Caching and performance

https://github.com/heig-vd-dai-course

Web · PDF

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Based on the original course by O. Liechti and J. Ehrensberger.

Objectives

- Understand the concepts of caching
- Understand how caching can improve performance
- Understand how HTTP features can help to cache data
- Implement caching in a web application

Caching

More details for this section in the course material. You can find other resources and alternatives as well.

Caching

Process of **storing a copy of a resource to serve it faster**.

Caching can **improve the performance** of a system and **reduce the load** on the backend.

Caching can be done on the **client-side** or **server-side**.

Types of caching

- **Client-side caching** (private caches): once a client has received a response from a server, it can store the response in a cache. The next time the client needs the same resource, it can use the cached response instead of sending a new request to the server.
- **Server-side caching** (shared caches): the server stores data in a cache with the help of a reverse proxy or by the web application. The next time the server needs the same resource, it can use the cached response instead of processing the request again.

CDN

Content Delivery Network (CDN) is a network of servers that are geographically distributed around the world.

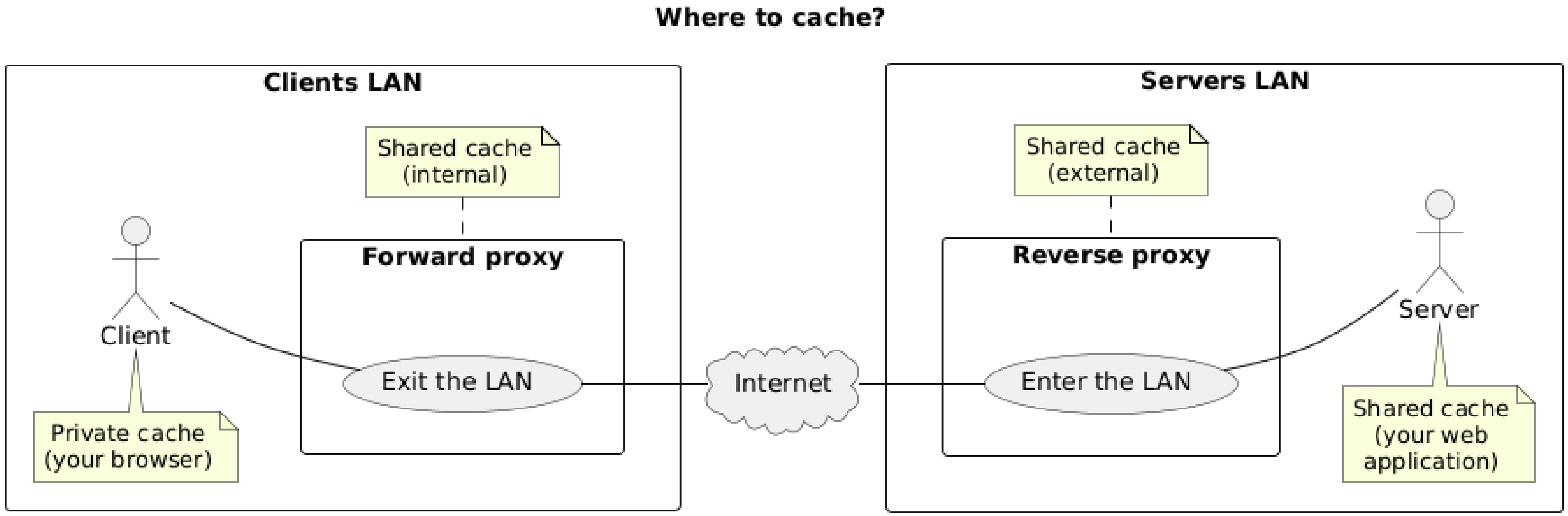
Improve performance by serving static content (images, videos, etc.) from the closest server.

Where to cache?

The best would be to cache at each level of the system to ensure the best performance but it is not always possible or faisable:

- **Client-side**: the cache is stored on the client
- **Server-side**: the cache is stored on the server
- **CDN**: the cache is stored on a CDN

Private caches are caches that are only used by one client. Public caches are caches that are used by multiple clients.


Where to cache?
Clients LAN
Shared cache (internal)
Forward proxy
Client
Exit the LAN
Private cache (your browser)
Internet
Servers LAN
Shared cache (external)
Reverse proxy
Enter the LAN
Server
Shared cache (your web application)

Managing cache with HTTP

More details for this section in the course material. You can find other resources and alternatives as well.

Managing cache with HTTP

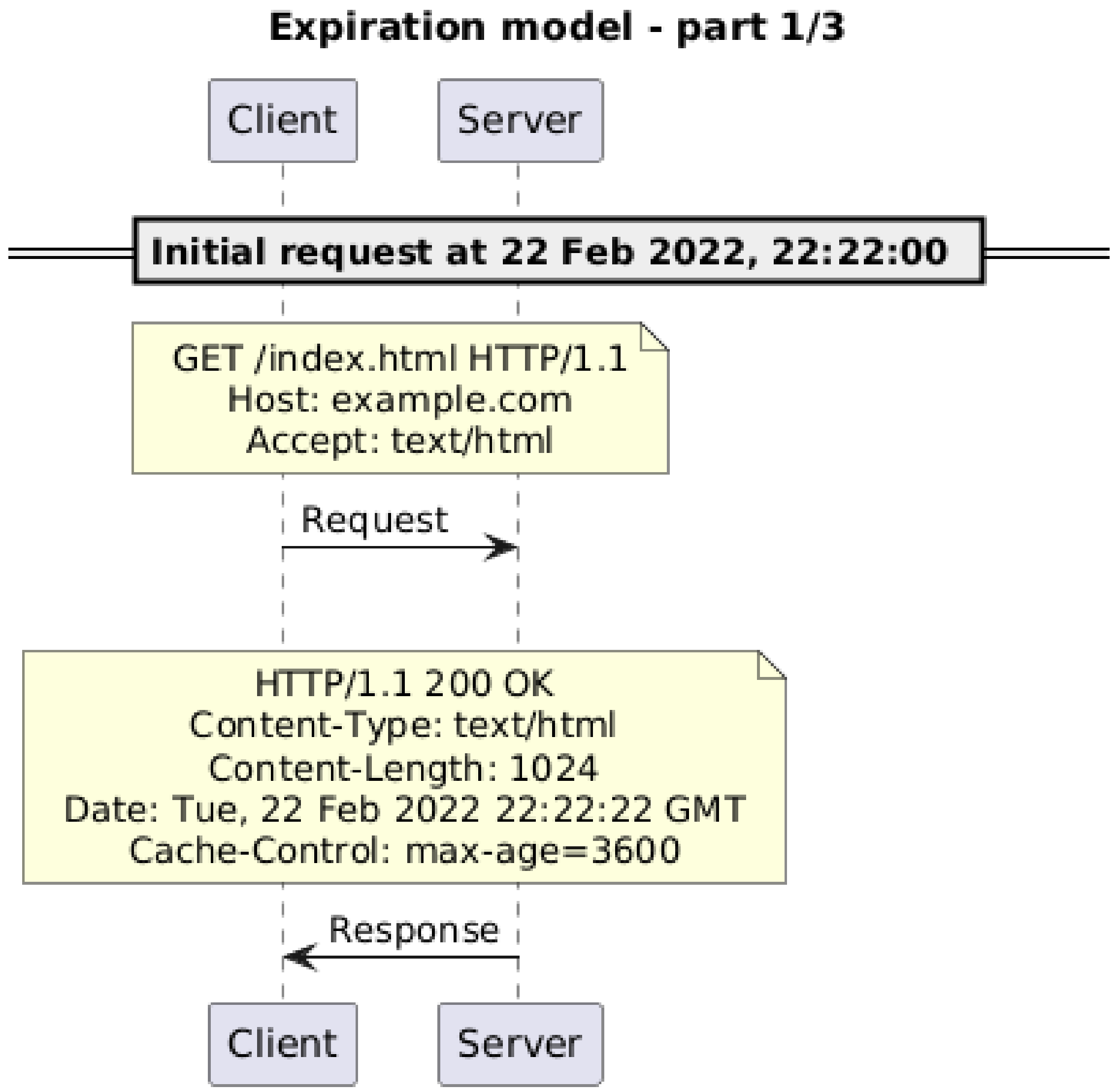
Managing cache is challenging because it is difficult to know when to invalidate the cache (the data can be stale (= outdated)).

Two main caching models:

- **Expiration model**: the cache is considered valid for a certain amount of time
- **Validation model**: the cache is considered valid until the data is modified

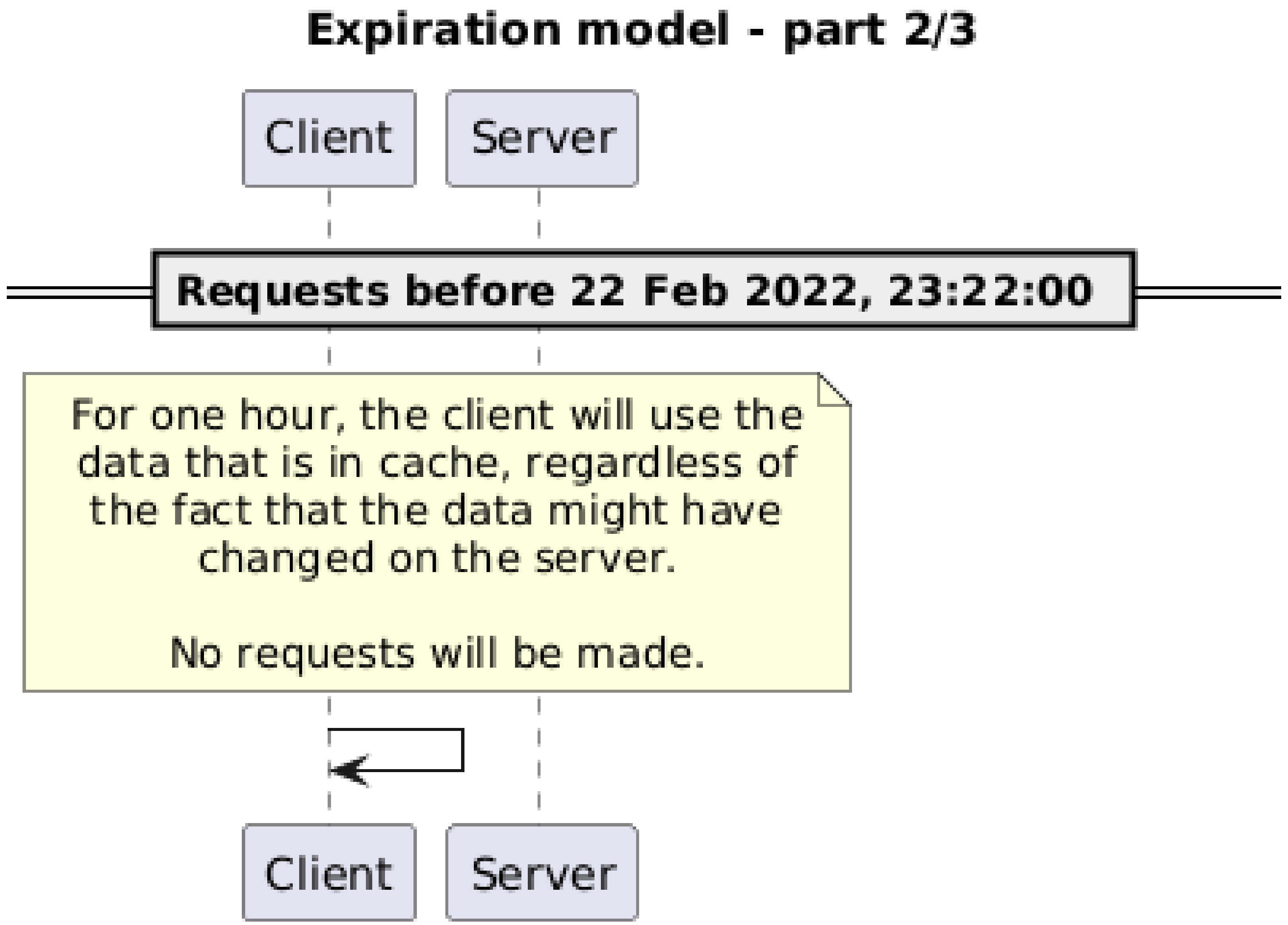
Expiration model

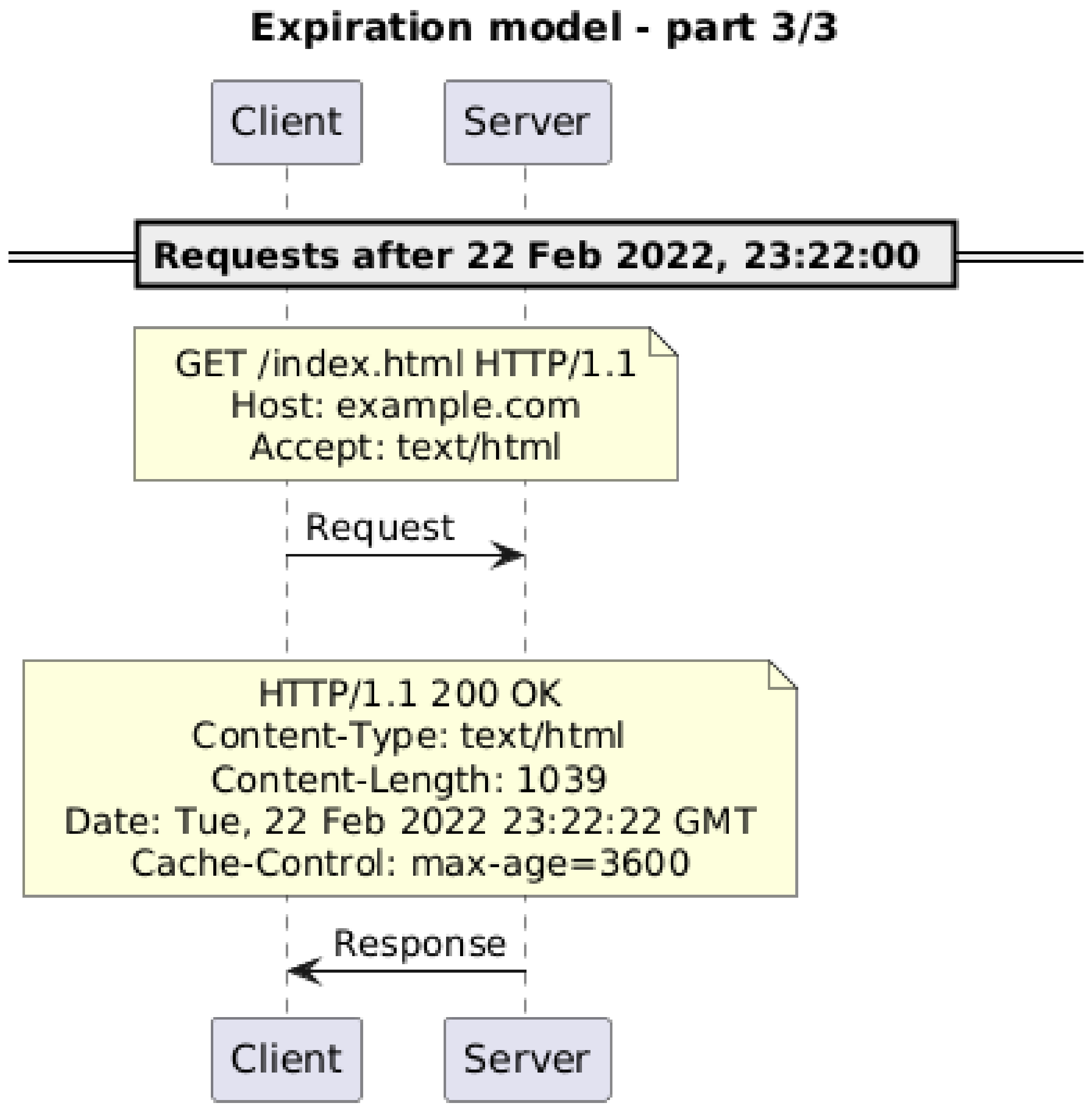
- The cache is valid for a certain amount of time
- If the cache is not expired, the cache is used
- Uses the `Cache-Control: max-age=<secondes>` header
- The cache is invalidated after the expiration time


Expiration model - part 1/3
Client
Server
Initial request at 22 Feb 2022, 22:22:00
Request
Response
Client
Server

```
GET /index.html HTTP/1.1
Host: example.com
Accept: text/html
```

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 1024
Date: Tue, 22 Feb 2022 22:22:22 GMT
Cache-Control: max-age=3600
```


Expiration model - part 2/3
Client
Server
Requests before 22 Feb 2022, 23:22:00
For one hour, the client will use the data that is in cache, regardless of the fact that the data might have changed on the server.
No requests will be made.
Client
Server

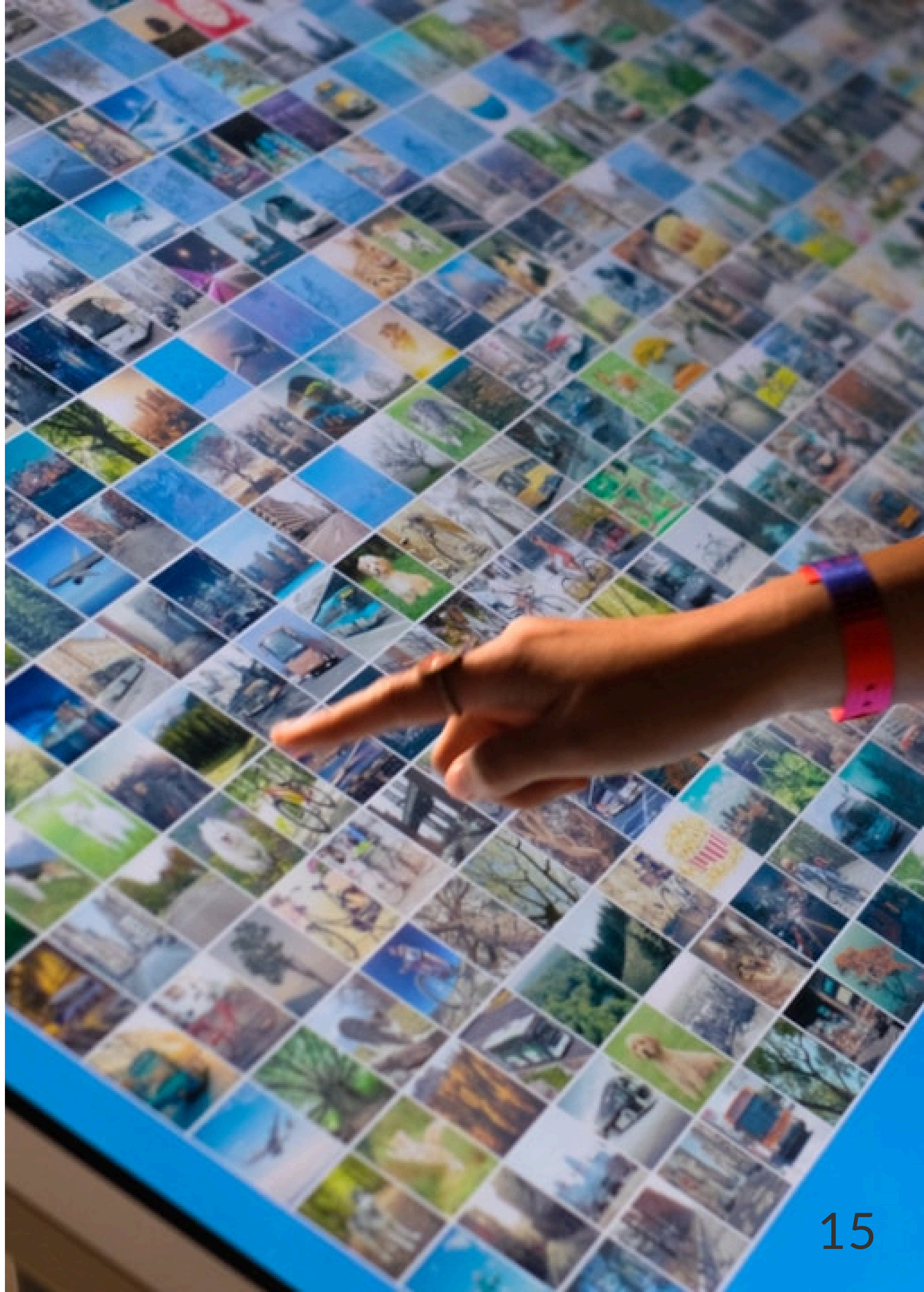

Expiration model - part 3/3
Client
Server
Requests after 22 Feb 2022, 23:22:00
Request
Response
Client
Server

```
GET /index.html HTTP/1.1
Host: example.com
Accept: text/html
```

```
HTTP/1.1 200 OK
Content-Type: text/html
Content-Length: 1039
Date: Tue, 22 Feb 2022 23:22:22 GMT
Cache-Control: max-age=3600
```

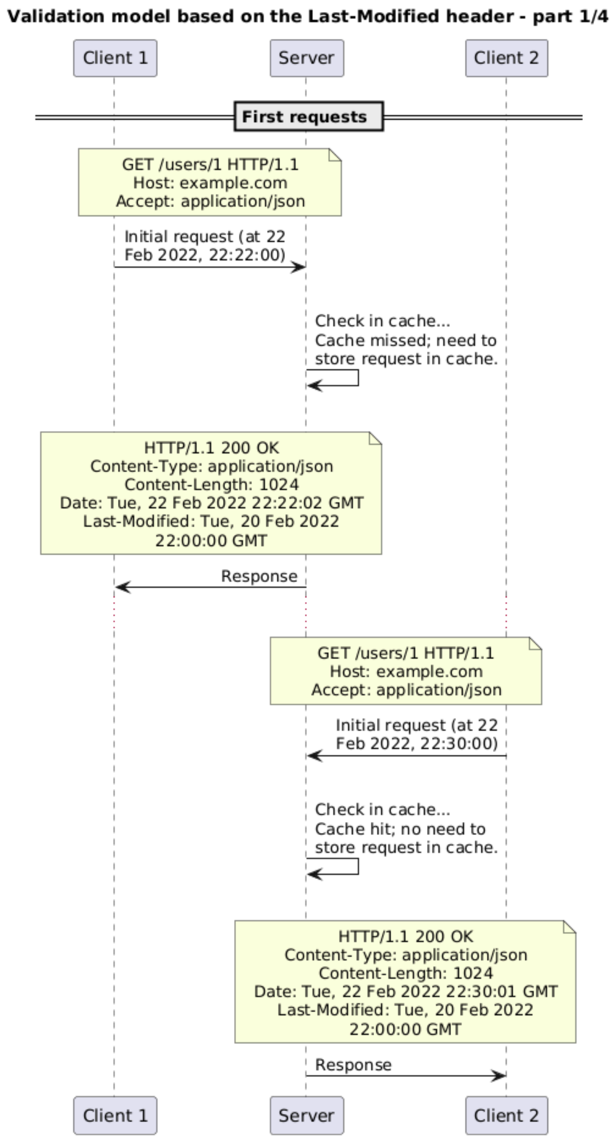
Validation model

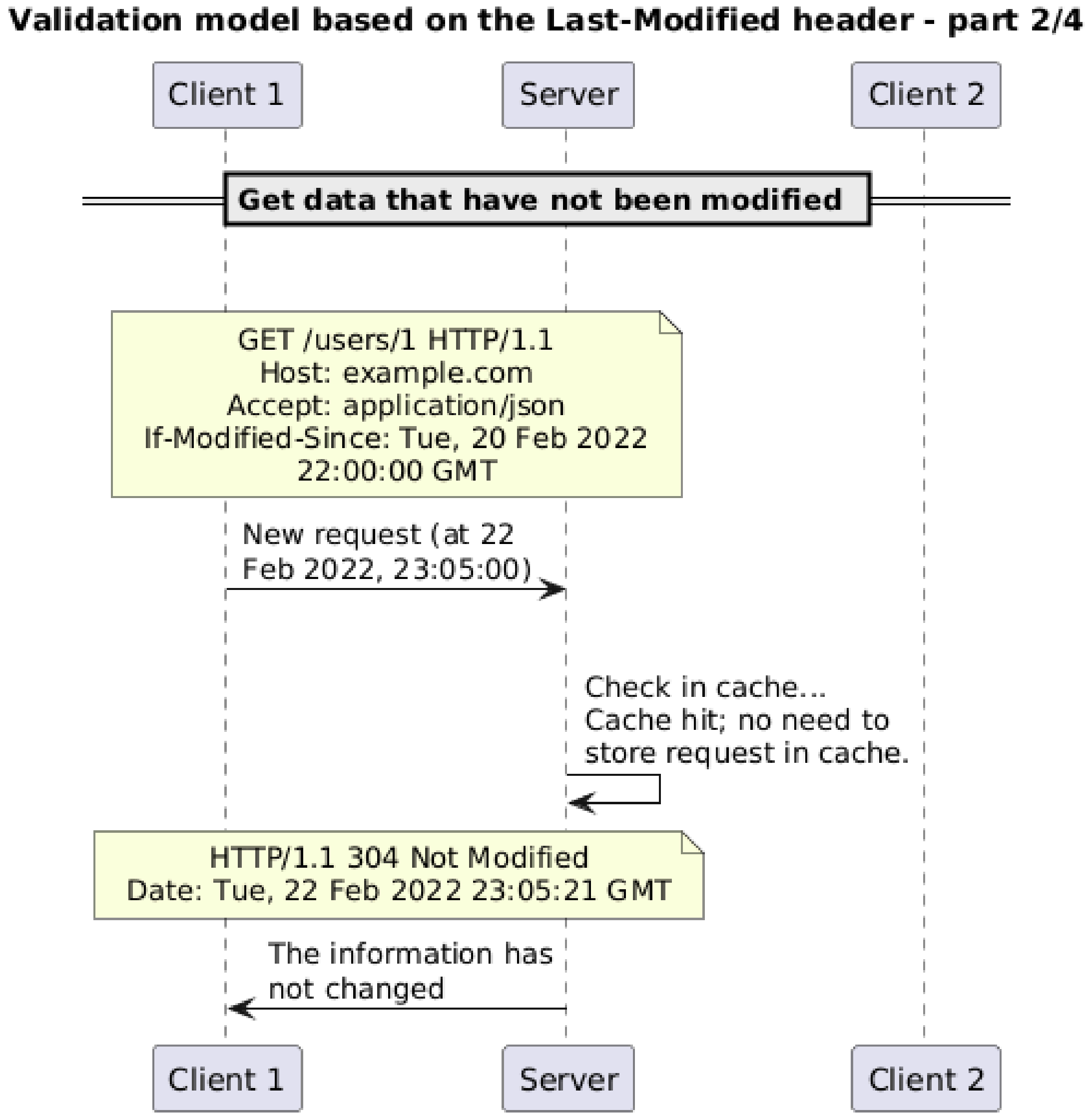
- The cache is valid until the data is modified
- If the cache is not expired, the cache is used
- Two ways to validate the cache:
  - Based on the `Last-Modified` header
  - Based on the `ETag` header



Based on the `Last-Modified` header

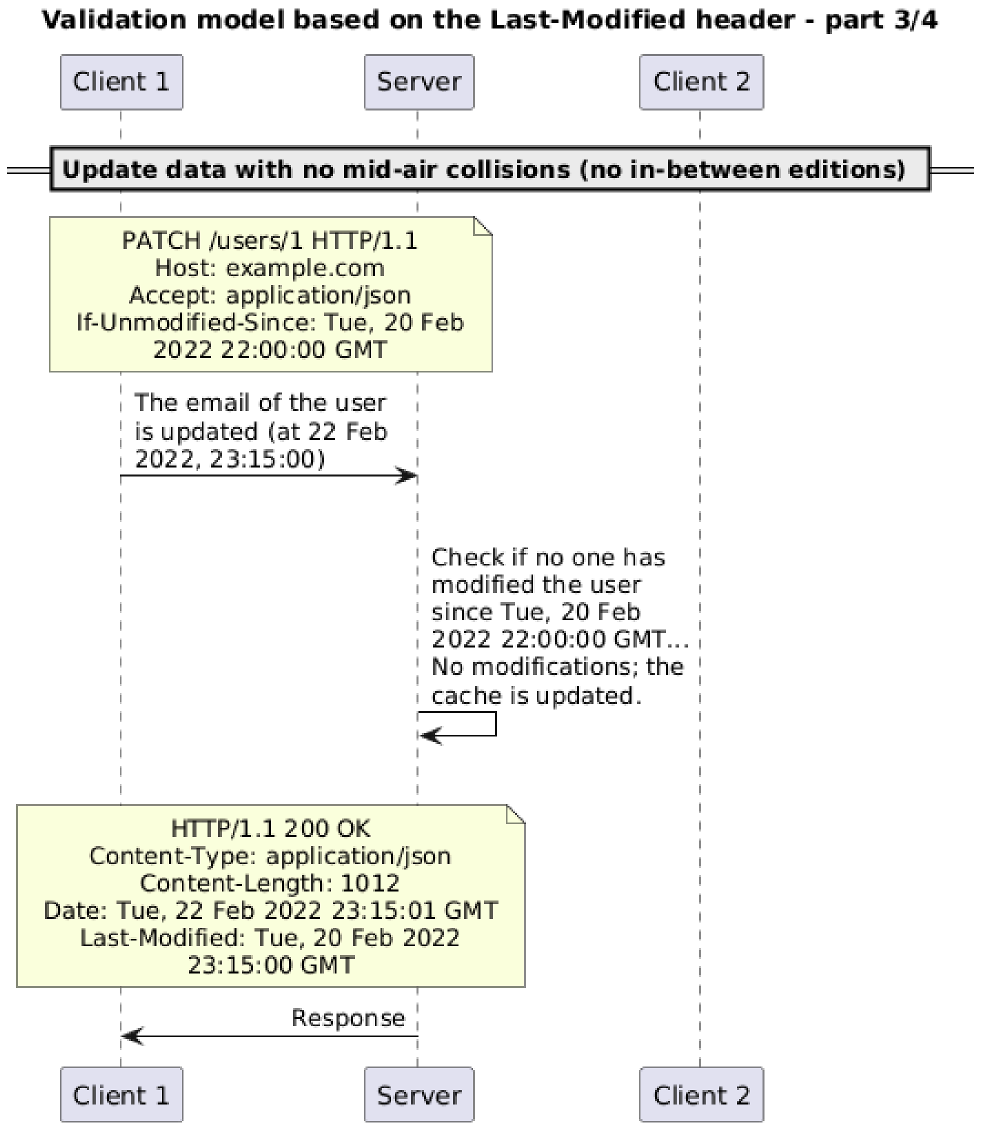
- `Last-Modified`: indicates the date and time at which the resource was last updated.
- `If-Modified-Since`: returns a `304 Not Modified` if content is unchanged since the time specified in this field (= the value of the `Last-Modified` header).
- `If-Unmodified-Since`: returns a `412 Precondition Failed` if content has changed since the time specified in this field (= the value of the `Last-Modified` header) **when you try to update/delete the resource**.


Validation model based on the Last-Modified header - part 1/4
Client 1
Server
Client 2
First requests
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
Initial request (at 22 Feb 2022, 22:22:00)
Check in cache... Cache missed; need to store request in cache.
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1024
Date: Tue, 22 Feb 2022 22:22:02 GMT
Last-Modified: Tue, 20 Feb 2022 22:00:00 GMT
Response
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
Initial request (at 22 Feb 2022, 22:30:00)
Check in cache... Cache hit; no need to store request in cache.
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1024
Date: Tue, 22 Feb 2022 22:30:01 GMT
Last-Modified: Tue, 20 Feb 2022 22:00:00 GMT
Response
Client 1
Server
Client 2


Validation model based on the Last-Modified header - part 2/4
Client 1
Server
Client 2
Get data that have not been modified

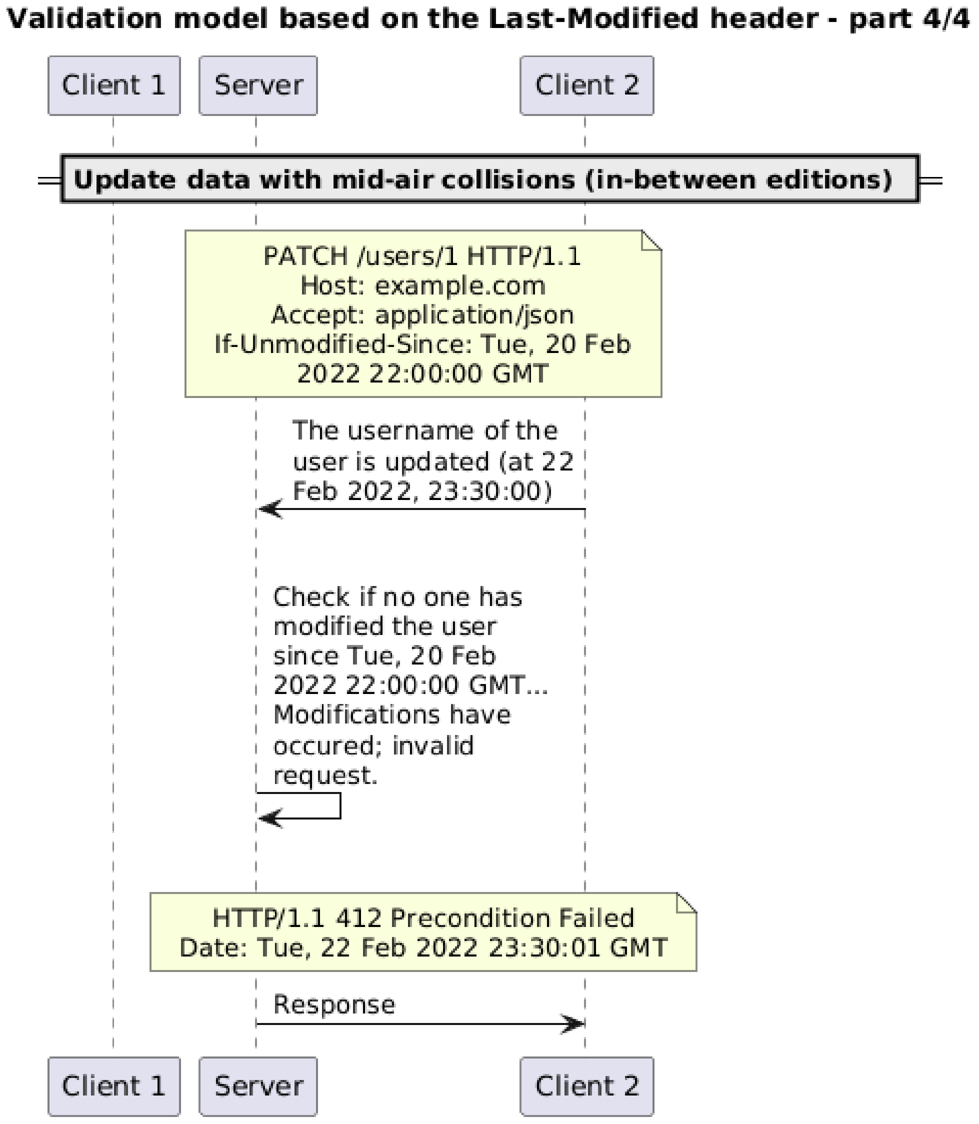
```
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-Modified-Since: Tue, 20 Feb 2022
22:00:00 GMT
```

```
HTTP/1.1 304 Not Modified
Date: Tue, 22 Feb 2022 23:05:21 GMT
```


Validation model based on the Last-Modified header - part 3/4
Client 1
Server
Client 2
Update data with no mid-air collisions (no in-between editions)
The email of the user is updated (at 22 Feb 2022, 23:15:00)
Check if no one has modified the user since Tue, 20 Feb 2022 22:00:00 GMT... No modifications; the cache is updated.
Response
Client 1
Server
Client 2

```
PATCH /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-Unmodified-Since: Tue, 20 Feb 2022 22:00:00 GMT
```

```
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1012
Date: Tue, 22 Feb 2022 23:15:01 GMT
Last-Modified: Tue, 20 Feb 2022 23:15:00 GMT
```

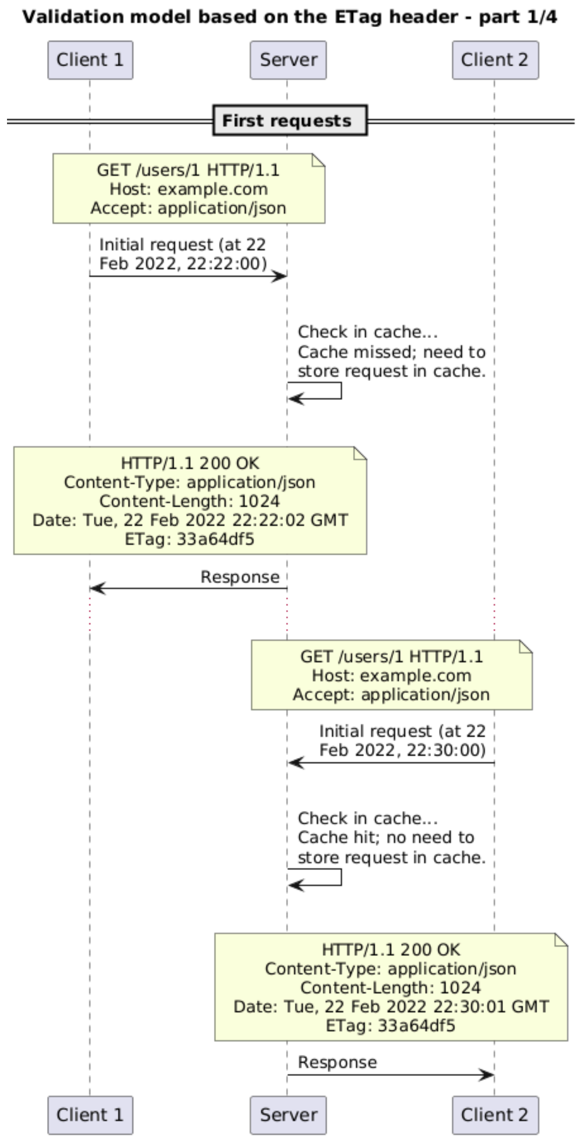

Validation model based on the Last-Modified header - part 4/4
Client 1
Server
Client 2
Update data with mid-air collisions (in-between editions)
The username of the user is updated (at 22 Feb 2022, 23:30:00)
Check if no one has modified the user since Tue, 20 Feb 2022 22:00:00 GMT... Modifications have occured; invalid request.
Response

```
PATCH /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-Unmodified-Since: Tue, 20 Feb 2022 22:00:00 GMT
```

```
HTTP/1.1 412 Precondition Failed
Date: Tue, 22 Feb 2022 23:30:01 GMT
```

Based on the `ETag` header

- `ETag` : provides the current entity tag for the selected representation. Think of it like a version number or a hash for the given resource.
- `If-None-Match` : returns a `304 Not Modified` if content is unchanged for the entity specified (`ETag`) by this field (= the value of the `ETag` header).
- `If-Match` : returns a `412 Precondition Failed` if content is changed for the entity specified (`ETag`) by this field (= the value of the `ETag` header) **when you try to update/delete the resource**.

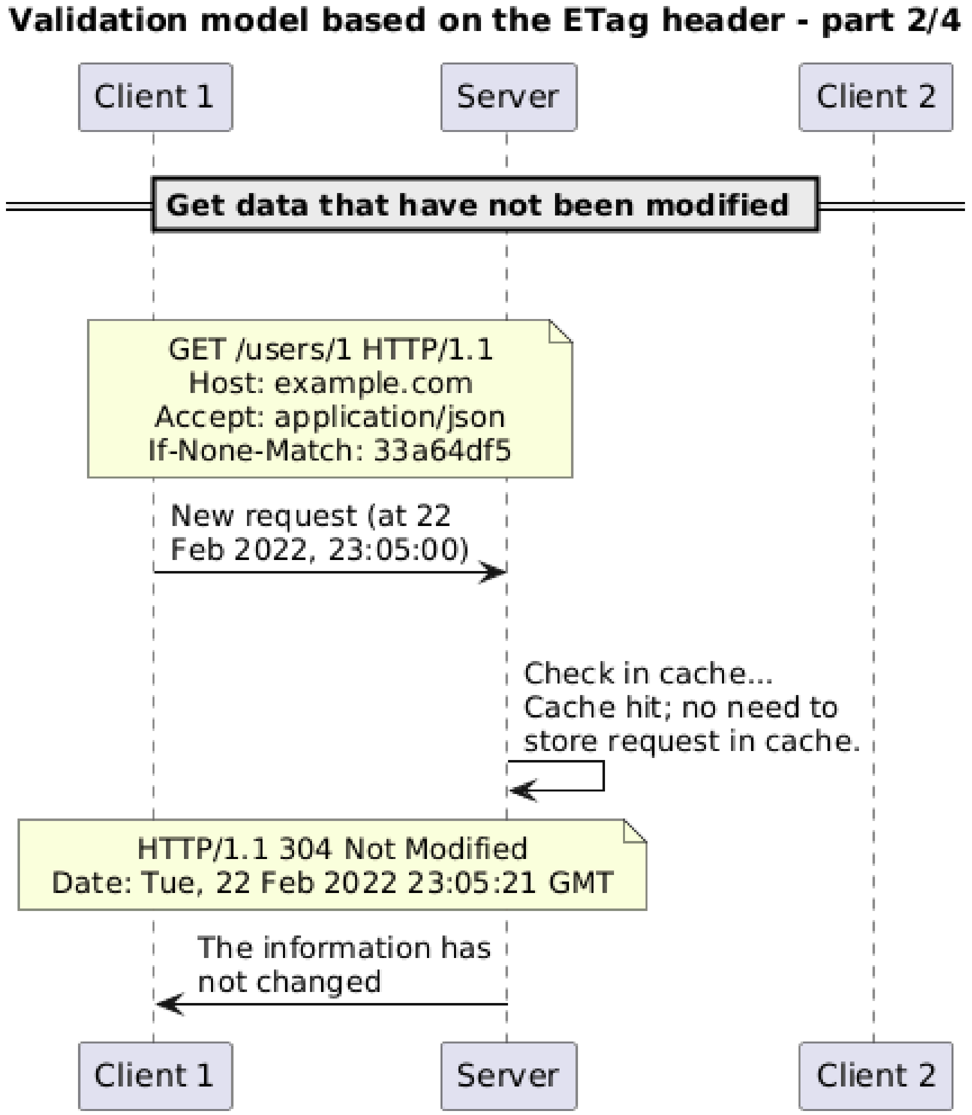

Validation model based on the ETag header - part 1/4
Client 1
Server
Client 2
First requests
Initial request (at 22 Feb 2022, 22:22:00)
Check in cache...
Cache missed; need to store request in cache.
Response
Initial request (at 22 Feb 2022, 22:30:00)
Check in cache...
Cache hit; no need to store request in cache.
Response
Client 1
Server
Client 2

```
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
```

```
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1024
Date: Tue, 22 Feb 2022 22:22:02 GMT
ETag: 33a64df5
```

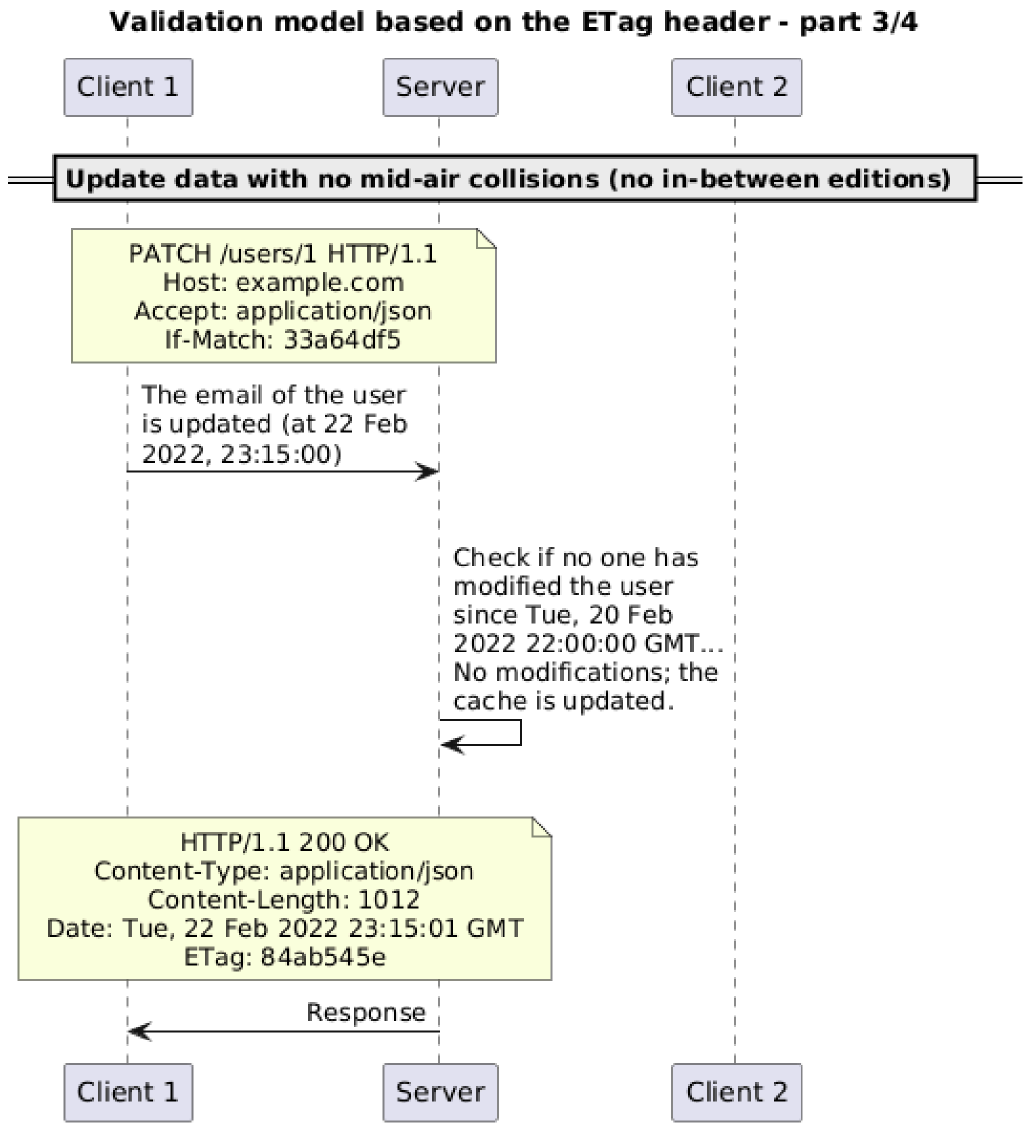
```
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
```

```
HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1024
Date: Tue, 22 Feb 2022 22:30:01 GMT
ETag: 33a64df5
```


Validation model based on the ETag header - part 2/4
Client 1
Server
Client 2
Get data that have not been modified
New request (at 22 Feb 2022, 23:05:00)
Check in cache... Cache hit; no need to store request in cache.
The information has not changed
Client 1
Server
Client 2

```
GET /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-None-Match: 33a64df5
```

```
HTTP/1.1 304 Not Modified
Date: Tue, 22 Feb 2022 23:05:21 GMT
```

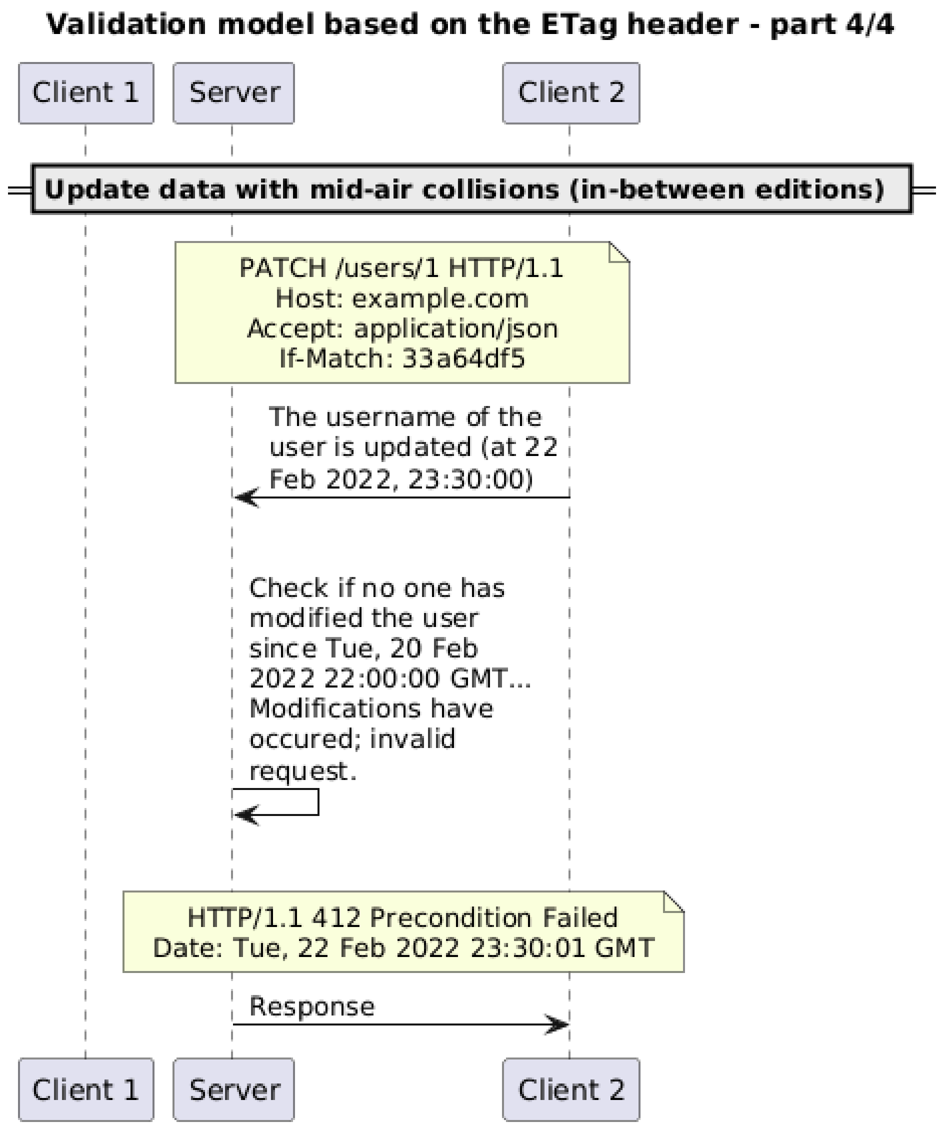

Validation model based on the ETag header - part 3/4
Client 1
Server
Client 2
Update data with no mid-air collisions (no in-between editions)

PATCH /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-Match: 33a64df5

The email of the user is updated (at 22 Feb 2022, 23:15:00)
Check if no one has modified the user since Tue, 20 Feb 2022 22:00:00 GMT... No modifications; the cache is updated.

HTTP/1.1 200 OK
Content-Type: application/json
Content-Length: 1012
Date: Tue, 22 Feb 2022 23:15:01 GMT
ETag: 84ab545e

Response
Client 1
Server
Client 2


Validation model based on the ETag header - part 4/4
Client 1
Server
Client 2
Update data with mid-air collisions (in-between editions)

```
PATCH /users/1 HTTP/1.1
Host: example.com
Accept: application/json
If-Match: 33a64df5
```

The username of the user is updated (at 22 Feb 2022, 23:30:00)
Check if no one has modified the user since Tue, 20 Feb 2022 22:00:00 GMT... Modifications have occured; invalid request.

```
HTTP/1.1 412 Precondition Failed
Date: Tue, 22 Feb 2022 23:30:01 GMT
```

Response
Client 1
Server
Client 2

Is it possible to use both models?

Yes, it is possible to use the expiration model and the validation model at the same time:

- No request attempt at all if the cache is not expired
- Validation model when the cache is expired

Managing cache with proxies

More details for this section in the course material. You can find other resources and alternatives as well.

Managing cache with proxies

Proxies can cache responses to reduce the load on the backend and improve performance.

Traefik offers a caching middleware in its Enterprise version. Out of reach for this course.

Managing cache with key-value stores

More details for this section in the course material. You can find other resources and alternatives as well.

Managing cache with key-value stores

Redis is a popular key-value store that can be used to store cache data.

We will implement this manually in Javalin.

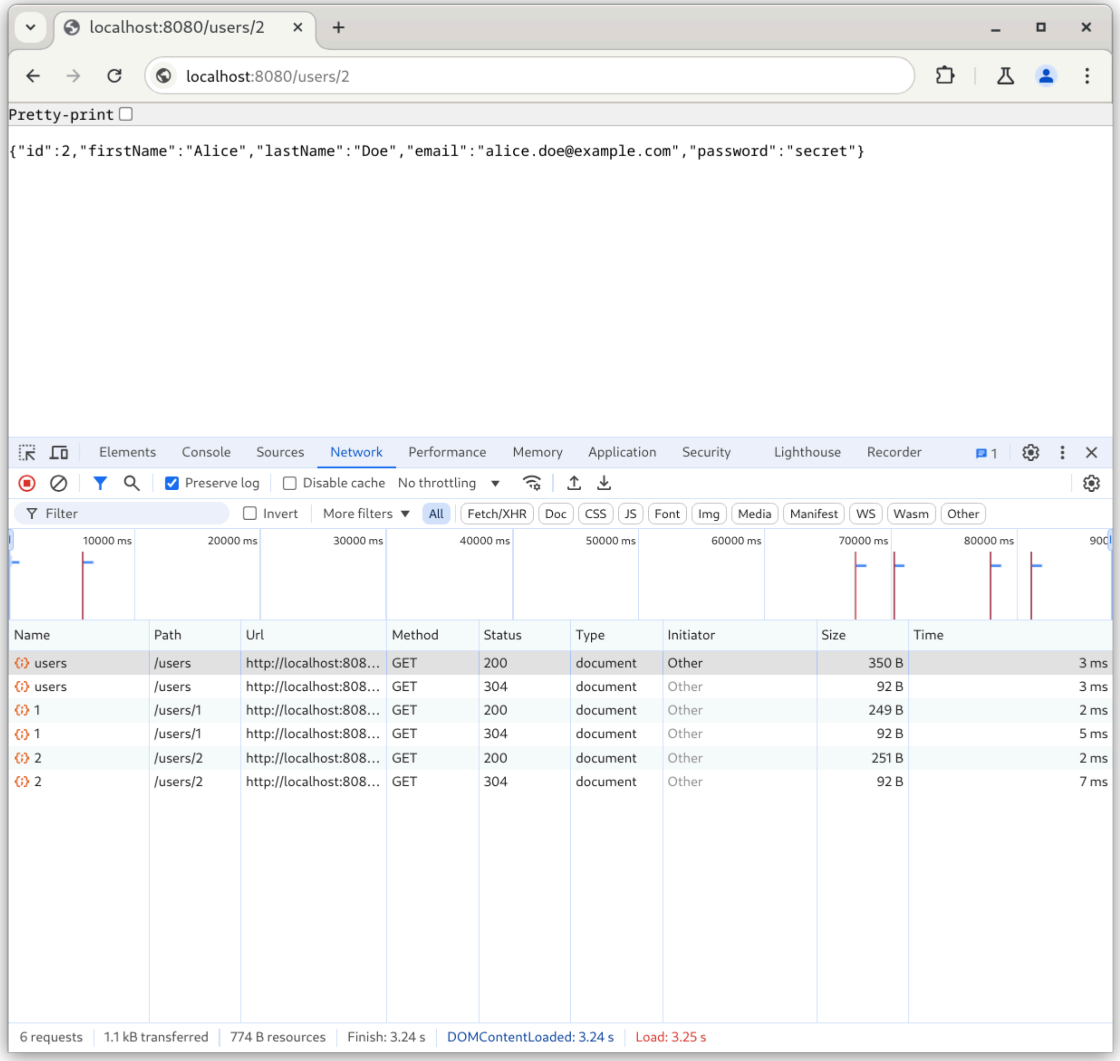
Questions

Do you have any questions?

Practical content

What will you do?

- Implement and validate the validation model based on the `Last-Modified` header in your previous web application using curl and a web browser
- This is your last practical content for this course..!



```
{"id":2,"firstName":"Alice","lastName":"Doe","email":"alice.doe@example.com","password":"secret"}
```

Name	Path	Url	Method	Status	Type	Initiator	Size	Time
users	/users	http://localhost:808...	GET	200	document	Other	350 B	3 ms
users	/users	http://localhost:808...	GET	304	document	Other	92 B	3 ms
1	/users/1	http://localhost:808...	GET	200	document	Other	249 B	2 ms
1	/users/1	http://localhost:808...	GET	304	document	Other	92 B	5 ms
2	/users/2	http://localhost:808...	GET	200	document	Other	251 B	2 ms
2	/users/2	http://localhost:808...	GET	304	document	Other	92 B	7 ms

6 requests | 1.1 kB transferred | 774 B resources | Finish: 3.24 s | DOMContentLoaded: 3.24 s | Load: 3.25 s

Find the practical content

You can find the practical content for this chapter on GitHub.

Finished? Was it easy? Was it hard?

Can you let us know what was easy and what was difficult for you during this chapter?

This will help us to improve the course and adapt the content to your needs. If we notice some difficulties, we will come back to you to help you.

➡️ GitHub Discussions

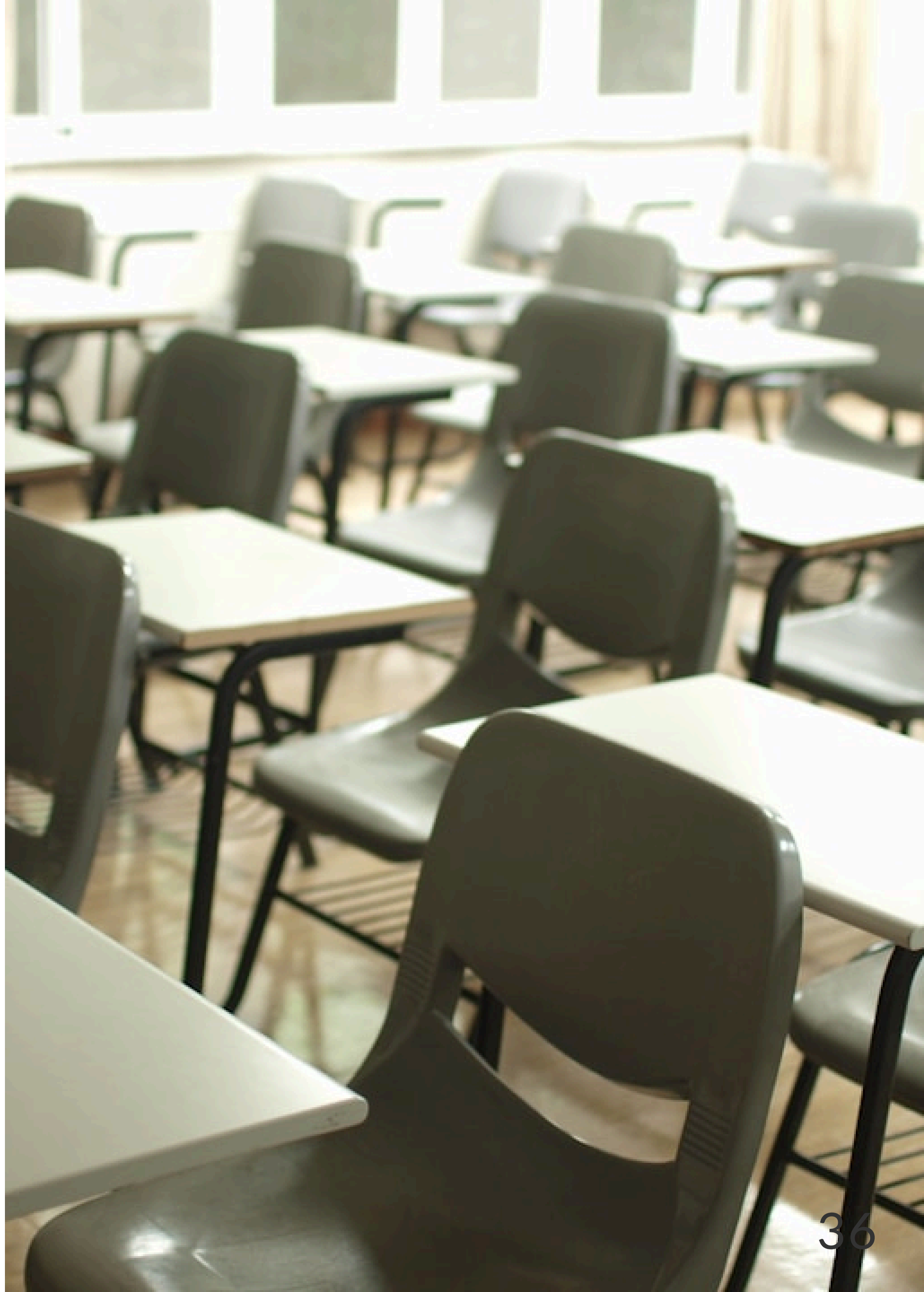
You can use reactions to express your opinion on a comment!

What will you do next?

We are arriving at the end of the third part of the course.

An evaluation will be done to check your understanding of all the content seen in this third part.

More details will be given in the next chapter.



Sources

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