COMPUTER ENGINEERING DEPARTMENT

Graduation Project Proposal Form

CMPE 405 /CMSE 405 /BLGM 405

Instructor Name:	**Gurcu Oz**
Project Title:	**Design YouTube**
Number of team members:	**4**
Semester & Year:	2023-2024 Spring
Type of Project (HW/SW)**:**	**S/W**

Project proposal should be in accordance with ABET requirements, which are stated as: **"The curriculum must include a culminating major engineering design experience that 1) incorporates appropriate engineering standards and multiple constraints, and 2) is based on the knowledge and skills acquired in earlier course work."**

1. Project Overview

In this project, you are asked to design YouTube. The solution to this question can be applied to other interview questions like designing a video sharing platform such as Netflix and Hulu. Figure 1 shows the YouTube homepage.

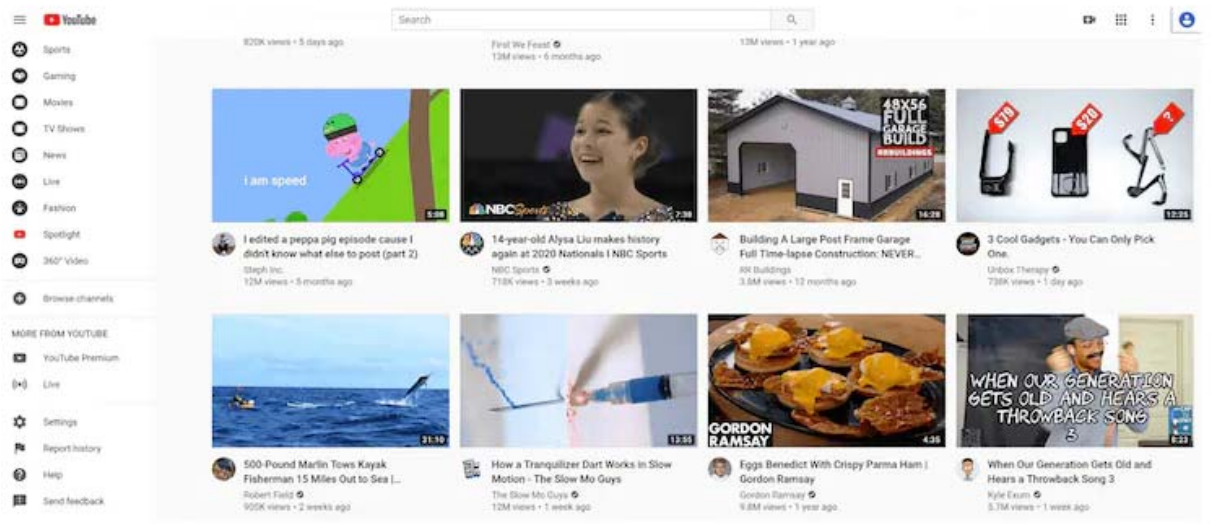

Figure 1

(Source: https://bytebytego.com/courses/system-design-interview/design-youtube)

YouTube looks simple: content creators upload videos and viewers click play. Is it really that simple? Not really. There are lots of complex technologies underneath the simplicity. Let us look at some impressive statistics, demographics, and fun facts of YouTube in 2020 [1] [2].

Total number of monthly active users: 2 billion.
Number of videos watched per day: 5 billion.
73% of US adults use YouTube.
50 million creators on YouTube
YouTube's Ad revenue was $15.1 billion for the full year 2019, up 36% from 2018.
YouTube is responsible for 37% of all mobile internet traffic.
YouTube is available in 80 different languages.
From these statistics, we know YouTube is enormous, global and makes a lot of money.

2. Detailed specification of the project

Step 1 - Understand the problem and establish design scope

As revealed in Figure 1, besides watching a video, you can do a lot more on YouTube. For example, comment, share, or like a video, save a video to playlists, subscribe to a channel, etc.

What features are important?
Ability to upload a video and watch a video.

What clients do we need to support?
Mobile apps, web browsers.

How many daily active users do we have?
100

What is the average daily time spent on the product?
30 minutes.

What are the supported video resolutions?
The system accepts most of the video resolutions and formats.

Is encryption required?
Yes

Any file size requirement for videos?
Our platform focuses on small and medium-sized videos. The maximum allowed video size is 1GB.

Can we leverage some of the existing cloud infrastructures provided by Amazon, Google, or Microsoft?
Building everything from scratch is unrealistic for most companies, it is recommended to leverage some of the existing cloud services.

In the project, we focus on designing a video streaming service with the following features:

- Ability to upload videos fast
- Smooth video streaming
- Ability to change video quality
- Low infrastructure cost
- High availability, scalability, and reliability requirements

Step 2 - Propose high-level design

Students may leverage existing cloud services or build everything from scratch.

Note:

- System design interviews are not about building everything from scratch. Within the limited time frame, choosing the right technology to do a job right is more important than explaining how the technology works in detail. For instance, mentioning blob storage for storing source videos is enough for the interview. Talking about the detailed design for blob storage could be an overkill.
- Building scalable blob storage or CDN is extremely complex and costly. Even large companies like Netflix or Facebook do not build everything themselves. Netflix leverages Amazon's cloud services [4], and Facebook uses Akamai's CDN [5].

At the high-level, the system comprises three components (Figure 2).

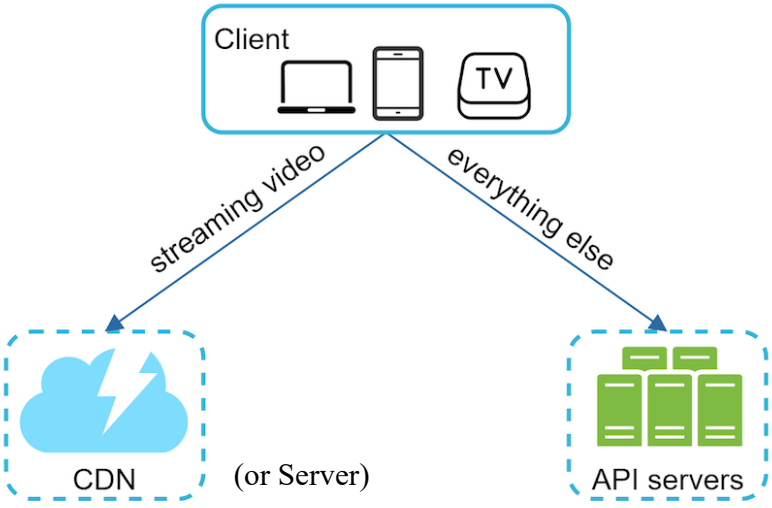

Figure 2

Client: You can watch YouTube on your computer, mobile phone (smart TV is optional).

CDN or Server: Videos are stored in CDN. When you press play, a video is streamed from the CDN.

API servers: Everything else except video streaming goes through API servers. This includes feed recommendation, generating video upload URL, updating metadata database and cache, user signup, etc.

Safety optimization: pre-signed upload URL

Safety is one of the most important aspects of any product. To ensure only authorized users upload videos to the right location, pre-signed URLs is introduced as shown in Figure 3.

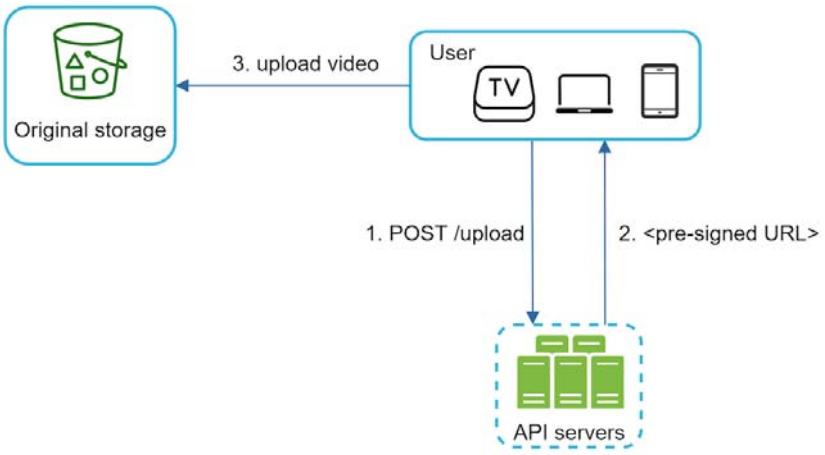

Figure 3

The upload flow is updated as follows:

1. The client makes a HTTP request to API servers to fetch the pre-signed URL, which gives the access permission to the object identified in the URL. The term pre-signed URL is used by uploading files to Amazon S3. Other cloud service providers might use a different name. For instance, Microsoft Azure blob storage supports the same feature, but call it "Shared Access Signature" [10].

2. API servers respond with a pre-signed URL.

3. Once the client receives the response, it uploads the video using the pre-signed URL.

3. Tasks to be completed by students

Provided in Section 2

4. Tools Required/Expected to be used in the development of the project

Available tools

5. Other related information

Reference materials

[1] YouTube by the numbers:
https://www.omnicoreagency.com/youtube-statistics/

[2] 2019 YouTube Demographics:

https://blog.hubspot.com/marketing/youtube-demographics

[3] Cloudfront Pricing:
https://aws.amazon.com/cloudfront/pricing/

[4] Netflix on AWS: https://aws.amazon.com/solutions/case-studies/netflix/

[5] Akamai homepage: https://www.akamai.com/

[6] Binary large object:
https://en.wikipedia.org/wiki/Binary_large_object

[7] Here's What You Need to Know About Streaming Protocols:
https://www.dacast.com/blog/streaming-protocols/

[8] SVE: Distributed Video Processing at Facebook Scale:
https://www.cs.princeton.edu/~wlloyd/papers/sve-sosp17.pdf

[9] Weibo video processing architecture (in Chinese):
https://www.upyun.com/opentalk/399.html

[10] Delegate access with a shared access signature:
https://docs.microsoft.com/en-us/rest/api/storageservices/delegate-access-with-shared-access-signature

[11] YouTube scalability talk by early YouTube employee:
https://www.youtube.com/watch?v=w5WVu624fY8

[12] Understanding the characteristics of internet short video sharing: A youtube-based measurement study.
https://arxiv.org/pdf/0707.3670.pdf

[13] Content Popularity for Open Connect:
https://netflixtechblog.com/content-popularity-for-open-connect-b86d56f613b