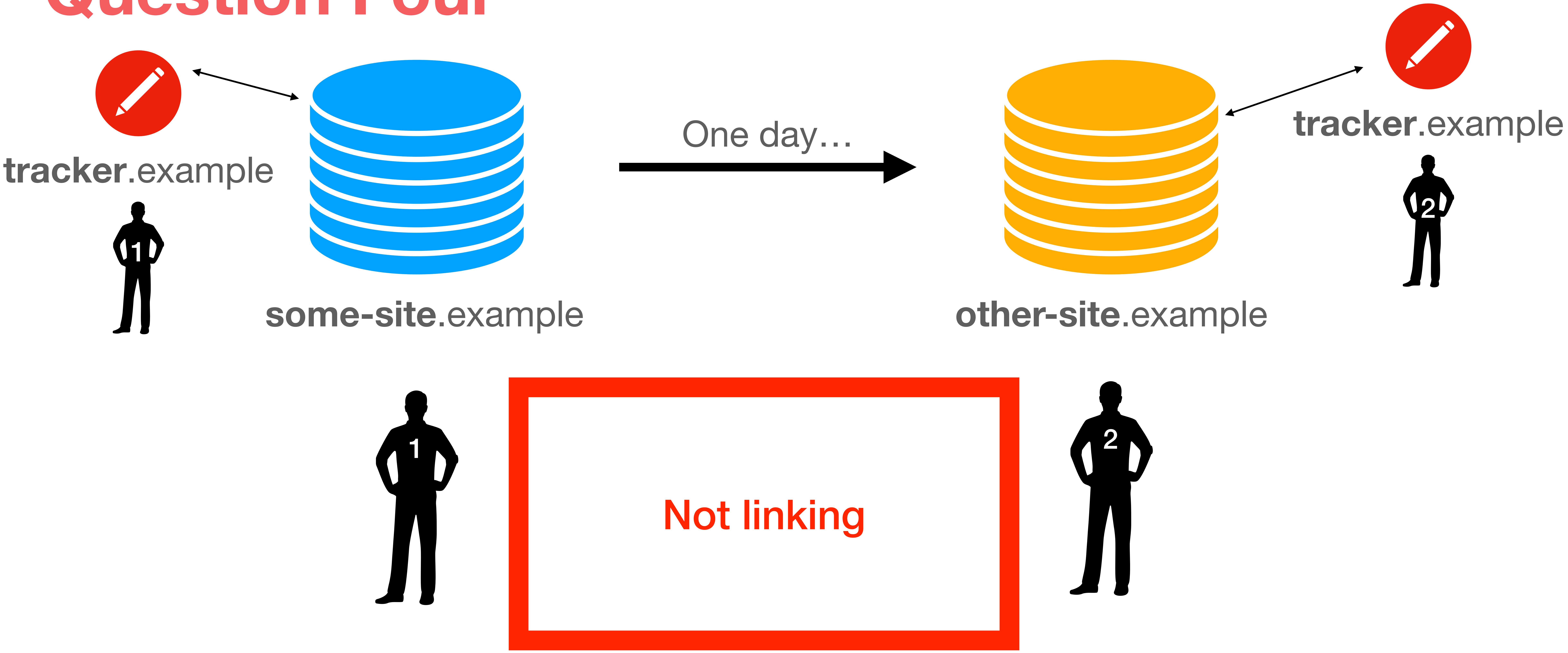
some-site.example

Linking
(first-party)

Question Four



Question Four



tracker.example

some-site.example

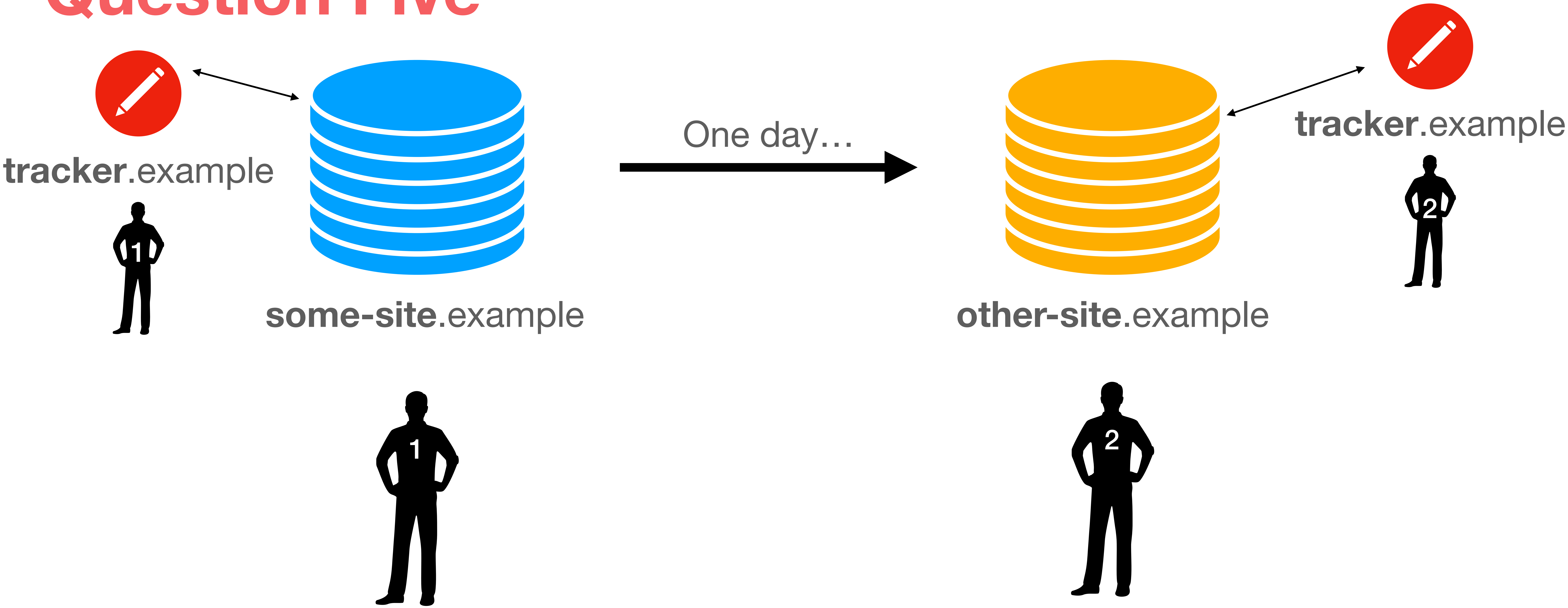
One day…

other-site.example

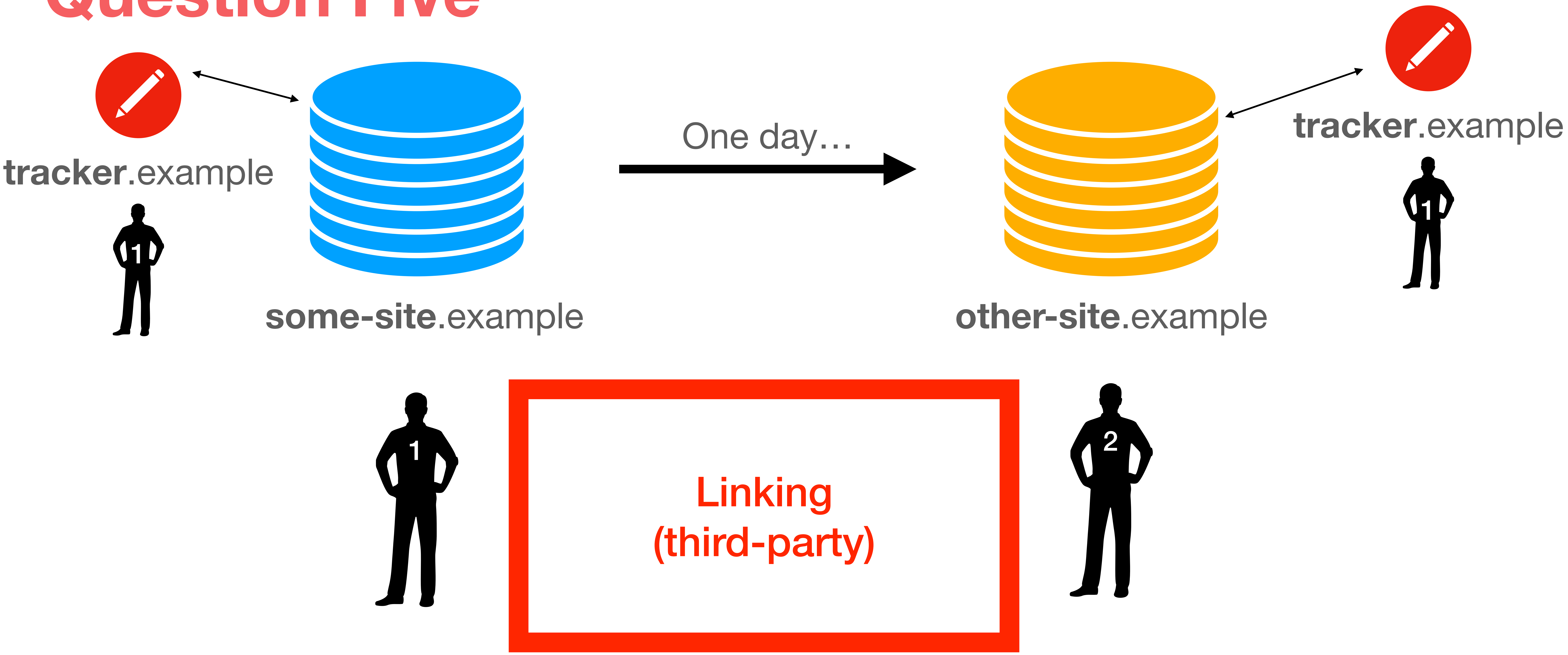
tracker.example

Not linking

Question Five



Question Five



tracker.example

some-site.example

One day…

other-site.example

tracker.example

1

1

1

2

Linking (third-party)

Tracking: Linking…

- **Tying behaviors to same identity**
  Could be pseudonymous, or a “real world” identity

- **Probabilistic or deterministic**
  For some definition of “probable enough”

A Rough Definition of Tracking

- **Linking activities…**
  e.g., being “followed”

- **across boundaries…**
  e.g., temporal, geographic, conceptual

- **In a way not expected or desired.**
  e.g., ignorance or non-consent

Tracking: …across boundaries…

- **Organizational boundaries**
  e.g., eTLD+1, origin, “first-party set”

- **Temporal boundaries**
  e.g., tying something done last year to something done today

- **Profile boundaries**
  e.g., private browsing, different browsers, accounts

A Rough Definition of Tracking

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  e.g., being “followed”

- **across boundaries…**
  e.g., temporal, geographic, conceptual

- **In a way not expected or desired.**
  e.g., ignorance or non-consent

Tracking: …expectations

- **Expectations differ across platforms**
  Facebook inapp browser vs Tor Browser Bundle

- **Expectations differ across people's expertise**
  e.g., my dad vs **Dworkin**

- **Expectations differ across backgrounds**
  e.g., outlook.com vs microsoft.com vs **github.com**

- **Consent is (sometimes) fuzzy**
  Terms of service <— — — — — — — — — —> Storage Access API

A Rough Definition of Tracking

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  e.g., being “followed”

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  e.g., temporal, geographic,
  conceptual

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  e.g., ignorance or non-consent

Overview

- **Why Privacy Matters**
  A sloppy manifesto

- **Defining Tracking**
  Abstracting the problem

- **Tracking in Practice**
  Methods and defenses

- **Privacy Beyond Tracking**
  Other issues and concerns

Tracking Techniques

- Third-party DOM storage
- Network state
- Bounce tracking
- Browser fingerprinting
- IP address
- Personal identifiers

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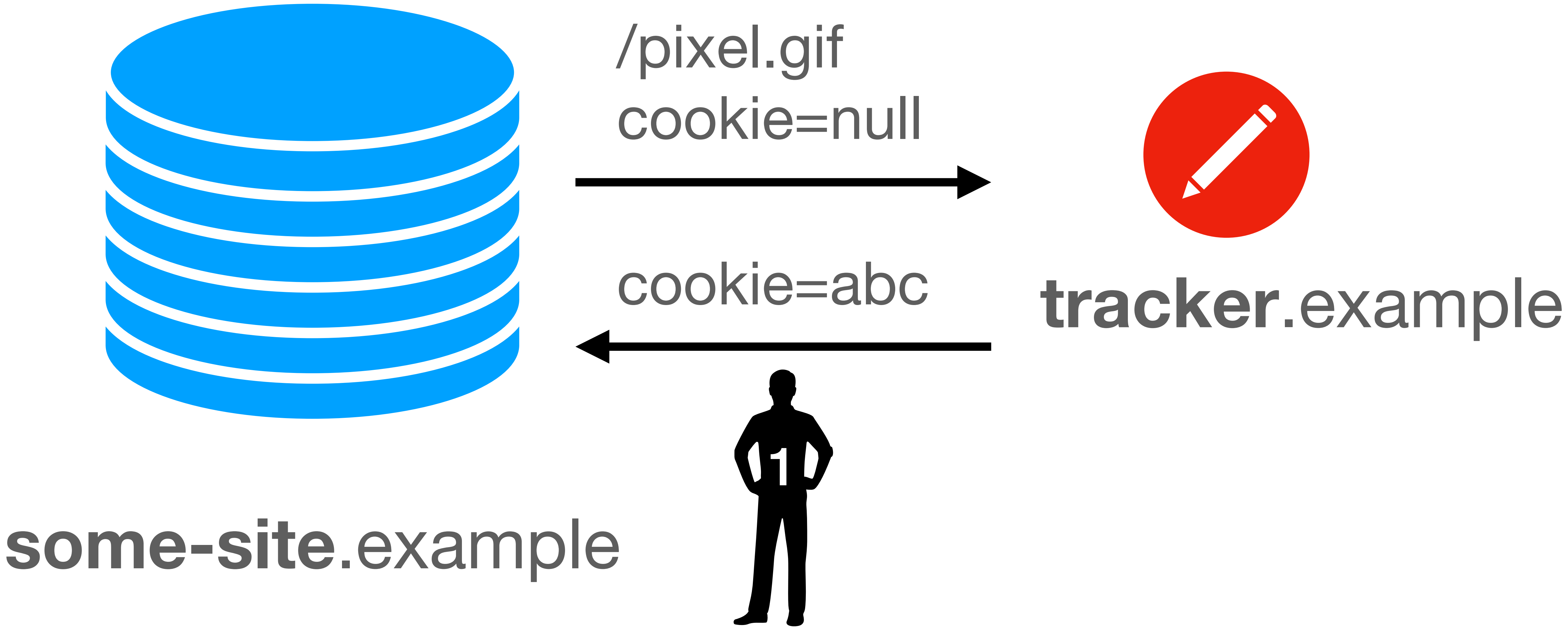
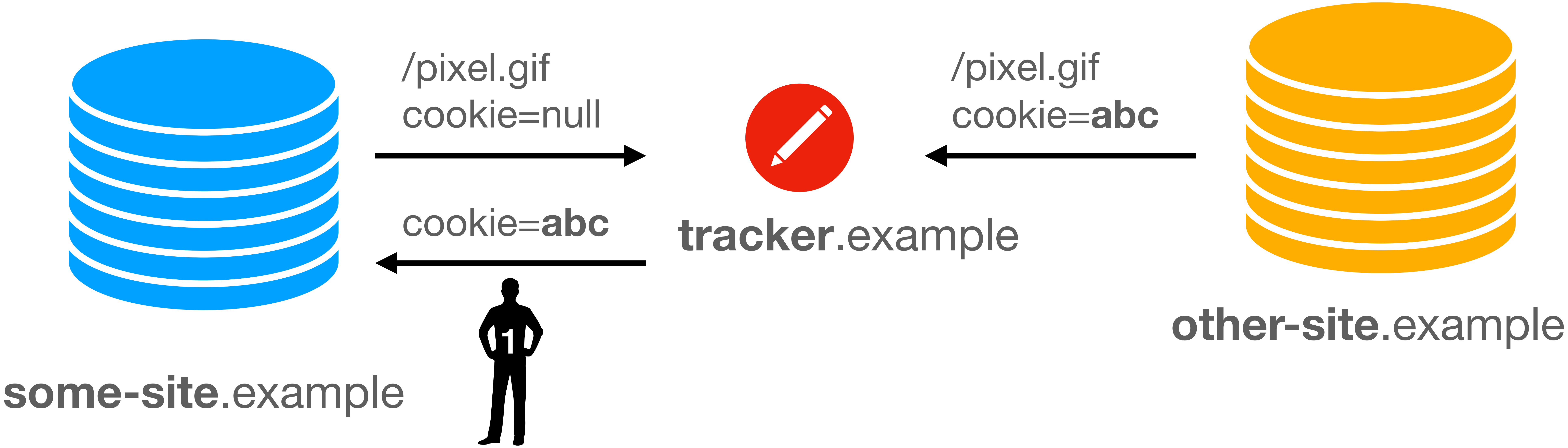
Third-party DOM storage



Third-party DOM storage: cookies



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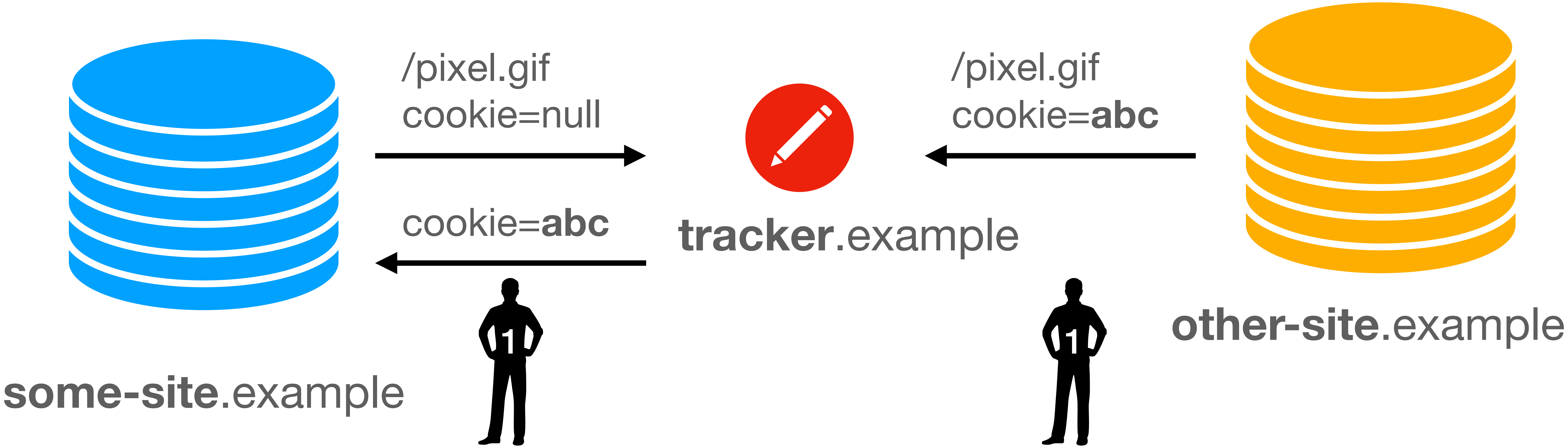
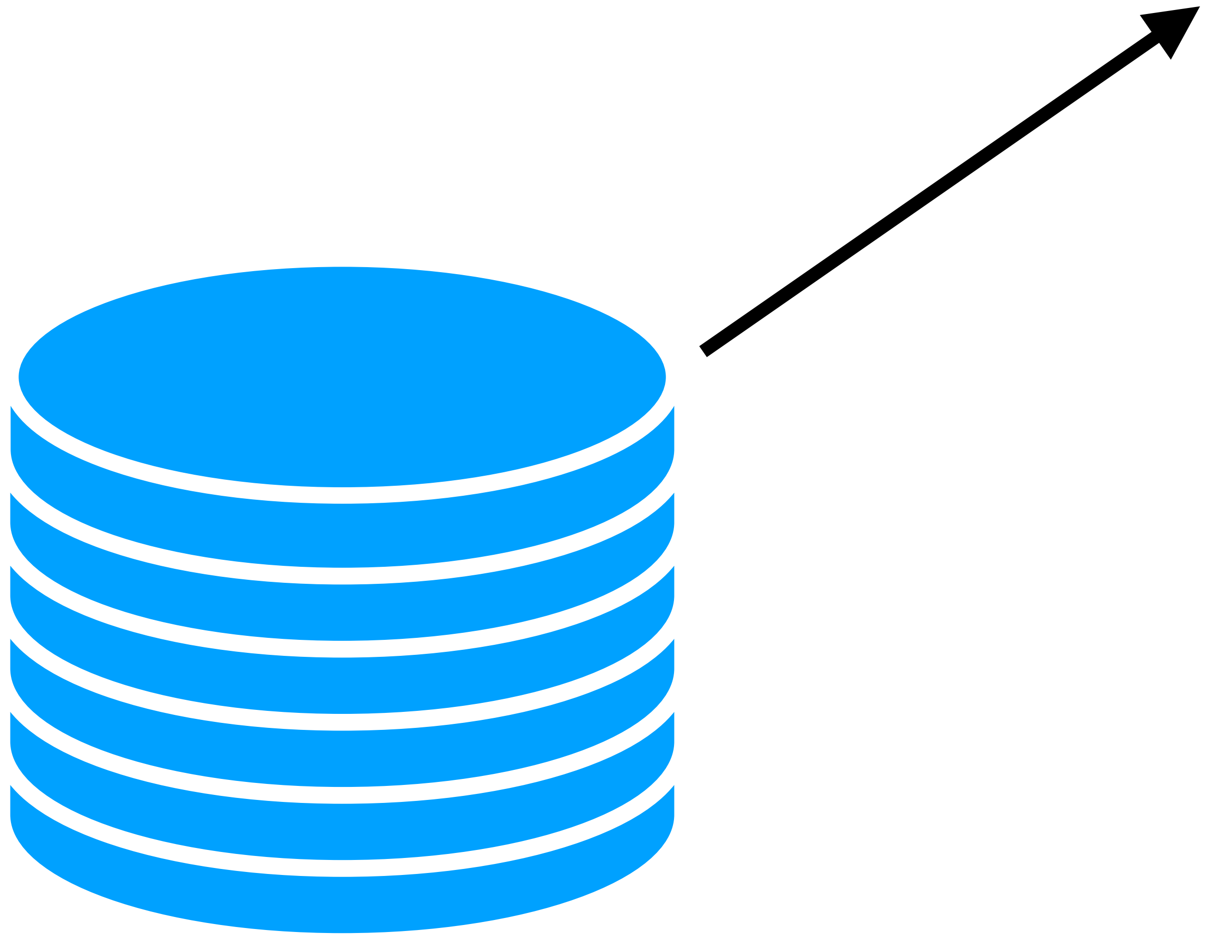
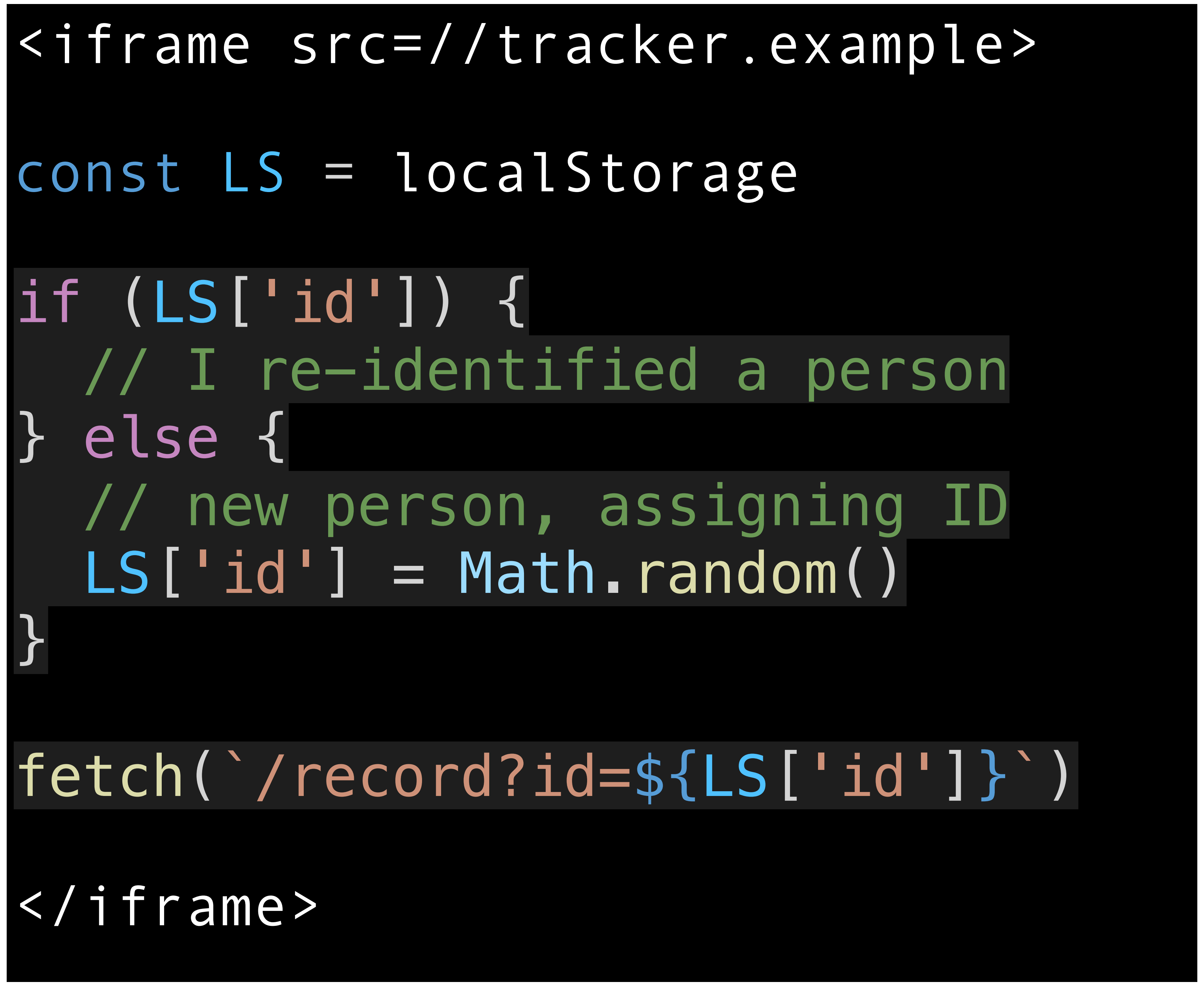


Third-party DOM storage: iframe



some-site.example



```
<iframe src=//tracker.example>

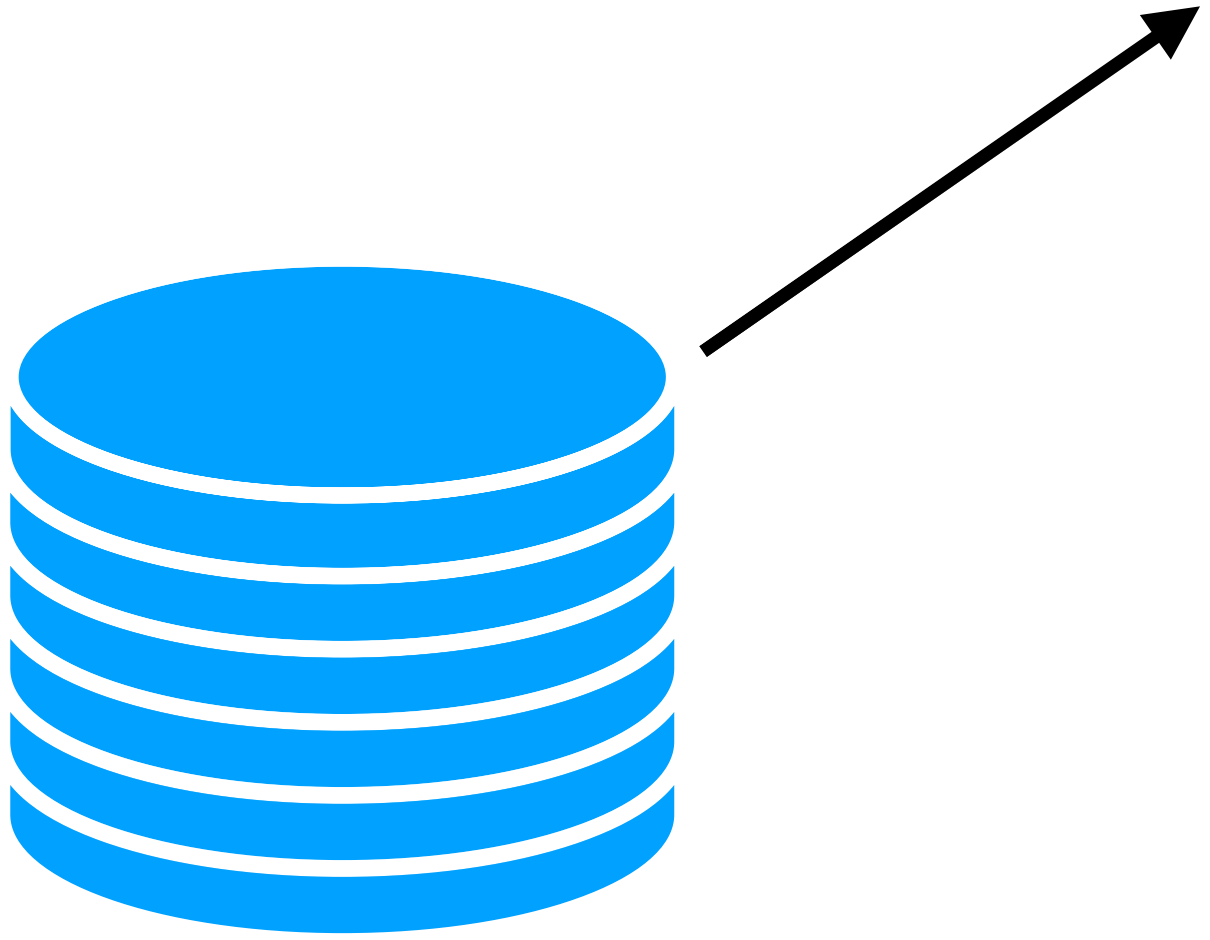
const LS = localStorage

if (LS['id']) {
  // I re-identified a person
} else {
  // new person, assigning ID
  LS['id'] = Math.random()
}

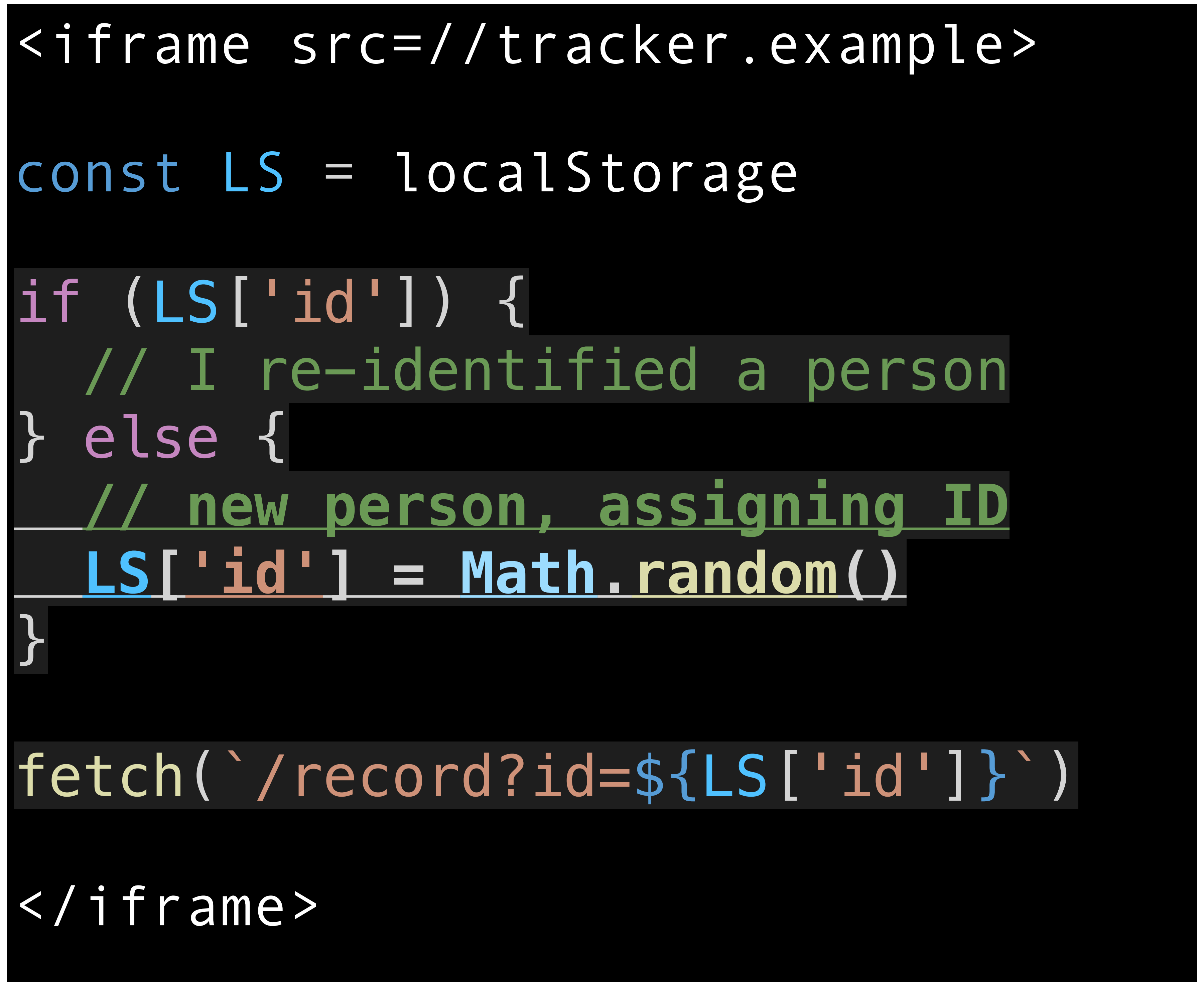
fetch(`/record?id=${LS['id']}`)

</iframe>
```

Third-party DOM storage: iframe



some-site.example



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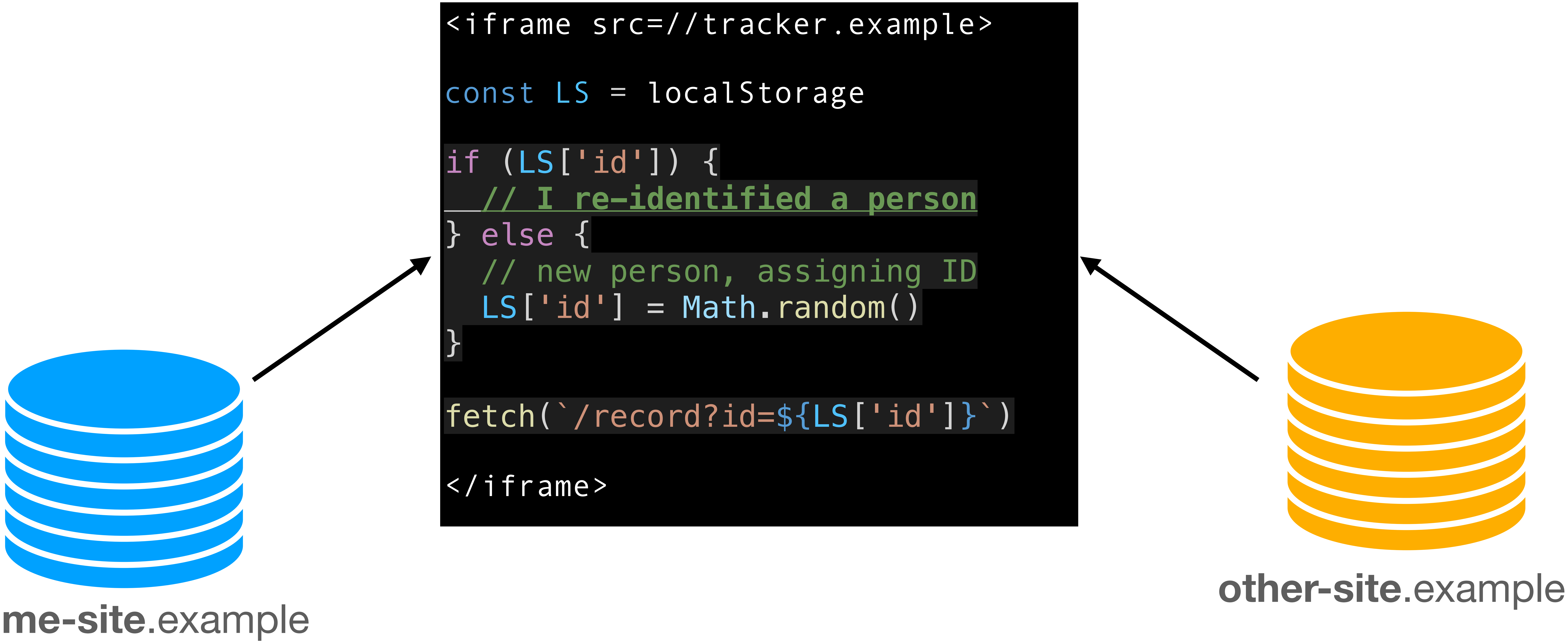

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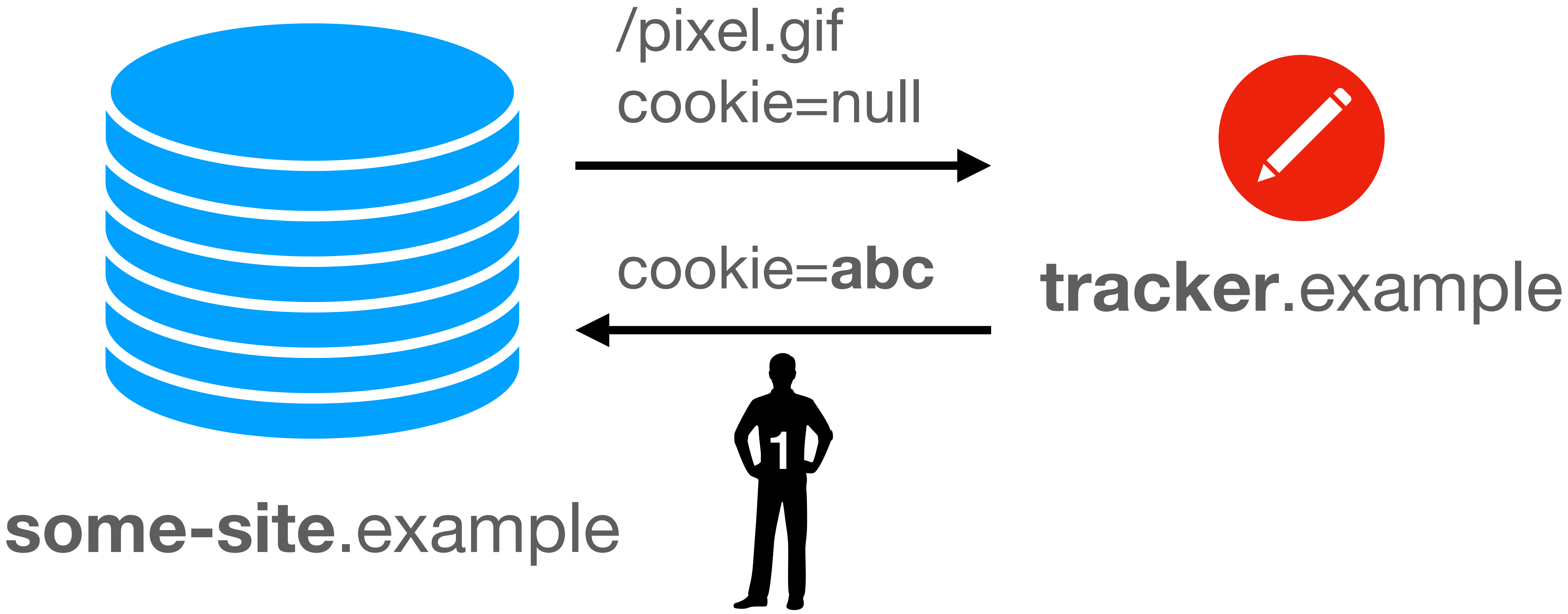
```

Third-party DOM storage: partitioning

- **Third-party storage is not shared across sites**
- **Sometimes called “dual-keying”**
- **Previous:**
  storage_data = browser_storage[<requested eTLD+1>]
- **Partitioning:**
  storage_data = browser_storage[<first-party eTLD+1>][<requested eTLD+1>]

Third-party DOM storage: partitioning



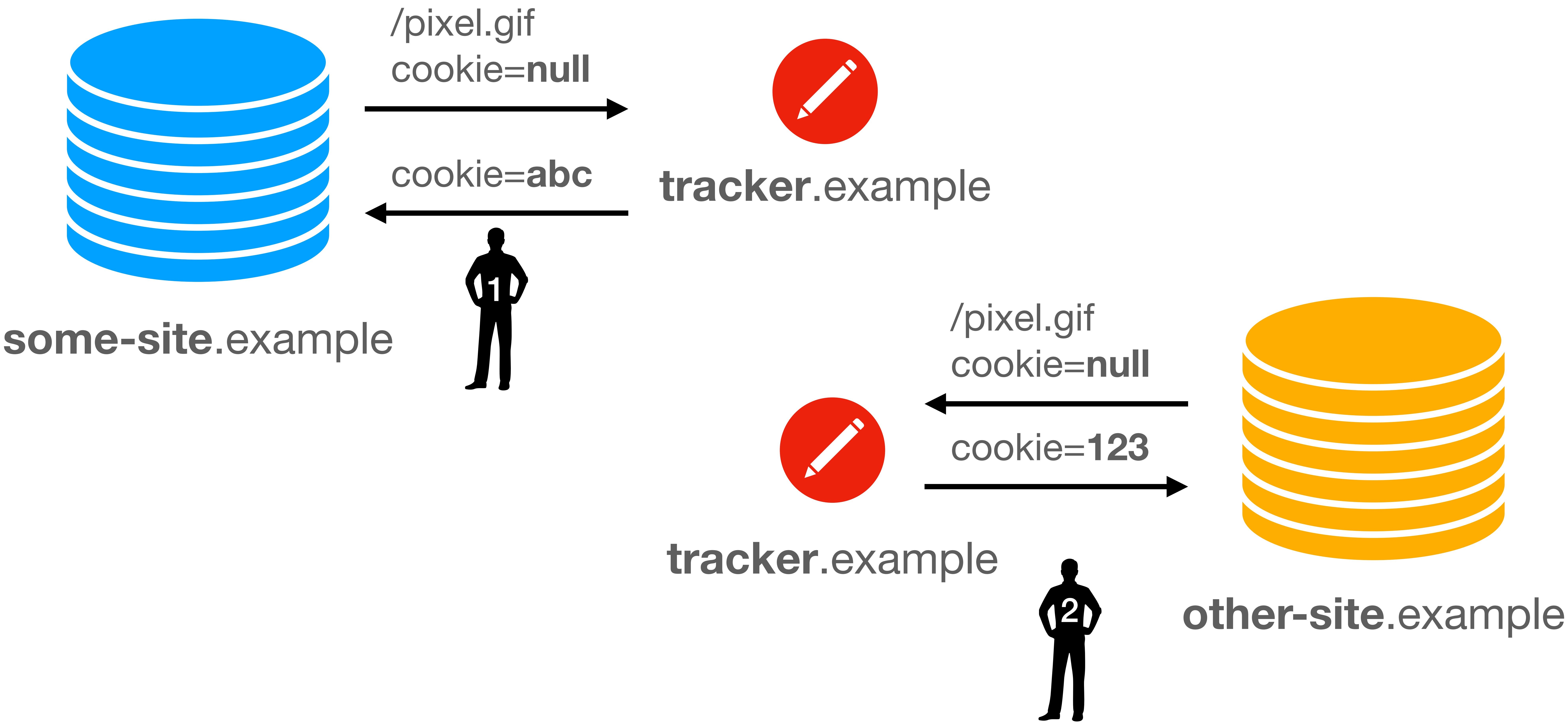
/pixel.gif
cookie=null

cookie=**abc**

tracker.example

some-site.example

Third-party DOM storage: partitioning



Third-party DOM storage: Defenses

	Chrome	Safari	Edge	Firefox	Brave
Block third-party cookies		✓		✓	✓
Partition storage		✓		✓	✓
Ephemeral partitions		✓			✓
List based defenses			⊖		⊖

Tracking Techniques

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Network State Example: HTTP Cache

- **Browsers cache things for speed**
  Images, JavaScript, etc.

- **Caches are generally unpartitioned**

- **Anything unpartitioned can be a linking key**

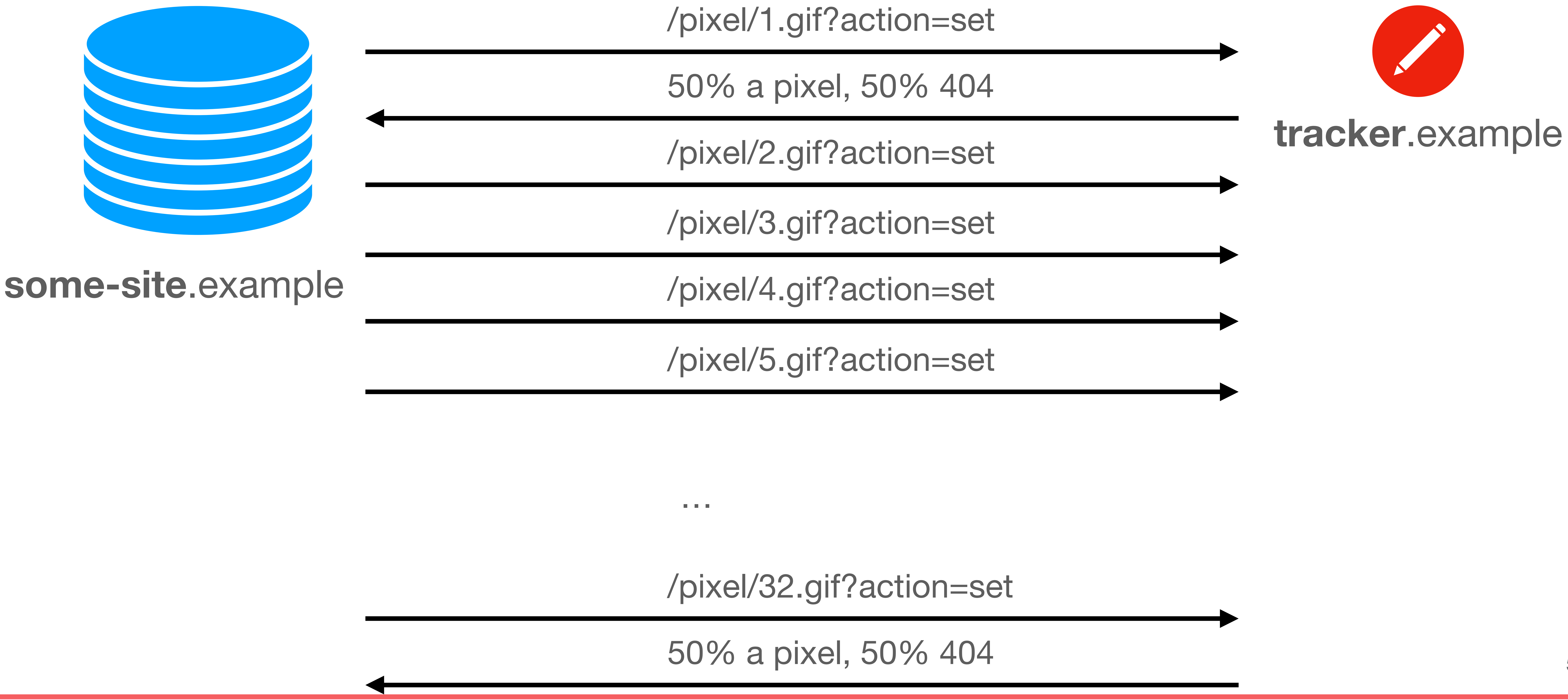
HTTP Cache Tracking

some-site.example

tracker.example

- /pixel/#.gif?action={set, read}
- action=set: 50% return pixel
: 50% 404
- action=read: 100% 404

HTTP Cache Tracking



some-site.example

tracker.example

/pixel/1.gif?action=set

50% a pixel, 50% 404

/pixel/2.gif?action=set

/pixel/3.gif?action=set

/pixel/4.gif?action=set

/pixel/5.gif?action=set

…

/pixel/32.gif?action=set

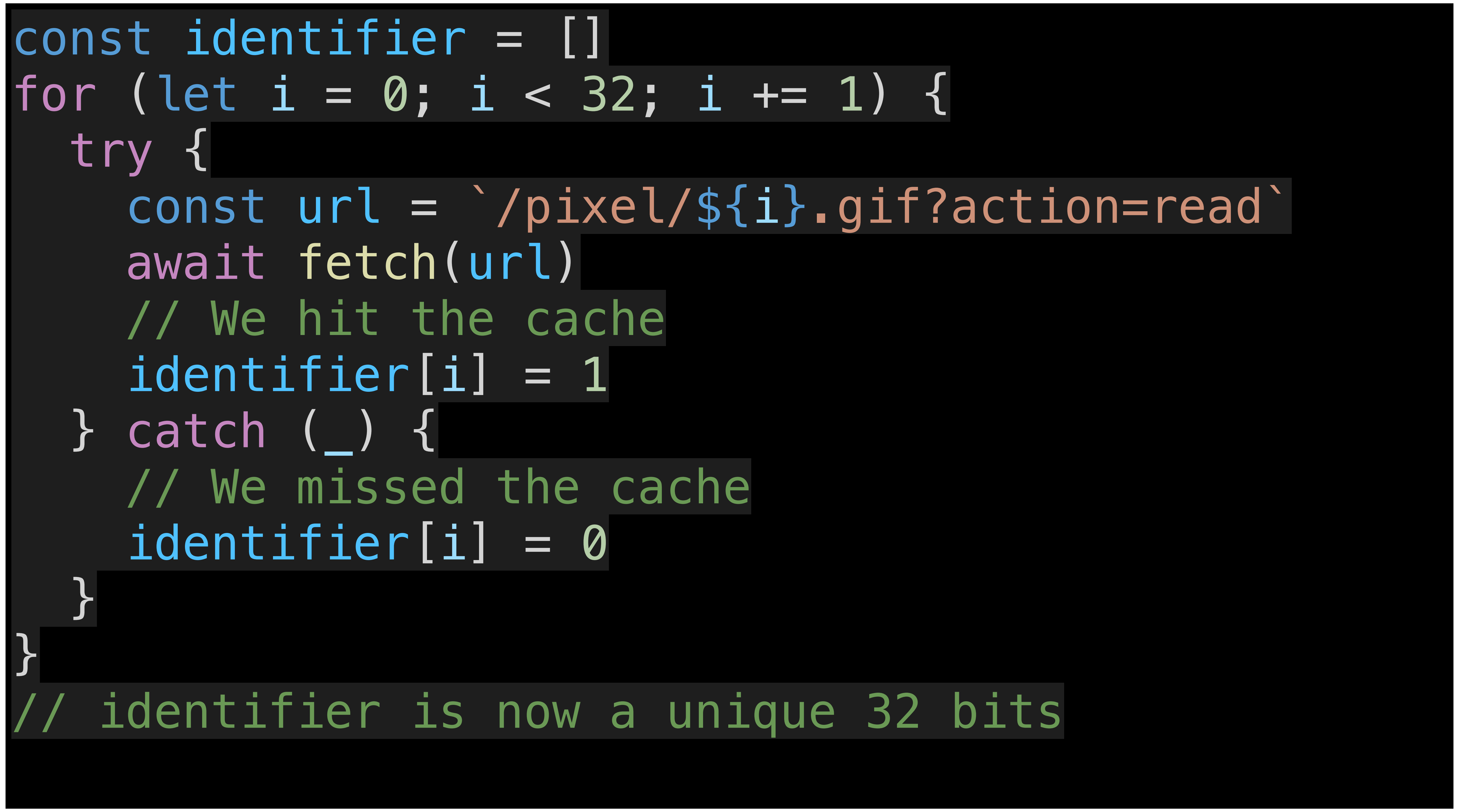
50% a pixel, 50% 404

HTTP Cache Tracking

https://tracker.example/script.js

other-site.example

tracker.example



```
const identifier = []
for (let i = 0; i < 32; i += 1) {
  try {
    const url = `/pixel/${i}.gif?action=read`
    await fetch(url)
    // We hit the cache
    identifier[i] = 1
  } catch (_) {
    // We missed the cache
    identifier[i] = 0
  }
}
// identifier is now a unique 32 bits
```

HTTP Strict Transport Security (HSTS)

- **Website Says “only HTTPS, forever”**
  e.g. persistent storage

- **Automatic Upgrade**
  http://example.org -> https://example.org

- **How to leverage?**

HSTS Tracking

- example.org
- a.example.org
- b.example.org
- a.a.example.org
- b.a.example.org

Network state: Defenses

	Chrome	Safari	Edge	Firefox	Brave
Partition network state	⟳	⊖		✓	⊖
List based defenses					⊖

Tracking Techniques

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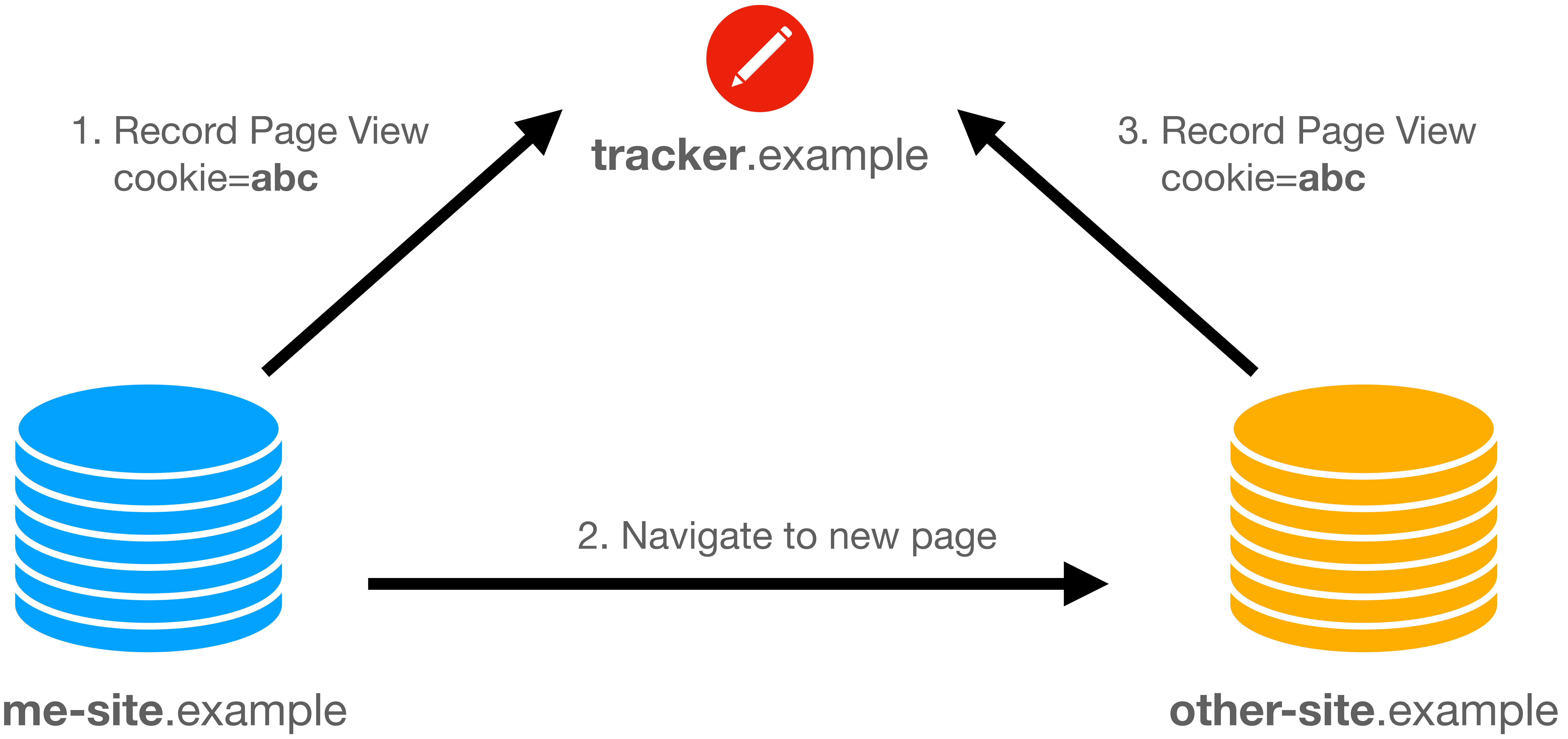
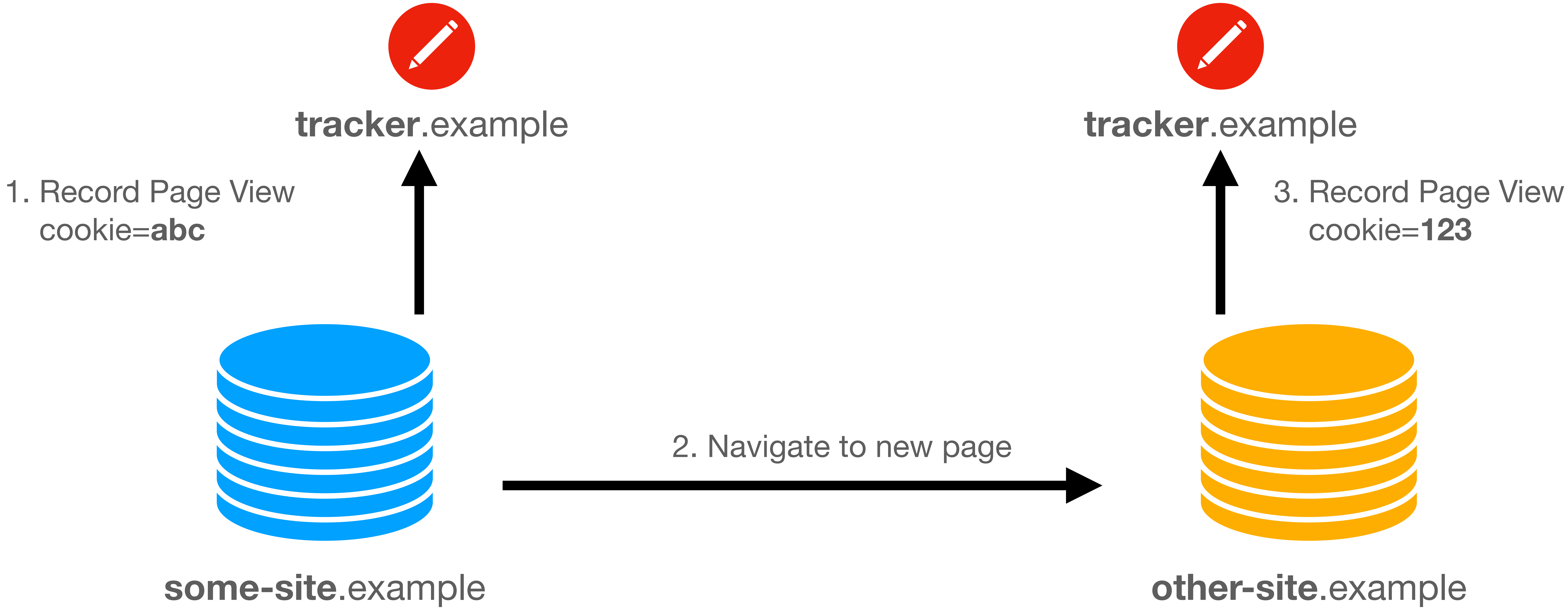
Bounce Tracking

- Response to partitioning
- Third parties use first-parties to track
- Growing in importance as partitioning is more common

Pre-partitioning



Storage partitioning



tracker.example

1. Record Page View
   cookie=**abc**

tracker.example

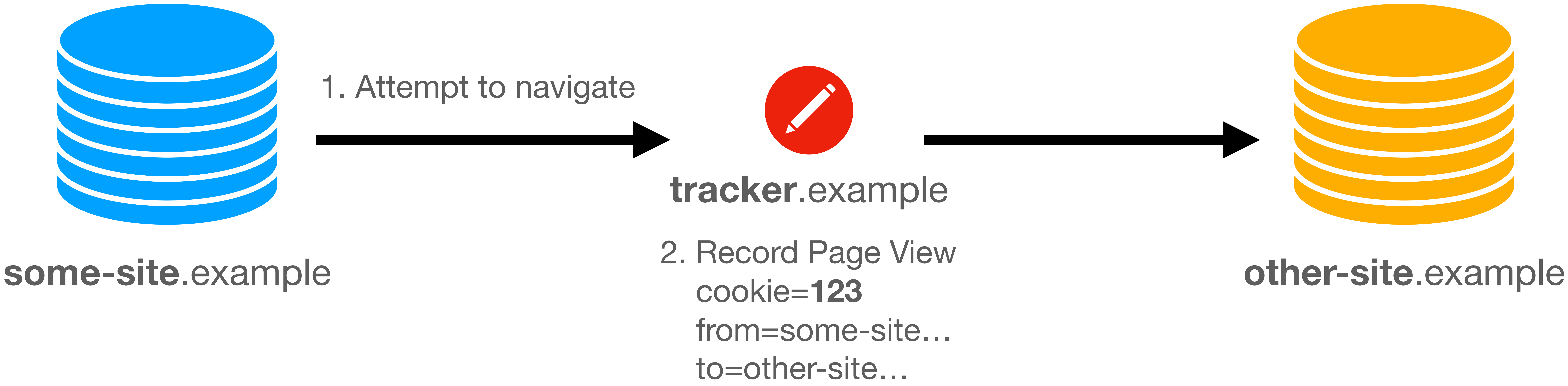
3. Record Page View
   cookie=**123**

2. Navigate to new page

some-site.example

other-site.example

Bounce tracking



1. Attempt to navigate

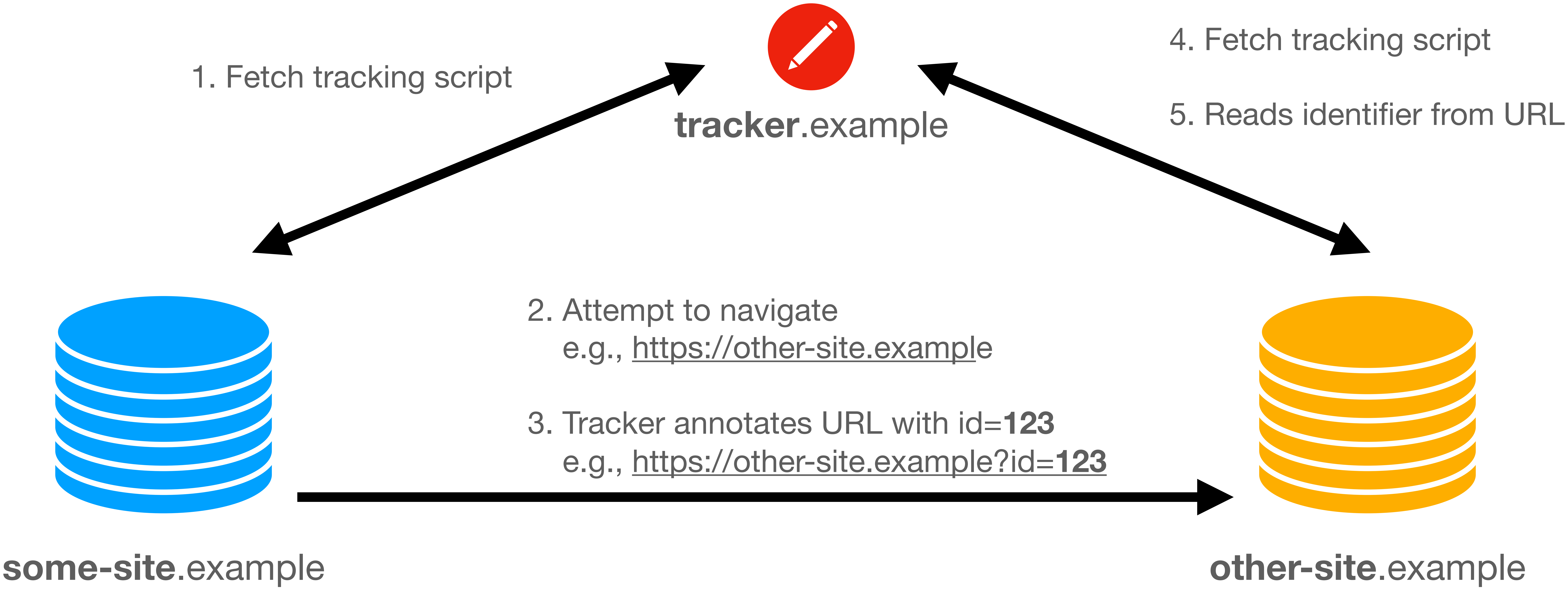
tracker.example

2. Record Page View
   cookie=**123**
   from=some-site…
   to=other-site…

some-site.example

other-site.example

Navigation tracking



1. Fetch tracking script

tracker.example

4. Fetch tracking script

5. Reads identifier from URL

2. Attempt to navigate
   e.g., https://other-site.example

3. Tracker annotates URL with id=**123**
   e.g., https://other-site.example?id=**123**

some-site.example

other-site.example

Bounce and Navigation Tracking: Defenses

	Chrome	Safari	Edge	Firefox	Brave
Limit storage		heuristic ⊖		List ⊖	↻
“Debounce”					List ⊖
Warn user					List ⊖

Tracking Techniques

- Third-party DOM storage
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Fingerprinting, contrasted

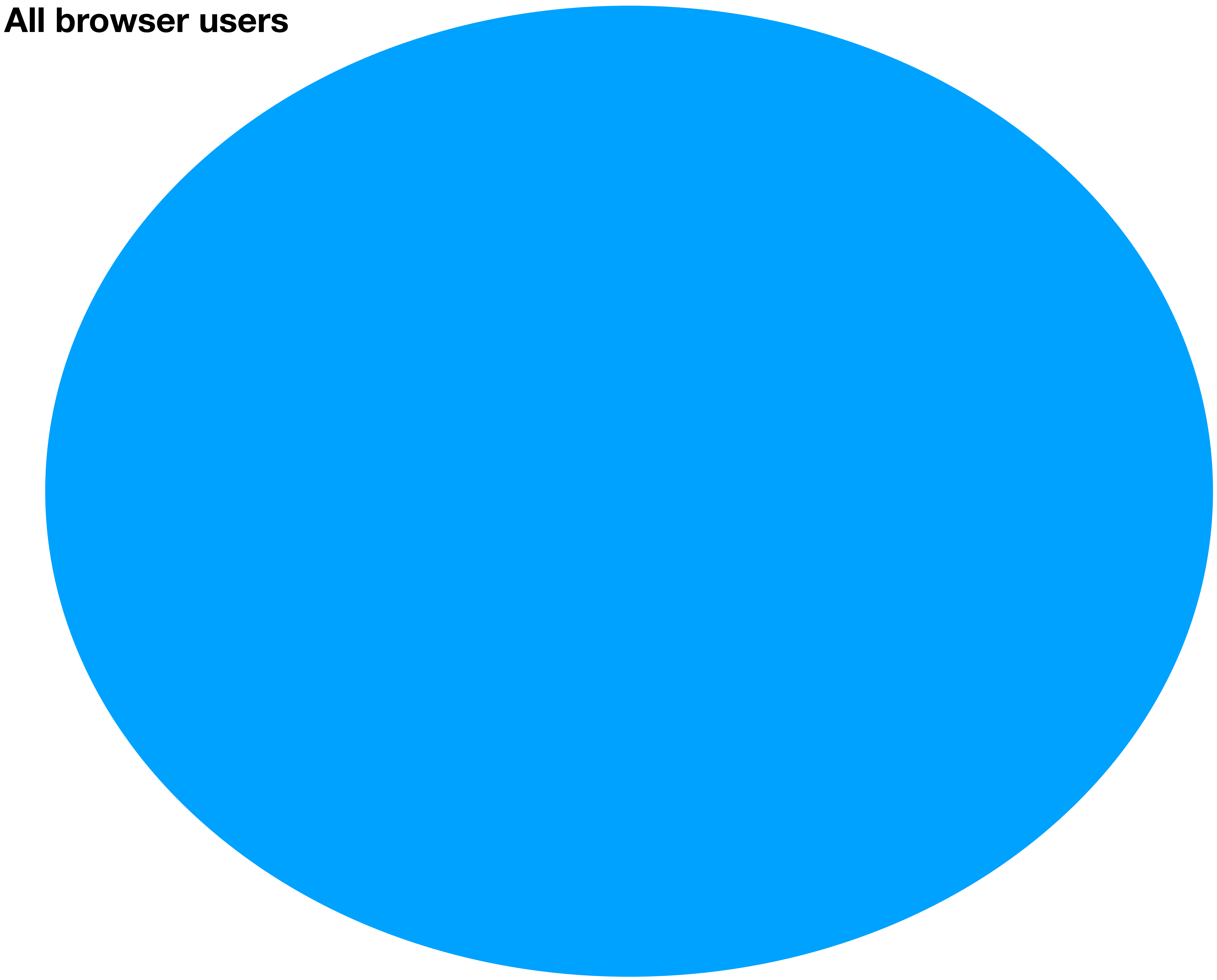
- **Classic tracking**
  - Website stores an id on the client
  - The client returns the id to the server (cookie or JS)
  - The id is what allows re-identification
  - “Stateful”

- **Fingerprinting / passive tracking**
  - Website finds things different about each visitor
  - Tracker derives the identifier from minor browser differences
  - “Stateless”

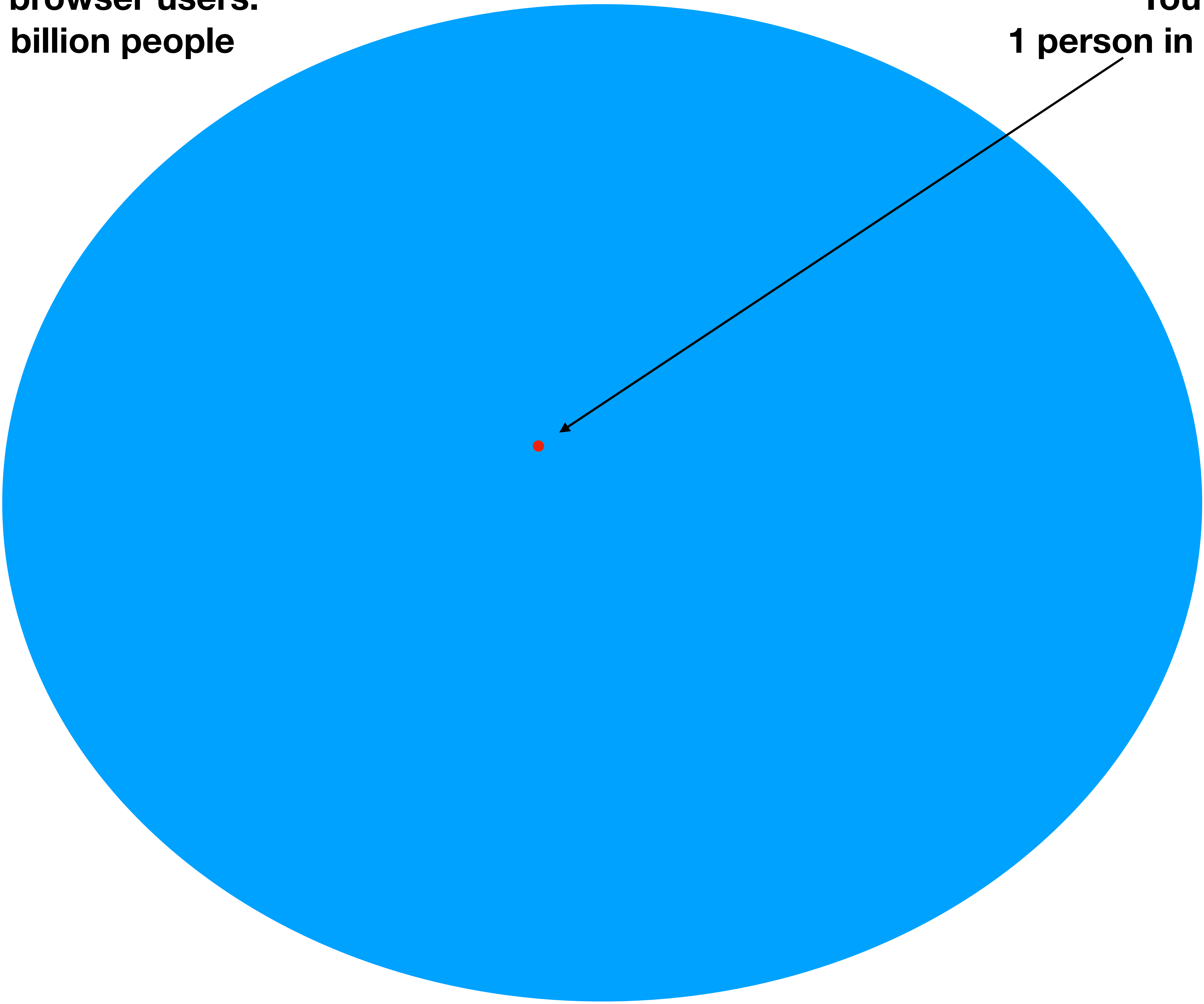
Fingerprinting, how?

- **Large number of semi-identifiers**
  - Browser size
  - Extra fonts
  - Audio hardware
  - Video hardware
  - Installed plugins
  - Color depth

- **Add the semi identification up…**

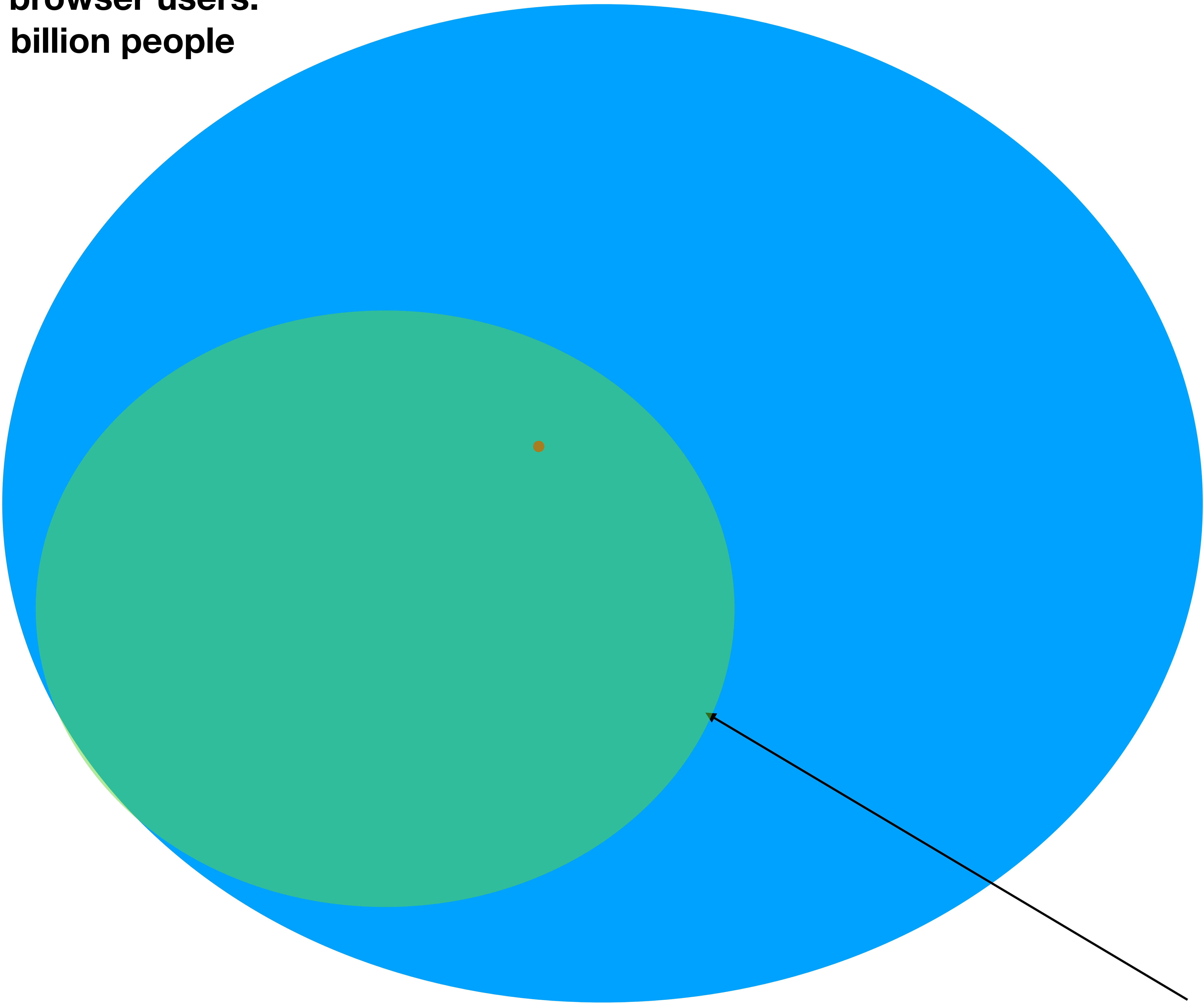


All browser users



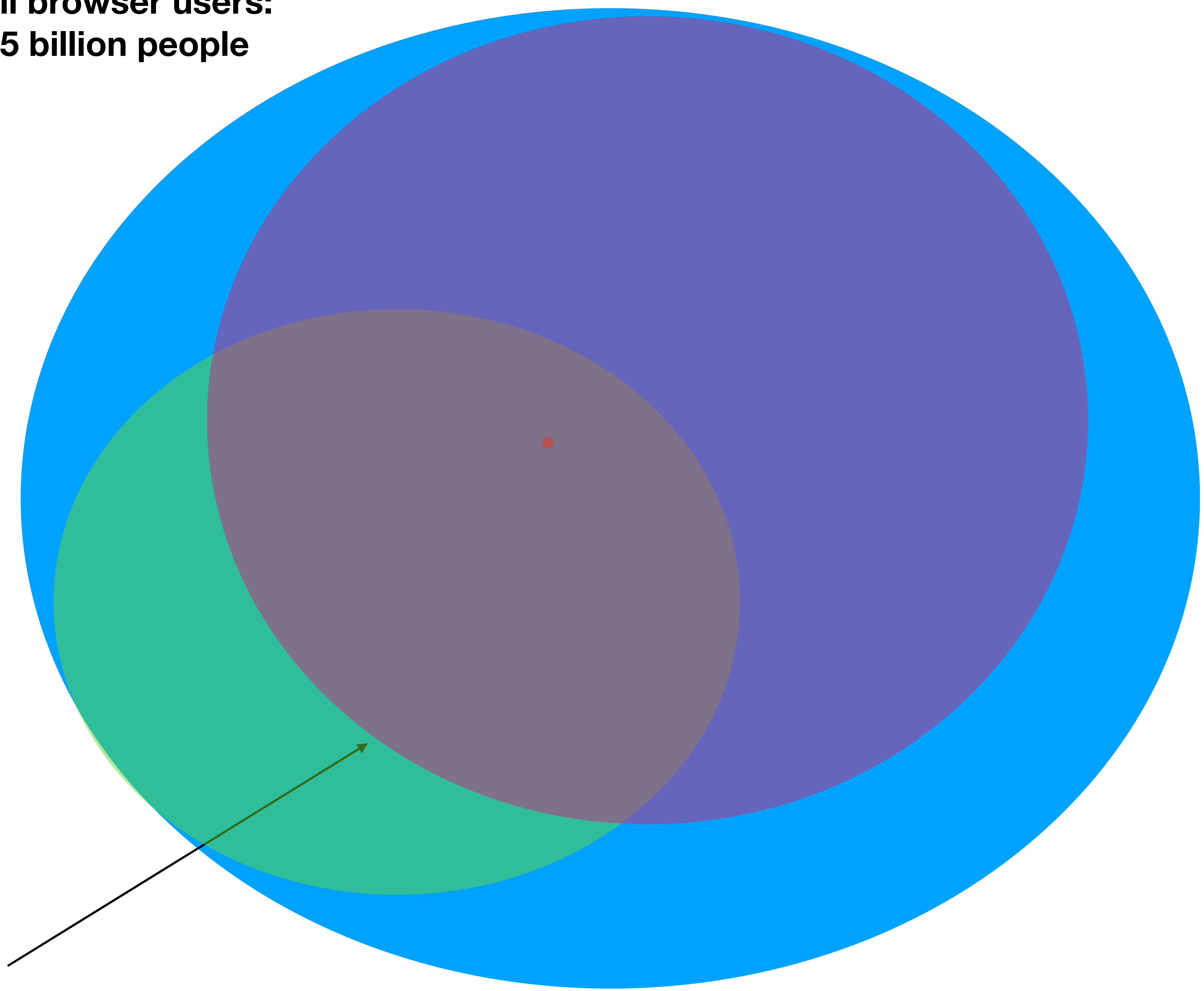
All browser users:
5 billion people

You
1 person in 5 billion



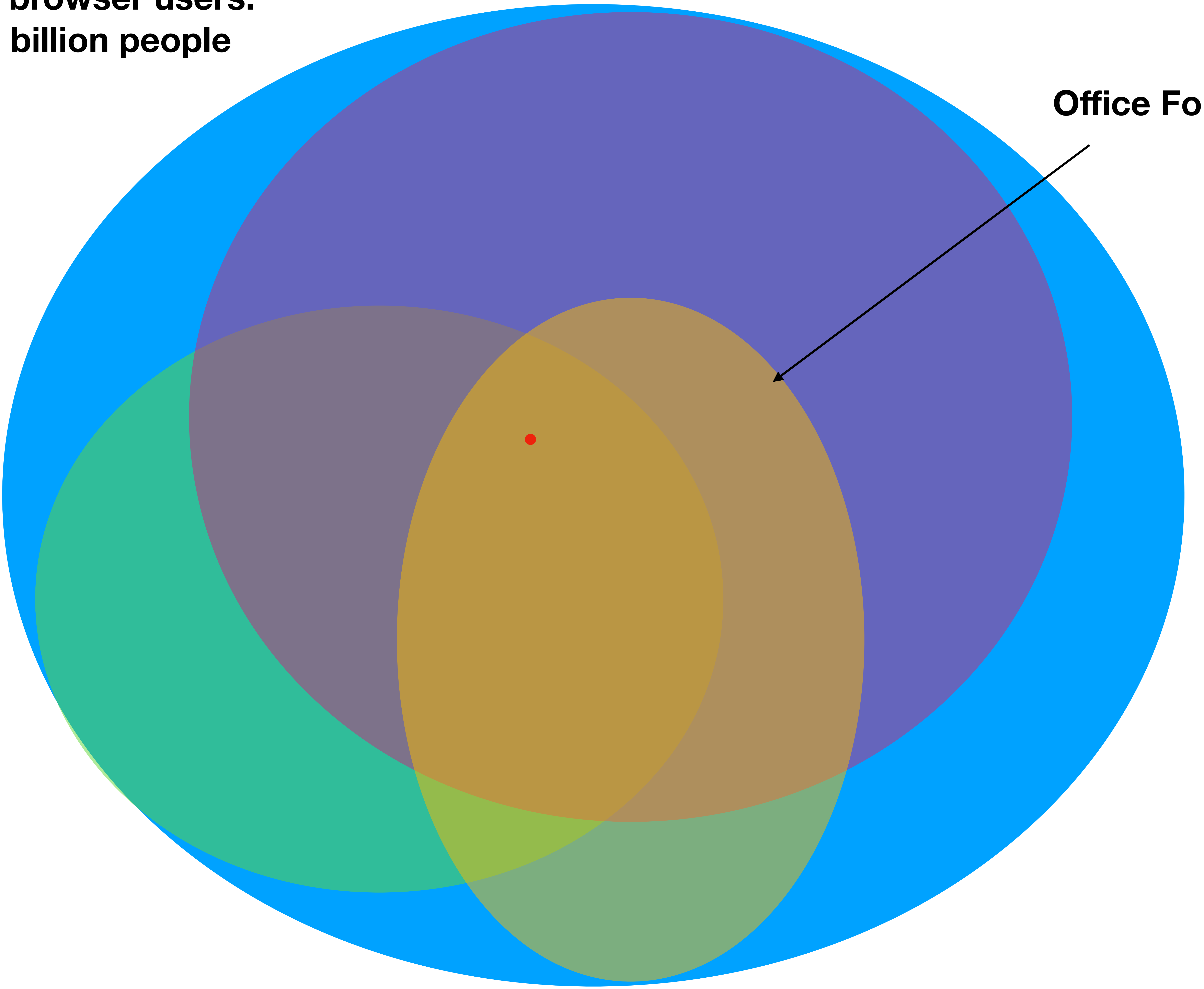
All browser users:
5 billion people

Firefox
Users



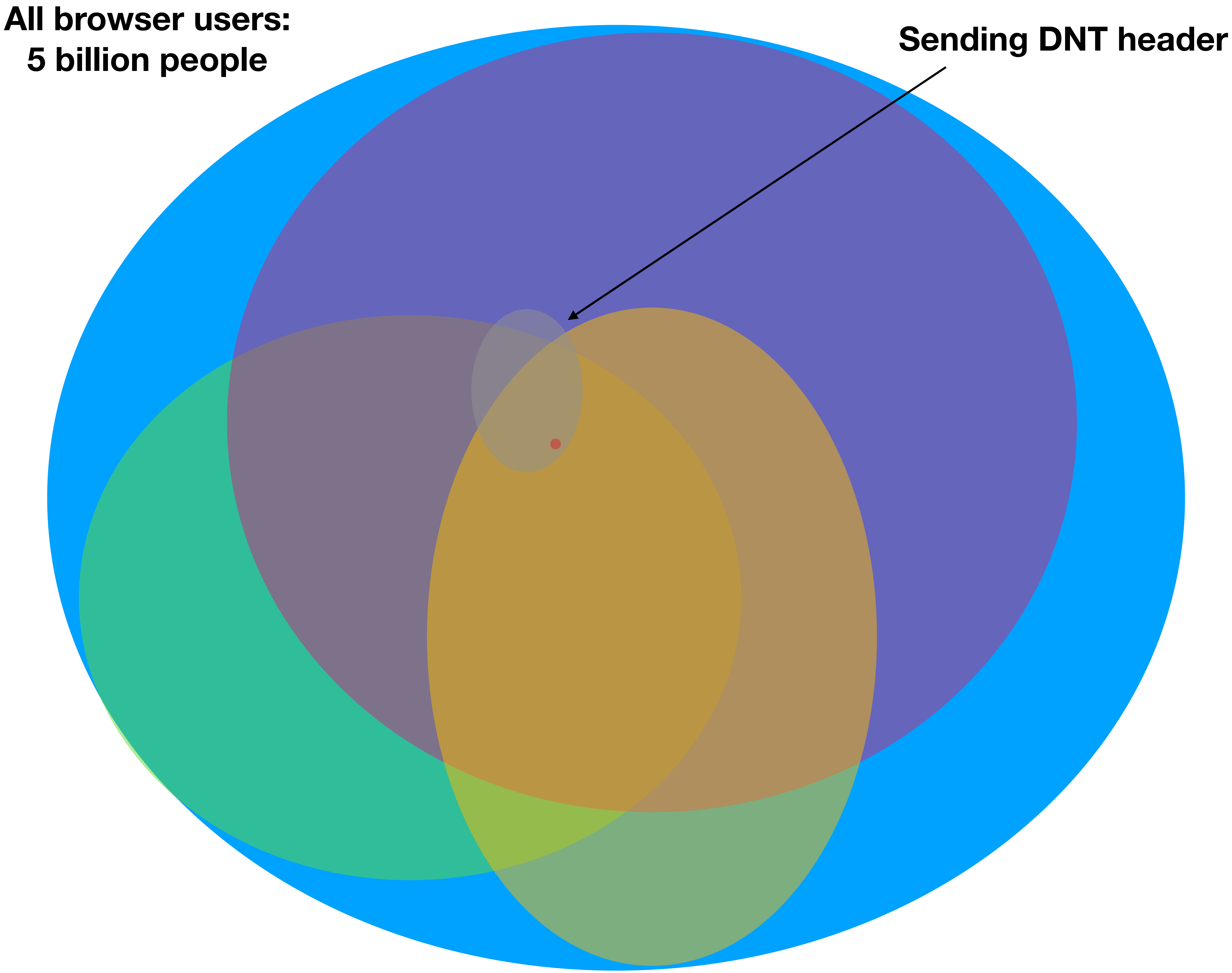
All browser users:
5 billion people

Windows users



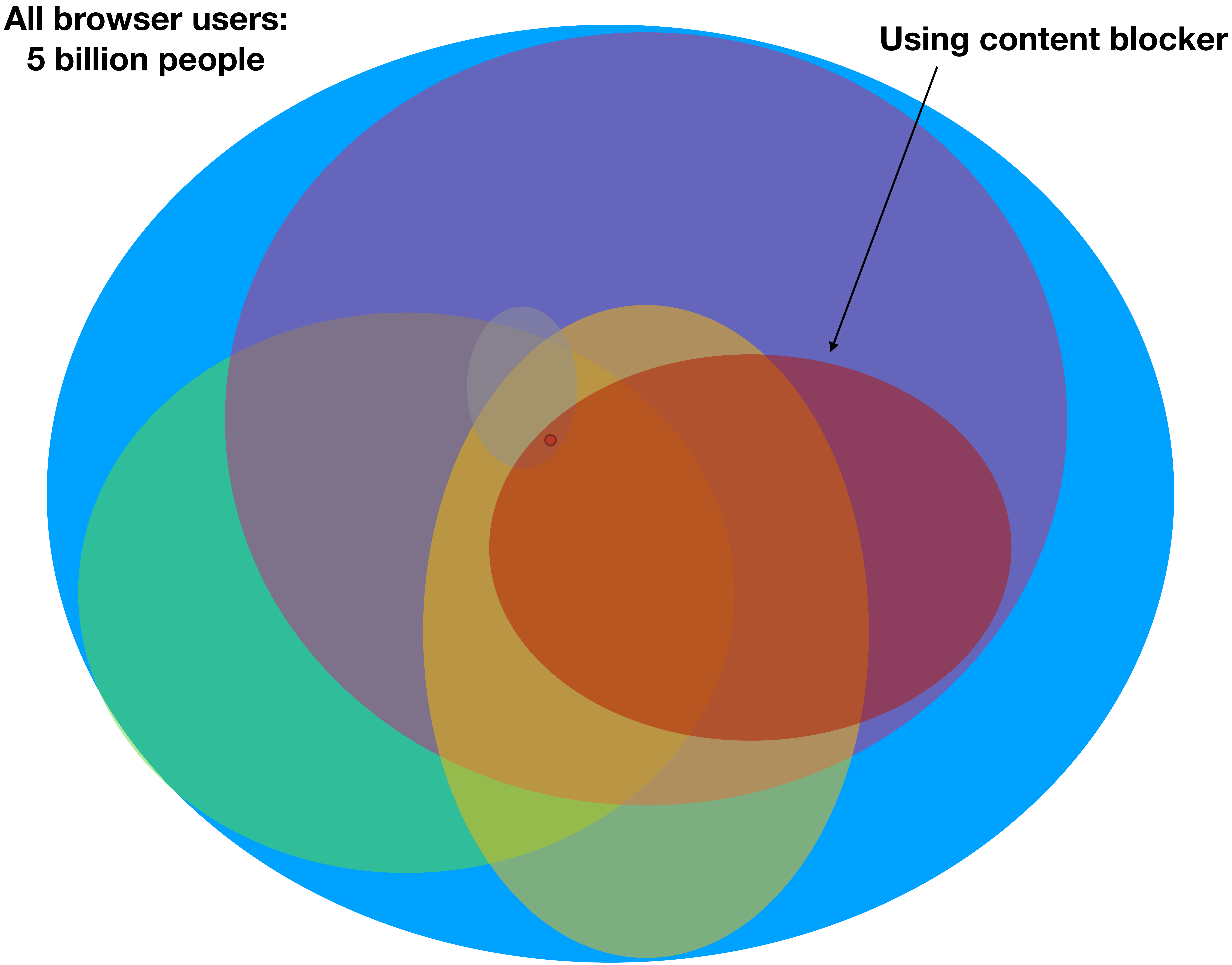
All browser users:
5 billion people

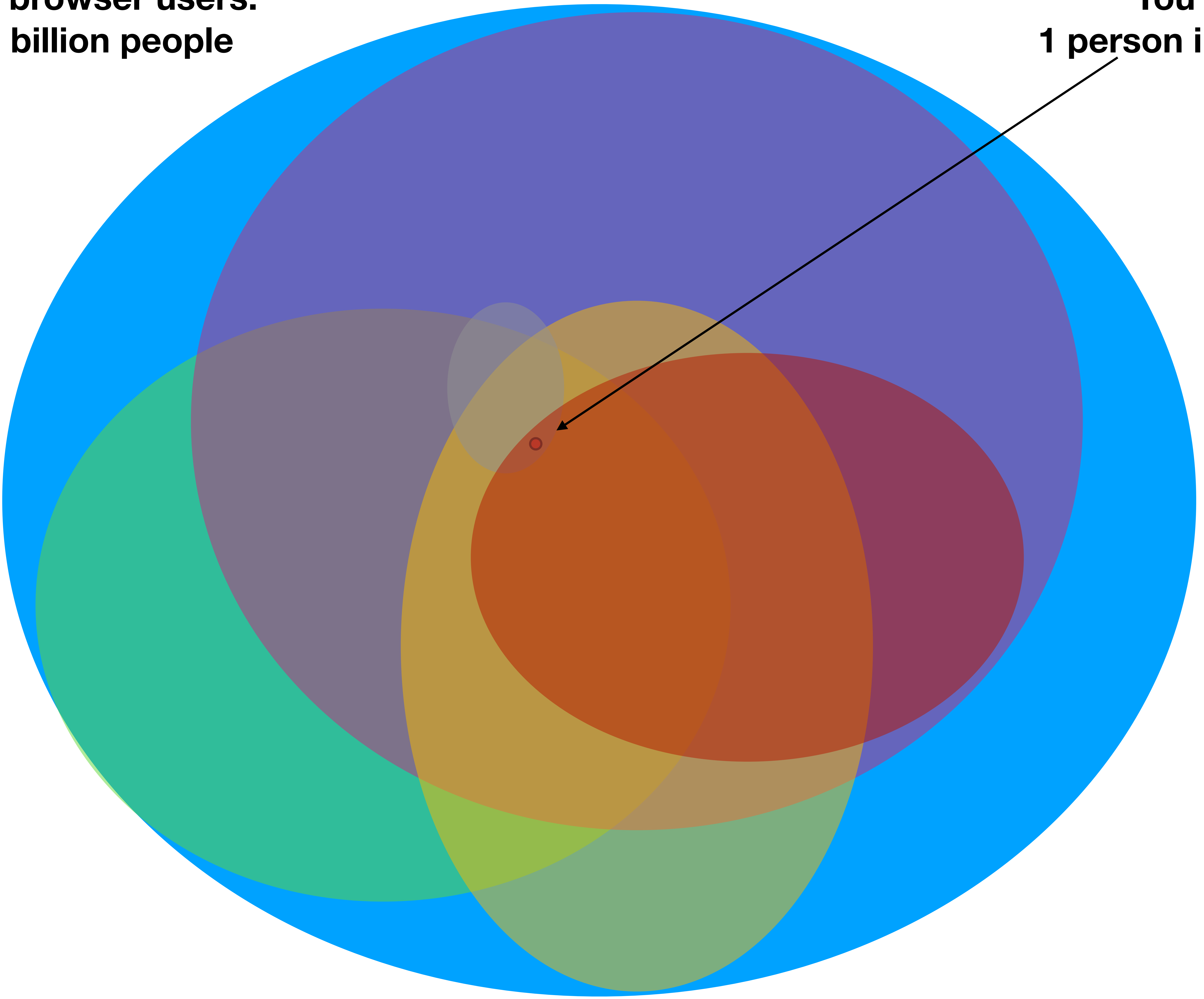
Office Fonts



All browser users:
5 billion people

Sending DNT header


All browser users:
5 billion people
Using content blocker



All browser users:
5 billion people

You
1 person in 100

Fingerprinting, abstracted

- **Still needs a common value across boundaries**
  Sites, sessions, time, etc

- **Value needs to be unique**
  Otherwise it mixes you up with others

- **Value needs to be consistent**
  Otherwise it doesn’t (re)identify you

Possible Defenses

- **Try to make browsers look similar**
  Reduce the “bits” available to fingerprinters

- **Try to block bad parties**
  Keep the “bad folks” out

- **Privacy budgets**
  Only allow sites to do so much identifying, e.g., 10 bits but not more

- **Randomization**
  Make browser look iIntentionally different, within each boundary

Fingerprinting: Defenses

	Chrome	Safari	Edge	Firefox	Brave
Restricted hardware		✓			
Feature selection / removal	↻	✓		✓	✓
Block fingerprinters			⊖	⊖	⊖
Randomization					✓

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- Third-party DOM storage
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IP Addresses are pretty unique!

- **…especially if you look for clusters**
  The 3 ips you most commonly connect from is very unique

- **IPv6 makes it a lot worse**
  Obviously… :-/

- **Four general approaches**
  - Contracts / promises
  - proxies
  - mix nets
  - block bad parties

IP Addresses Defenses

	Chrome	Safari	Edge	Firefox	Brave
Websites promise	↻				
Proxies	↻	Private relay ✓		Optional VPN ⊖	Optional VPN ⊖
Mix networks					Optional Tor ⊖
Block bad parties			⊖	⊖	✓

Tracking Techniques

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Personal Identifiers

- **Names, email addresses, CCN, etc**
  “old school”

- **Can be combined with offline sources**
  Credit agencies, public legal records, tax documents, etc

- **Baked into the web**
  Authentication, user accounts, etc

Partitioning to the Rescue (?)

- **User holds the “true” value**
  e.g., true email address

- **Browser holds a secret**
  e.g., secret = rand()

- **Derive per site identities**
  e.g. hash(email + secret + eTLD+1) + @private-email.com

- **Applicable to a range of identifiers**
  Email, CCN, Crypto addresses

Personal Identifiers: Defenses

	Chrome	Safari	Edge	Firefox	Brave
Partition email		✓		✓	↻
Partition Web3					↻
Block scripts					⊖

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  A sloppy manifesto

- **Defining Tracking**
  Abstracting the problem

- **Tracking in Practice**
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  Other issues and concerns

Privacy is more than Absence of Tracking

- **Browsers shouldn't share information unless its helpful to user**
  e.g., FLoC

- **Browsers should serve users first and exclusively**
  e.g., Reporting API, FLEDGE

- **Browsers shouldn't introduce capabilities that remove user choice**
  WebBundles

- **Browsers shouldn't confuse users!**
  First-party sets, SXG

- **First-parties are suspect too…**

Other privacy protections

- **Governments increasing provide legal protections**
  GDPR, CCPA, etc

- **Browsers can help users assert their privacy rights**
  e.g., GlobalPrivacyControl

- **Authored by activists, academics, New York Times, DuckDuckGo, Brave**
  Implemented in Brave and DDG

- **Beware of conflating with “consent management” systems**

A final plea…

- You are all plainly, amazingly smart people
- You'll be able to (mostly) choose your job
- Privacy harms are particularly difficult to remediate
- Consider the privacy implications of a job before you take it

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Thanks!