# Top K Heavy Hitters

## Requirements

Functional : 1) Given user views count for a video, find top k most frequent visitors

2) Top k visitors for given time duration which can be max 1 year

Non Functional: 1) Highly available, Eventually consistent

2) Scalable, should be able to work for geographically distributed data.

## APIs

1) UserID<String> getTopKVisitors( videoID<String>, startTime, endTime, k <Int>)

2) incrementCount( videoID, userID, currentTime )

## Assumptions and Capacity estimation

1) Assume 1M views per day for trending videos. Assume 100M registered users.

2) ~1500 views/min. Assume 5-10 views/user => 0.1M unique users.

3) Maximum time duration can be 6 months -> Assuming eventual slowdown of visit distribution -> need to store data for ~ 0.1M x (30 x 4) days x 100B which is ~ 120GB/video

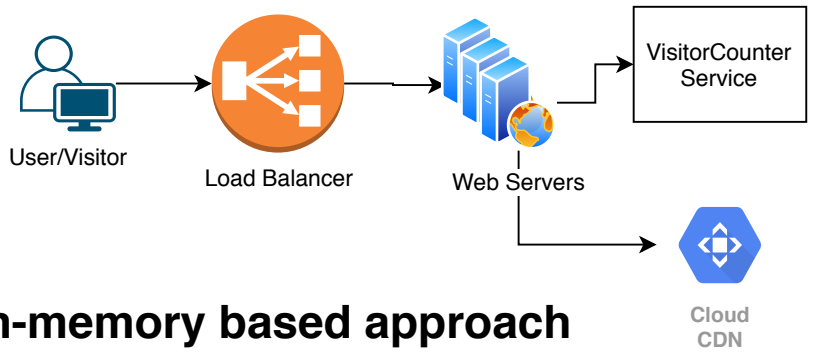
Observations - 1) The service invocation needs to be async since web server's main task is to load the content. The service is basically used for analytics

2) No of writes is very frequent compared to read results from the service.

3) Since the read API is not customer facing, some processing can be done at runtime before getting final results.

4) Due to large data/video, need to use partitioning and parallelization for computation.

## HLD




## Approach using DB(users<100k)

1. Instead of directly sending to counter processor, add the visitor details to a message queue.
2. The processor picks the user details, from the queue and update minHeap and counter.
3. For every elapsed time interval add the top k visitors to DB.
4. NoSQL can be used as DB since it fits into k-v structure, preferable HBase since it supports fast multiple writes.

## In-memory based approach (users<1k)

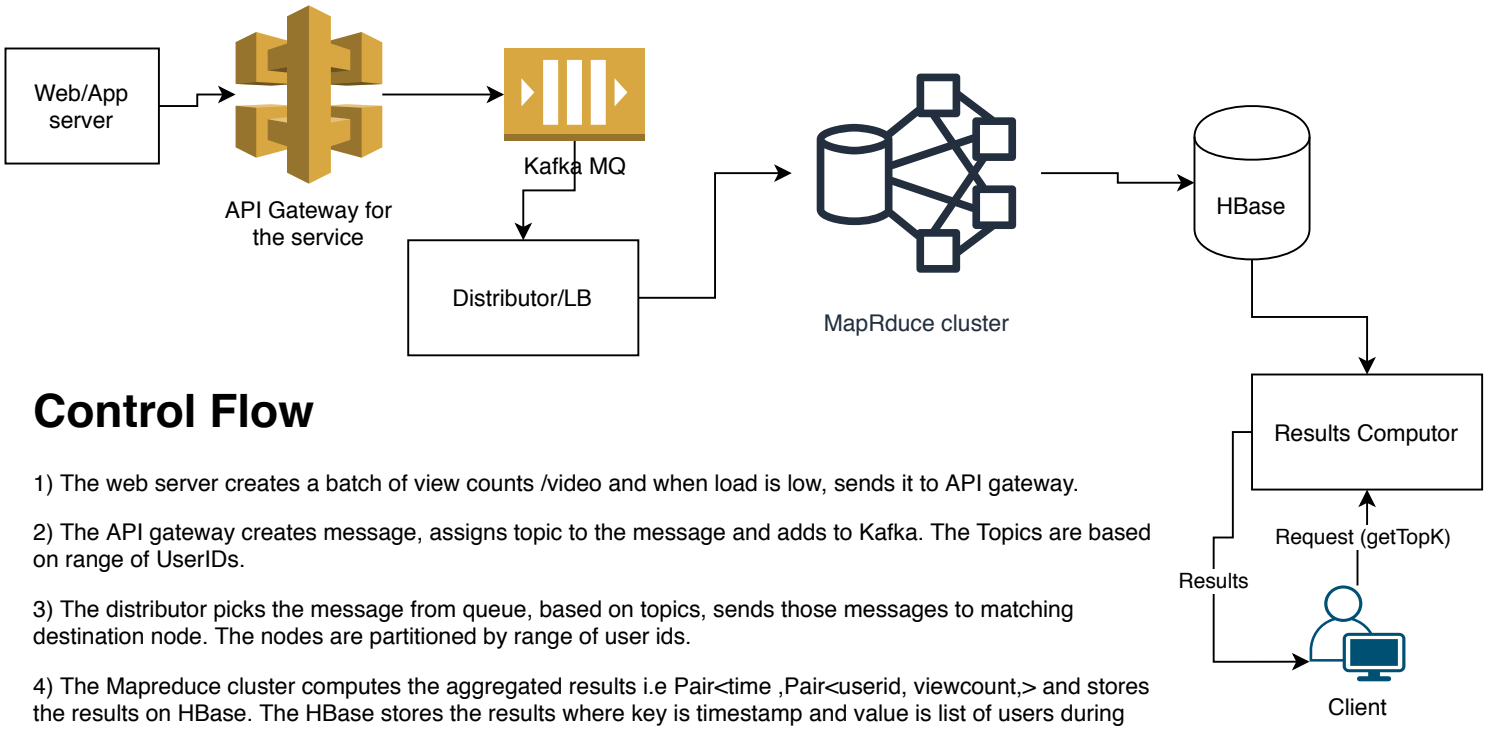
Use data structure which is combination of minHeap and Counter Map.

Algo -

1. Initialize a minHeap and a counter map
2. For each user id do
3. If count (userid ) > top(minHeap) then
4. remove top of minheap and add new userid to heap
5. After every fixed time interval, add top k users to a result queue, also decrement view counts of users whose time was outside current window.

Problems with this approach for large no of users -

1. Cannot be used for large #userids which can't fit in memory
2. Historical details difficult to obtain.
3. Cannot distribute load to multiple servers. Best case possible is to put heap on one server and counter map on another.




# Control Flow

1) The web server creates a batch of view counts /video and when load is low, sends it to API gateway.

2) The API gateway creates message, assigns topic to the message and adds to Kafka. The Topics are based on range of UserIDs.

3) The distributor picks the message from queue, based on topics, sends those messages to matching destination node. The nodes are partitioned by range of user ids.

4) The Mapreduce cluster computes the aggregated results i.e Pair<time ,Pair<userid, viewcount,> and stores the results on HBase. The HBase stores the results where key is timestamp and value is list of users during that time interval ( mostly 5 min interval). The results are stored to HBase for each fixed time interval.

5) HBase is used since it supports fast writes, schema flexibility and nicely fits with MapReduce.

6) The result computor reads the data from HBase, based on input time range, finds viewcount of top users by using cumulative's difference approach, finds top k users from those users and returns the results.

# Side Notes

Try to refrain from task specific algorithms like CountMinSketch since interviewee is expected to use generic problem solving approach and not any learned algorithm.