Anonymization, privacy

Motivation: What do Internet companies know about you?

Pierre Senellart

22 January 2021

Dissecting the title

Internet companies

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

Dissecting the title

Internet companies

- "Internet companies" is the unfortunate established term
- Only talking about Web-based services (dot-com's)
- Amazon, Google, Facebook... 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 can a new company have access to the same data?

Dissecting the title

Internet companies

- "Internet companies" is the unfortunate established term
- Only talking about Web-based services (dot-com's)
- Amazon, Google, Facebook... 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 can a new company have access to the same data?

Not discussing legal, ethical, or economic aspects!

A primer on the Web 1/3

How does the Web work? Say I want to visit
`https://www.ens.psl.eu/l-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/l-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/l-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/l-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/l-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/l-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
`/l-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/l-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
`/l-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/l-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
`/l-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, 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, 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, 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/l-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, 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/l-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, 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/l-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, 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/l-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 142 requests and download 1.9 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 142 requests and download 1.9 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/ 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/ no reference to material hosted by third parties
  https://www.lamsade.dauphine.fr/wp/iasd/ only (?) a few references to material (fonts) hosted by Google

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 can a new company have access to the same 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 can a new company have access to the same 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 can a new company have access to the same 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://panopticlick.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 can a new company have access to the same 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 can a new company have access to the same 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.

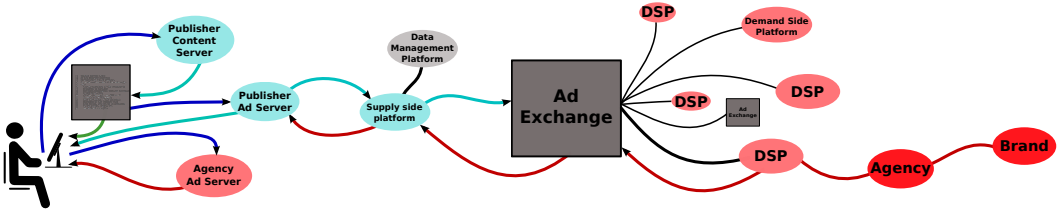
How can a user hide this information?

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

How can a new company have access to the same data?

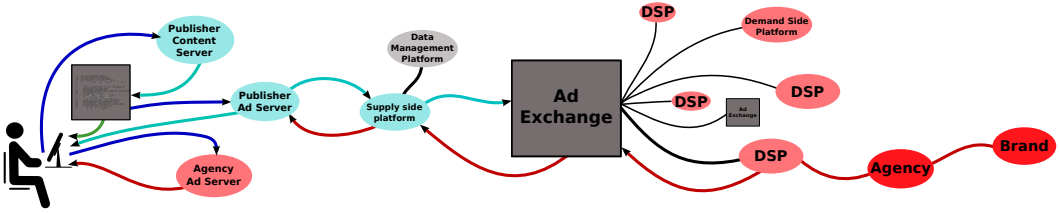
Very hard! Requires convincing thousands (or more) of third-party Web sites to include a link to your site. Have to provide a service (ads, analytics, social networking, CDN, widget) that people want to include on their site.

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



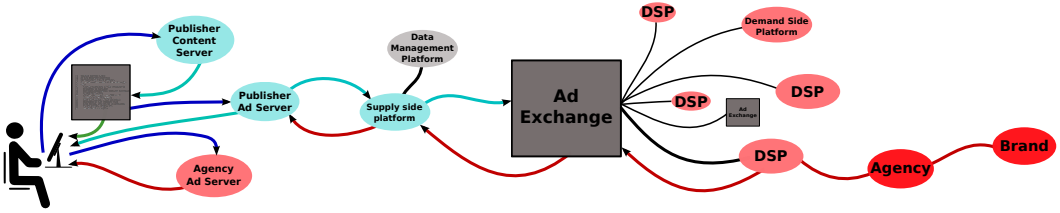
- The publisher ad server and its supply-side platform (Google DFP, Rubicon) can identify the user with cookies...

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



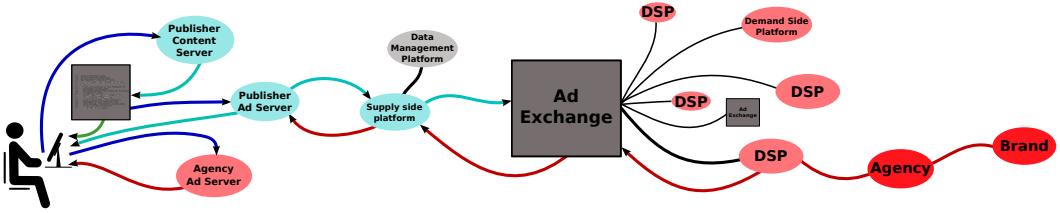
- The publisher ad server and its supply-side platform (Google DFP, Rubicon) can identify the user with cookies...
- ... but the demand-side platform (say, AppNexus, Criteo) cannot, since it does not directly interact with the user (at least until the ad is displayed to the user)

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



- The publisher ad server and its supply-side platform (Google DFP, Rubicon) can identify the user with cookies...
- ... but the demand-side platform (say, AppNexus, 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 Doubleclick) 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 DFP, Rubicon) can identify the user with cookies...
- ... but the demand-side platform (say, AppNexus, 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 Doubleclick) 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 Locations services 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 Doubleclick (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: Facebook

What can Facebook 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, Facebook Messenger, Oculus...) 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.

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. App 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. App 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)
- Masking the originating IP (e.g., with the Tor Browser)
- Activate the "Do Not Track" option (but not clear meaning for this option!)
- Plugins to spoof 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:Adservingfull.svg