

Privacy on the Web

What do Internet companies know about you?

Pierre Senellart



23 September 2025

Plan

Introduction

Sources of Data

The Angle of Law – A Primer on GDPR

Conclusion

What do Internet companies know about you?

Internet companies

- “Internet companies” is the unfortunate established term
- Only talking about **Web-based services** (dot-com’s)
- Amazon, Google, Meta... and smaller ones as well
- Internet is **not the same thing** as the Web!

What do Internet companies know about you?

Internet companies

- “Internet companies” is the unfortunate established term
- Only talking about **Web-based services** (dot-com’s)
- Amazon, Google, Meta... and smaller ones as well
- Internet is **not the same thing** as the Web!

What do they know about you?

- What **can** they technically know?
- What do they typically **use** it for?
- How can a user **hide** this information?
- How **easy** is it to have this data?

A primer on the Web 1/3

How does the Web work? Say I want to visit

`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211!`

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211`!

My browser: Hello `129.199.166.211`, I would like to talk to your Web server.

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211`!

My browser: Hello `129.199.166.211`, I would like to talk to your Web server.

`129.199.166.211:` Sure thing!

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211`!

My browser: Hello `129.199.166.211`, I would like to talk to your Web server.

`129.199.166.211:` Sure thing!

My browser: Web server, can you give me the page
`/1-ecole-normale-superieure-psl?`

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211`!

My browser: Hello `129.199.166.211`, I would like to talk to your Web server.

`129.199.166.211:` Sure thing!

My browser: Web server, can you give me the page
`/1-ecole-normale-superieure-psl?`

My browser: Oh, and by the way, here is a bunch of other things about who I am
and what I like.

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/1-ecole-normale-superieure-psl.`

My browser: Hum, who is `www.ens.psl.eu`?

My ISP's DNS server: It's the machine `129.199.166.211`!

My browser: Hello `129.199.166.211`, I would like to talk to your Web server.

`129.199.166.211:` Sure thing!

My browser: Web server, can you give me the page
`/1-ecole-normale-superieure-psl?`

My browser: Oh, and by the way, here is a bunch of other things about who I am
and what I like.

My browser: And here is the weird character string you asked me to remind you of
the last time I visited you.

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

My browser: Hum ok, sure.

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

My browser: Hum ok, sure.

My browser: Hey Twitter, could you give me that script that `https://www.ens.psl.eu/1-ecole-normale-superieure-psl` told me to ask you?

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

My browser: Hum ok, sure.

My browser: Hey Twitter, could you give me that script that `https://www.ens.psl.eu/1-ecole-normale-superieure-psl` told me to ask you?

My browser: Oh, and by the way, here is a bunch of other things about who I am and what I like.

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

My browser: Hum ok, sure.

My browser: Hey Twitter, could you give me that script that `https://www.ens.psl.eu/1-ecole-normale-superieure-psl` told me to ask you?

My browser: Oh, and by the way, here is a bunch of other things about who I am and what I like.

My browser: And here is the weird character string you asked me to remind you of the last time I visited you.

A primer on the Web 2/3

Web server on 129.199.166.211: Here is what you requested; if you really want to see the content in full, you should also load all these scripts and images on the same site, as well as this bunch of scripts from the following companies: Twitter/X, Google, MaxCDN, and Scoop.it.

My browser: Hum ok, sure.

My browser: Hey Twitter, could you give me that script that `https://www.ens.psl.eu/1-ecole-normale-superieure-psl` told me to ask you?

My browser: Oh, and by the way, here is a bunch of other things about who I am and what I like.

My browser: And here is the weird character string you asked me to remind you of the last time I visited you.

...

A primer on the Web 3/3

My browser: Finally! Got all the content. Now I need to execute all these scripts, I am pretty sure some of which will make me fetch content again from all over the internet

A primer on the Web 3/3

My browser: Finally! Got all the content. Now I need to execute all these scripts, I am pretty sure some of which will make me fetch content again from all over the internet

...

A primer on the Web 3/3

My browser: Finally! Got all the content. Now I need to execute all these scripts, I am pretty sure some of which will make me fetch content again from all over the internet

...

My browser: Hey, user, your page is ready! Had to do 150 requests and download 2.2 MB of data, so took me a few seconds. But the result is pretty cool, isn't it?

A primer on the Web 3/3

My browser: Finally! Got all the content. Now I need to execute all these scripts, I am pretty sure some of which will make me fetch content again from all over the internet

...

My browser: Hey, user, your page is ready! Had to do 150 requests and download 2.2 MB of data, so took me a few seconds. But the result is pretty cool, isn't it?

My browser: By the way, as long as you are on this page, I'll keep contacting Twitter every 30 seconds, they asked me to, and it would be rude not to.

Not all Web sites are like that

- Fairly **typical** example

Not all Web sites are like that

- Fairly **typical** example
- **Worse** on Web sites that publish ads (news sites, blogs, etc.) or that have agreements with ad networks (e-commerce sites)

Not all Web sites are like that

- Fairly **typical** example
- **Worse** on Web sites that publish ads (news sites, blogs, etc.) or that have agreements with ad networks (e-commerce sites)
- **Better** on some “old-school” institutional Web site:

Not all Web sites are like that

- Fairly **typical** example
- **Worse** on Web sites that publish ads (news sites, blogs, etc.) or that have agreements with ad networks (e-commerce sites)
- **Better** on some “old-school” institutional Web site:
<https://www.di.ens.fr/> no reference to material hosted by third parties

Not all Web sites are like that

- Fairly **typical** example
- **Worse** on Web sites that publish ads (news sites, blogs, etc.) or that have agreements with ad networks (e-commerce sites)
- **Better** on some “old-school” institutional Web site:
<https://www.di.ens.fr/> no reference to material hosted by third parties
<https://dauphine.psl.eu/> reference to material (fonts, video) hosted by Google

Not all Web sites are like that

- Fairly **typical** example
- **Worse** on Web sites that publish ads (news sites, blogs, etc.) or that have agreements with ad networks (e-commerce sites)
- **Better** on some “old-school” institutional Web site:
<https://www.di.ens.fr/> no reference to material hosted by third parties
<https://dauphine.psl.eu/> reference to material (fonts, video) hosted by Google
<https://www.masteriasd.eu/> only (?) a few references to material (fonts) hosted by Google

Why is this a problem?

- Leak of **potentially identifying** or **sensitive information** (see further) to a bunch of private companies
- This data can be used for **targeted marketing** or **profiling** purposes, can be **stolen** if the company is under a cyberattack, etc.
- US companies are subject to the **CLOUD Act**, a US federal law that states that the US government can impose to get access to this data, even if it is not stored on US soil
- Sending personal data to companies outside the EU without a user's specific agreement is mostly **forbidden by the GDPR**. Not just a theoretical concern:

January 2022 The Austrian Data Protection Authority (DPA) rules usage of Google Analytics is in violation of the GDPR

February 2022 A regional court in Munich fines a Web site for use of Google Fonts

February 2022 CNIL (French DPA) rules Google Analytics to be in violation of the GDPR

July 2023 EU-US Data Privacy Framework allowing again transfer of data to the US (but still requires explicit, informed consent!)

Different kinds of data

- Data provided by the user
- Network-level data
- HTTP meta-information
- Browser scripting data
- Past interactions with the Web site
- Past interactions with a third-party Web site that uses a resource of mine

Different kinds of data

- Data provided by the user
- Network-level data
- HTTP meta-information
- Browser scripting data
- Past interactions with the Web site
- Past interactions with a third-party Web site that uses a resource of mine

Don't forget: also technically easy for companies to **share** this information with each other (for a fee, with a reciprocity agreement, etc.)

Data provided by the user 1/2

What can they technically know?

- Any data that they user needs to provide to interact with the service:
 - Email (serves as a **pseudo-identifier**)
 - User-chosen identifier (may be **reused** on other Web sites!)
 - Password (beware of **password reuse!**)
 - For e-commerce: credit card numbers, address, etc.
- Any other data readily **provided by the user** (birthdate, friends, job, interests, etc.)

Data provided by the user 2/2

What do they typically use it for?

Some is needed for **technical** reasons. Some can be used for **profiling**.

How can a user hide this information?

Provide **throwaway** email accounts and logins. Don't **reuse** passwords from a site to the next. Don't provide optional information.

How easy is it for a company to have this data?

Easy... as long as you manage to **attract users**.

Network-level data 1/3

What can they technically know?

- **IP address** (v4 or v6) of the computer sending the request
- From the IP address:
 - **Institution** the IP address belongs to (company, ISP, mobile phone operator)
 - Approximate **geolocation** of the IP address (somewhat precise at the country level, sometimes at the city level)
- **Network quality** information (latency and bandwidth of the communication)

Network-level data 2/3

What do they typically use it for?

- Proposing a different **default choice** of Web site (language, market) based on the geolocation
- Serving different content to **different markets** (e.g., copyrighted material with license only in specific countries)
- Optimizing **connection speeds** (serving a user from a server closer to her)
- Potentially, remembering **past interactions** (but very imprecise)

Network-level data 3/3

How can a user hide this information?

Hard. Route the traffic through a **VPN**, a **proxy**, **Tor**... but Web sites can use databases of IP addresses commonly used by these services. Always possible to route the traffic through another private computer, though.

How easy is it for a company to have this data?

- IP addresses are **readily available**
- **Databases** mapping IP addresses to geolocations, companies, information about uses as VPNs, can **easily** be obtained, with various levels of quality (for free, for a fee, or semi-automatically built over time)
- Network quality information **not as immediate**, but can be obtained with a little work

HTTP meta-information 1/2

What can they technically know?

User-Agent identifies the **browser**, its version, its **operating system**, possibly some other information

Referer gives the URL of the Web page the browser is **coming from**

Accept-Language gives information on the user's **preferred languages** (typically, the language the OS is configured for)

Other headers (**Accept**, **Accept-Encoding**...) **indirectly** and partially **identify** the browser software; also possible through some analysis of protocol-level behavior (support of SPDY, of HTTP/2, of some cryptographic algorithms, of behavior w.r.t. pipelining, etc.)

HTTP meta-information 2/2

What do they typically use it for?

- Serving **different content** to different browsers (in particular desktop vs mobile sites)
- Serving content in the **appropriate language**
- Collect **statistics** about origin of the visit

How can a user hide this information?

The browser can be customized to **hide or spoof** the explicit data. Near impossible for indirect clues identifying the browser.

How easy is it for a company to have this data?

Explicit information **readily available**. Identifying a browser through indirect clues (very) hard, but feasible with effort.

Browser scripting data 1/2

What can they technically know?

- **Timezone** of the user
- Characteristics (resolution, color) of the user's **screen**
- (If the user agrees) Fine **geolocation** data
- Indirectly, computer **performance** data
- Information about the browser **configuration** (e.g., are images or ads displayed? is third-party content loaded?)
- Potentially, every single information about how the user is **interacting** with browser windows displaying the Web site (but not other Web sites! “same-origin policy”):
 - Every mouse move, every key press, every click
 - Indirectly, every copy/paste operation
- Indirectly, device **fingerprinting** (e.g., through canvas fingerprinting or listing of installed fonts), see <https://coveryourtracks.eff.org/>, <https://amiunique.org/>

Browser scripting data 2/2

What do they typically use it for?

- **Customize** a Web site appearance based on a user's configuration
- Run **user experience studies** for fine analysis of a user's interaction with the Web site
- Improve the **user experience** with more reactive Web pages

How can a user hide this information?

Only reliable possibility is to **block all scripts**, but will make many Web sites unusable. Fuzz unique data returned by the browser.

How easy is it for a company to have this data?

Readily available. Advanced tracking or fingerprinting requires important development effort.

Past interactions with the Web site 1/2

What can they technically know?

The browser will happily provide the same piece of information (a **cookie**) every time it visits **the same Web site**. Can be stored (the Web site's choice):

- for a given navigation session;
- or until some date (possibly very far out in the future).

Past interactions with the Web site 2/2

What do they typically use it for?

Remember **who the user is** and **previous interactions** it had with her. Critical for many features of Web sites: keeping a user logged in, shopping baskets, etc.

How can a user hide this information?

Possible to selectively **remove cookies**, or to destroy all cookies after a navigation session (e.g., **private mode**). Possible to block all cookies, but will break many Web sites.

How easy is it for a company to have this data?

Readily available. Obviously, only valuable if the user has had **many interactions**.

Past interactions with a third-party Web site 1/2

What can they technically know?

If a **third-party** Web site requests a **resource** (image, stylesheet, script, media) **hosted** by a company's Web site, this company can have access to **all** previously mentioned information while visiting the third-party Web site (even client-side scripting if the resource is a script), including the **Referer** URL.

In particular, **cookies** are provided, so that the company's Web site can identify the user requesting the resource.

Past interactions with a third-party Web site 2/2

What do they typically use it for?

User tracking. Ad networks in particular heavily rely on this to build a profile of what pages a user visits.

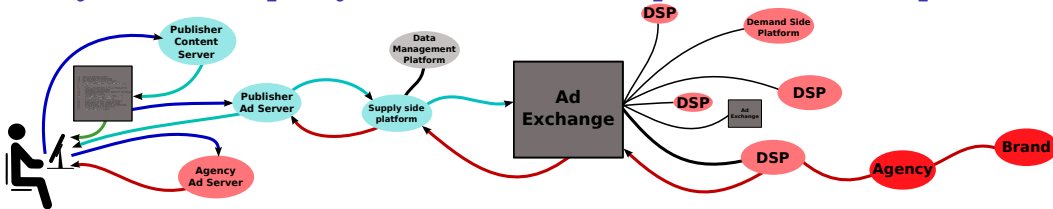
How can a user hide this information?

Block third-party scripts using plugins. **Block third-party cookies.** Will break some functionalities.

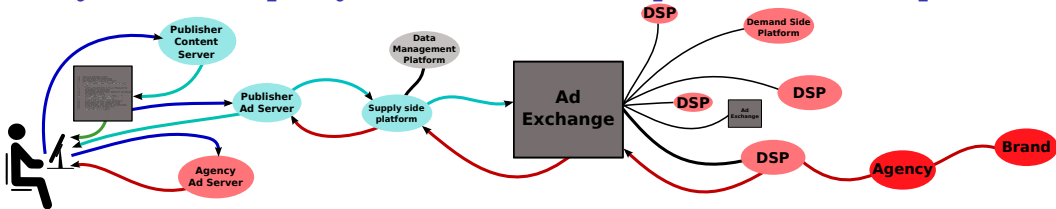
How easy is it for a company to have this data?

Very hard! Requires convincing thousands (or more) of third-party Web sites to include a link to your site. Have to provide a service (ads, analytics, social networking, CDN, widget) that people want to include on their site.

Beyond third-party Web sites: third parties of third parties

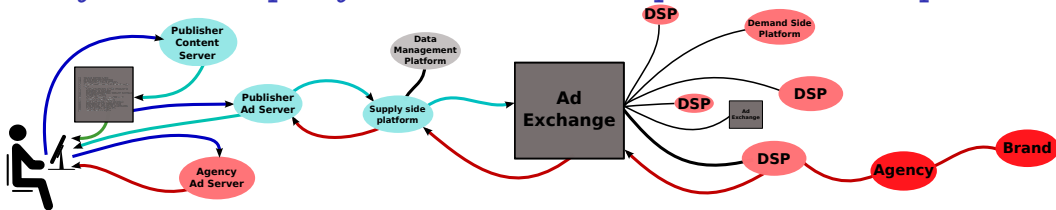


Beyond third-party Web sites: third parties of third parties



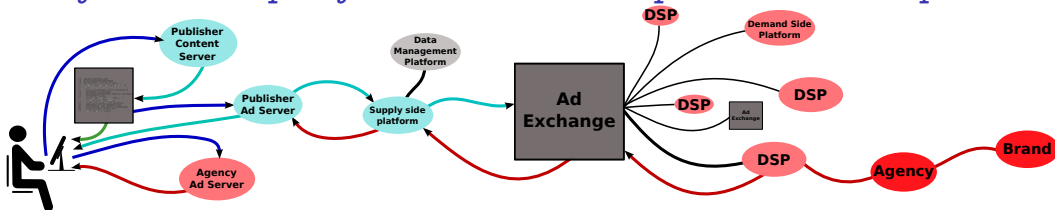
- The publisher ad server and its supply-side platform (Google Ad Manager, Rubicon) can identify the user with cookies...

Beyond third-party Web sites: third parties of third parties



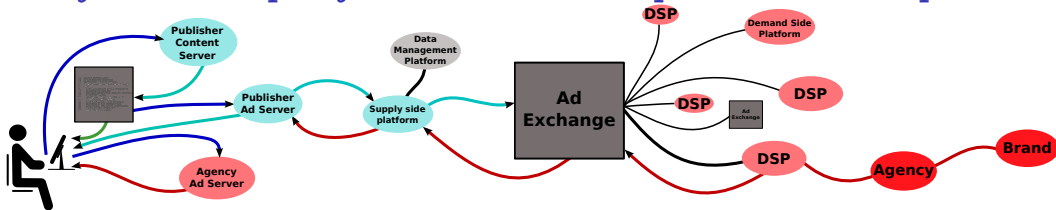
- The publisher ad server and its supply-side platform (Google Ad Manager, Rubicon) can **identify** the user with cookies...
- ... but the demand-side platform (say, Xandr, Criteo) cannot, since it does **not directly** interact with the user (at least until the ad is displayed to the user)

Beyond third-party Web sites: third parties of third parties



- The publisher ad server and its supply-side platform (Google Ad Manager, Rubicon) can **identify** the user with cookies. . .
- . . . but the demand-side platform (say, Xandr, Criteo) cannot, since it does **not directly** interact with the user (at least until the ad is displayed to the user)
- To solve this “problem”, the SSP shares, through the ad exchange (typically Google Ad Exchange) its cookie information with the DSP, which can then perform **cookie matching** to reidentify the user

Beyond third-party Web sites: third parties of third parties



- The publisher ad server and its supply-side platform (Google Ad Manager, Rubicon) can **identify** the user with cookies. . .
- . . . but the demand-side platform (say, Xandr, Criteo) cannot, since it does **not directly** interact with the user (at least until the ad is displayed to the user)
- To solve this “problem”, the SSP shares, through the ad exchange (typically Google Ad Exchange) its cookie information with the DSP, which can then perform **cookie matching** to reidentify the user
- Huge leak of information! Mechanisms obscure, https://www.usenix.org/system/files/conference/usenixsecurity16/sec16_paper_bashir.pdf

Use case: Google

What can Google know about you?

- Every information you **willingly** or **semi-willingly** provided the company (credit card for Google Play, real name for Google Pay, full GPS history for Google Location History on Android, etc.)
- Every **past interaction** you had with a Web site **owned** by Google (Search, Maps, Mail, Drive, etc.) unless you were not logged in and cookies were not shared (e.g., private mode)
- Every visit of a Web site that uses one of Google's **hosted services** (Google Analytics, Google Hosted Libraries, Google Fonts, Google AdSense. . .) unless third-party cookies are not shared
- Every visit of a Web site that includes **advertisements** served by a chain involving Google Ad Exchange (the vast majority of Web sites with ads) unless third-party cookies are not shared

Not necessarily making full use of this, but the technical potential is there.

Use case: Google

What can Google know about you?

- Every information you **willingly** or **semi-willingly** provided the company (credit card for Google Play, real name for Google Pay, full GPS history for Google Location History on Android, etc.)
- Every **past interaction** you had with a Web site **owned** by Google (Search, Maps, Mail, Drive, etc.) unless you were not logged in and cookies were not shared (e.g., private mode)
- Every visit of a Web site that uses one of Google's **hosted services** (Google Analytics, Google Hosted Libraries, Google Fonts, Google AdSense. . .) unless third-party cookies are not shared
- Every visit of a Web site that includes **advertisements** served by a chain involving Google Ad Exchange (the vast majority of Web sites with ads) unless third-party cookies are not shared

Not necessarily making full use of this, but the technical potential is there. Want to be scared? Check <https://takeout.google.com/>

Use case: Meta

What can Meta know about you?

- Every information you **willingly** or **semi-willingly** provided the company (Facebook account information, detailed profile, information about friends, posts and uploaded media, likes, comments... as well as data gathered by Facebook app on smartphones, such as geolocation, contact information, etc.)
- Every **past interaction** (pages visited, etc.) you had with a Web site (or app) **owned** by Facebook (Facebook, but also Instagram, Messenger, Meta Quest...) unless you were not logged in and cookies were not shared (e.g., private mode)
- Every visit of a Web site or app that uses one of Facebook's **hosted services** (Facebook like button, embedded comments, etc.), unless third-party cookies are not shared
- Every visit of a Web site or app that includes **advertisements** served by a chain involving Facebook (Facebook Audience) unless third-party cookies are not shared

Not necessarily making full use of this, but the technical potential is there.

Plan

Introduction

Sources of Data

The Angle of Law – A Primer on GDPR

Conclusion

General Data Protection Regulation

- **EU Regulation** 2016/679
- Regulates the use of **personal data** in the EU
- Applies to every processing of personal data of an EU resident, even by companies **not resident in the EU**
- In France, completes the historical law on “Informatique et liberté” from 1978, which was revised to implement the GDPR in 2019; data protection office: CNIL
- It's not because something is technically possible that it's legal!

Article 4

For the purposes of this Regulation:

- *'personal data' means any information relating to an identified or identifiable natural person ('data subject'); an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person;*
- *(...)*
- *'pseudonymisation' means the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organisational measures to ensure that the personal data are not attributed to an identified or identifiable natural person;*
- *(...)*

Recital 26

The principles of data protection should apply to any information concerning an identified or identifiable natural person.

Personal data which have undergone pseudonymisation, which could be attributed to a natural person by the use of additional information should be considered to be information on an identifiable natural person.

To determine whether a natural person is identifiable, account should be taken of all the means reasonably likely to be used, such as singling out, either by the controller or by another person to identify the natural person directly or indirectly.

To ascertain whether means are reasonably likely to be used to identify the natural person, account should be taken of all objective factors, such as the costs of and the amount of time required for identification, taking into consideration the available technology at the time of the processing and technological developments.

The principles of data protection should therefore not apply to anonymous information, namely information which does not relate to an identified or identifiable natural person or to personal data rendered anonymous in such a manner that the data subject is not or no longer identifiable.

Article 6

Processing shall be lawful only if and to the extent that at least one of the following applies:

- *the data subject has given consent to the processing of his or her personal data for one or more specific purposes;*
- *processing is necessary for the performance of a contract to which the data subject is party or in order to take steps at the request of the data subject prior to entering into a contract;*
- *processing is necessary for compliance with a legal obligation to which the controller is subject;*
- *processing is necessary in order to protect the vital interests of the data subject or of another natural person;*
- *processing is necessary for the performance of a task carried out in the public interest or in the exercise of official authority vested in the controller;*
- *processing is necessary for the purposes of the legitimate interests pursued by the controller or by a third party, except where such interests are overridden by the interests or fundamental rights and freedoms of the data subject which require protection of personal data (...)*

Plan

Introduction

Sources of Data

The Angle of Law – A Primer on GDPR

Conclusion

What about apps?

- Much worse!

What about apps?

- Much **worse!**
- Everything that a Web site can do, but...

What about apps?

- Much **worse!**
- Everything that a Web site can do, but...
- At least Web sites follow (vaguely) clear technical protocols and standards. Apps can do what they want (within the limits imposed by the OS).

What about apps?

- Much **worse!**
- Everything that a Web site can do, but...
- At least Web sites follow (vaguely) clear technical protocols and standards. Apps can do what they want (within the limits imposed by the OS).
- At least a browser can work in the user's interest. Apps don't.

What about apps?

- Much **worse!**
- Everything that a Web site can do, but...
- At least Web sites follow (vaguely) clear technical protocols and standards. Apps can do what they want (within the limits imposed by the OS).
- At least a browser can work in the user's interest. Apps don't.
- At least a browser can be customized to fuzz or not provide some information. Apps can't.

A paranoid's toolbox for browsing the Web

- An **open-source** and heavily configurable Web browser that **doesn't phone home** (Firefox, Chromium, Pale Moon, Brave)
- **Mask** the originating IP (e.g., with the Tor Browser)
- Activate the “**Do Not Track**” option (but not clear meaning for this option!)
- Plugins to **spooof** the User-Agent and Referer information
- Plugins such as Adblock Plus or uBlock Origin to **block third-party ads** (based on lists and heuristics)
- Plugins such as Ghostery or DoNotTrackMe to **block tracking cookies and fingerprinting code**
- Plugins such as NoScript to selectively **block scripts**
- Possible to block **all third-party cookies** altogether (but some features won't work)
- Possible to block **all client-side scripts** (many sites won't work!)
- Use Private Mode to have information (esp., cookies) **not retained** from one navigation session to the next

Questions?

Online advertising schema CC-BY-SA John Nagle, see <https://commons.wikimedia.org/wiki/File:Adsgivingfull.svg>