Design a Recommendation System

It starts with a simple question: How to design a recommendation system?

It seems that this question has been asked for multiple times in recent system design interviews. In addition, recommendation system is so important nowadays that almost every company has its own recommendation systems which can be used to provide all sorts of suggestions. So this topic can be quite interesting to discuss.

In this post, I'll mainly talk about various aspects of recommendation systems that can be discussed in system design interviews. Topics that will be covered include recommendation system in general, collaborative filtering (CF), recommendation system infrastructure and so on.

Recommendation system

Recommendation system (https://en.wikipedia.org/wiki/Recommender_system) has been a hot topic for a long time. It seems that almost every company is building such systems. For instance, Amazon is using recommendation system to provide goods that customers might also like. Hulu is using recommendation system to suggest other popular shows or episodes.

To limit the scope of discussion, we can mainly focus on recommendation system for Youtube. More specifically, the system is responsible for recommending videos that a user might like to watch.

Heuristic solution

Although machine learning (ML) is commonly used in building recommendation systems, it doesn't mean it's the only solution. There are many cases where we want simpler approaches, for example, we may have very few data, or we may want to build a minimal solution fast etc..

In such cases, we can start with some heuristic (https://en.wikipedia.org/wiki/Heuristic) solutions. In fact, there are lots of hacks we can do to build a simple recommendation system. For instance, based on videos a user has watched, we can simply suggest videos from same authors. We can also suggest videos with similar titles or labels. If we use the popularity (number of comments, shares) as another signal, the recommendation system can work pretty well as a baseline.

Collaborative filtering

When talking about recommendation system, I can hardly avoid mentioning collaborative filtering (CF) (https://en.wikipedia.org/wiki/Collaborative_filtering), which is the most popular technique used in recommendation systems. Since not everyone has a machine learning background, I won't go deeper about the algorithm. In fact, the beauty of collaborative filtering is that the basic idea is so simple that everyone can easily understand it.

In a nutshell, to recommend videos for a user, I can provide videos liked by similar users. For instance, if user A and B have watched a bunch of same videos, it's highly likely that user A will like videos liked by B. Of course, there are many ways to define what "similar" means here. It could be two users have liked same videos, it could also mean that they share the same location.

The above algorithm is called user-based collaborative filtering. Another version is called item-based collaborative filtering, which means to recommend videos (items) that are similar to videos a user has watched.

Feature engineer

In fact, mentioning collaborative filtering in a system design interview is not impressive at all since the algorithm is so common. What most interviewers care about is how to build the system specific to the interview question. So for Youtube video recommendation, what features can be used to build the recommendation system?

Usually, there are two types of features – explicit and implicit features. Explicit features can be ratings, favorites etc.. In Youtube, it can be the like/share/subscribe actions. Implicit features are less obvious. If a user has watched a video for only a couple of seconds, probably it's a negative sign. Given a list of recommended videos, if a user clicks one over another, it can mean that he prefer to the one clicked. Usually, we need to explore a lot about implicit features.

Back to the Youtube problem, there are several features are quite obvious:

- Like/share/subscribe – As mentioned above, they are strong signs about a user's preferences.
- Watch time
- Video title/labels/categories
- Freshness

It's worth to note that when building machine learning systems, you have to experiment a lot with different combination of features so that you won't know which one is good unless you give it a try.

Infrastructure

Another reason that recommendation system is a great system design interview question is that it can also be used to discuss infrastructure. Apparently, the system contains multiple steps/components. so how would you design the whole system in terms of infrastructure?

Given that comparing similar users/videos can be time-consuming on Youtube, this part should be done in offline pipelines. Therefore, we can divide the whole system into online and offline.

For the offline part, all the user models and videos need to store in distributed systems (it could be a whole article about storage, this post (http://blog.gainlo.co/index.php/2016/03/01/system-design-interview-question-create-a-photo-sharing-app/) covers this topic briefly). Pipelines that calculate similar users/videos are also running regularly in order to keep data updated. In fact, for most machine learning systems, it's common to use offline pipeline to process big data as you won't expect it to finish with few seconds.

For the online part, based on the user profile and his actions (like videos just watched), we should be able to provide a list of recommended videos from offline data. Normally, the system fetches more videos than needed and then do filtering and ranking on the fly. We can filter videos that are obviously irrelevant like videos the user has watched. And then we should also rank the suggestions. Few factors should be considered include video popularity (share/comment/like numbers), freshness, quality and so on.

Summary

In reality, there are many ways to improve the system that we haven't covered yet. I'd like to briefly mention few techniques:

- Freshness can be a very important factor. We should figure out how to recommend fresh content.
- Eval is an essential component of recommendation system, which allows us to understand how well the system works.
- To train the collaborative filtering system, we may also include video position signals. Usually, videos ranked on top have much higher chance to be clicked.

It's hard to predict what will be discussed in a system design interview, that's why I try to cover as many topics as possible in the post instead of digging deeper into a particular area.

If you find this post helpful, I would really appreciate if you can share it with your friends. Also, you can check more system design interview questions (http://blog.gainlo.co/index.php/category/system-design-interview-questions/) and analysis here.

Related Posts:

1. **How to Design Youtube (Part I) (http://blog.gainlo.co/index.php/2016/10/22/design-youtube-part/)**
2. **8 Things You Need to Know Before a System Design Interview (http://blog.gainlo.co/index.php/2015/10/22/8-things-you-need-to-know-before-system-design-interviews/)**
3. **Design Facebook Chat Function (http://blog.gainlo.co/index.php/2016/04/19/design-facebook-chat-function/)**
4. **Design News Feed System (Part 1) (http://blog.gainlo.co/index.php/2016/03/29/design-news-feed-system-part-1-system-design-interview-questions/)**

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4 thoughts on "Design a Recommendation System"

ASHOK
June 1, 2016 at 11:34 am (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/#comment-1011)

Hi,
The system design articles here are great, but they are not covered in details. The articles just introduce us to some concepts which can be applied to the question. I request you to provide in-depth answers for some of the questions (including things like getting numbers in the right ballpark, how to distribute our solution among many servers, the final architecture design diagram, iterating from the first solution and removing each bottleneck, etc.)

Reply (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/?replytocom=1011#respond)

JAKE
June 3, 2016 at 10:40 pm (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/#comment-1062)

Hi Ashok,

Thanks for the suggestion. We will cover more details in future posts 🙂

Reply (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/?replytocom=1062#respond)

AMIT
October 11, 2016 at 2:06 pm (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/#comment-2914)

Good article but lacks depth

Reply (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/?replytocom=2914#respond)

BRAJ (HTTP://WWW.NROUTES.COM)
October 25, 2016 at 7:17 am (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/#comment-3092)

I have gone through almost all of design questions over here ...two suggestions
1. Provide some in-depth details along with tools , references of real design
2. Show them pictorially , sometime that makes more sense than wordings

Reply (http://blog.gainlo.co/index.php/2016/05/24/design-a-recommendation-system/?replytocom=3092#respond)

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Subarray With Given Sum (http://blog.gainlo.co/index.php/2016/06/01/subarray-with-given-sum/)

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