40. Typeahead

Requirements clarification

Functional requirements

- As the user types in their search, our system should suggest top K frequent words matching the prefix the user has typed.

Non-functional requirements

- This suggestion functionality should happen in real-time with minimal latency.

Estimation

Traffic estimation

- Number of searches per day = 5 billion (Assumed)
- Number of searches per second (QPS) = Number of searches per day / 24 hours / 3600 seconds = 60000 times/s

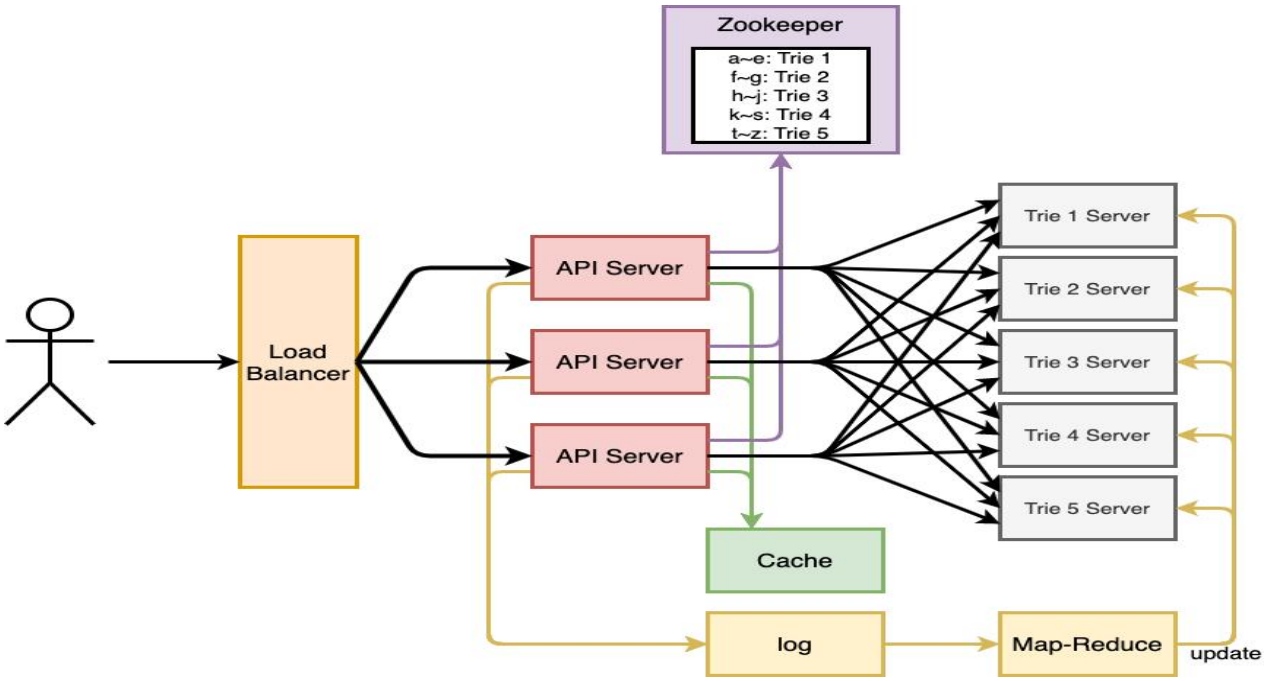
Storage estimation

- Types
  - Data: Yes
  - File: No
- Capacity
  - Number of terms need to build an index
    - 5 billion searches per day.
    - Only 20% of these will be unique. (Assumed)
    - We only want to index the top 50% of the search terms. (Assumed)

- Number of terms we need to build an index per day = 5 billion x 20% x 50% = 5 million

- Size for storing the index
  - Each search has 3 words.
  - Each words has 5 characters.
  - Each character needs 2 bytes
  - Total size for storing the index per day = 5 million x 3 x 5 x 2 = 15 GB

High-level design



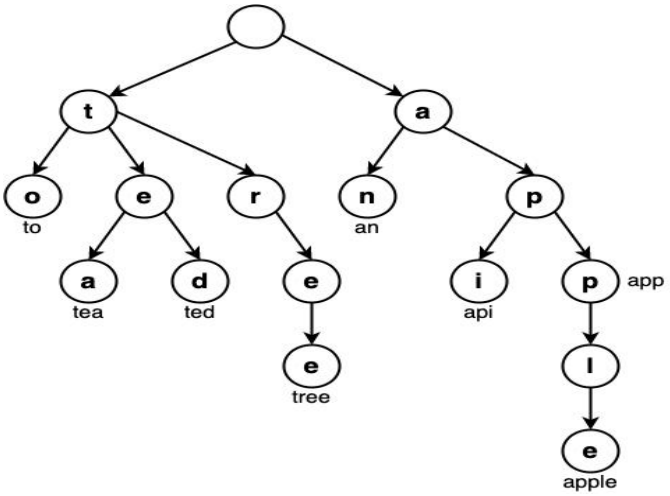
- **API Servers**
  - Handle the requests from clients.
- **Trie Servers**
  - Each trie server stores a sub-trie of the whole trie.
- **Cache**
  - Cache stores top searched words.

- API server will try to find the result from the cache first. If there is no result from the cache, it will check tries servers later.

- **Zookeeper**
  - Zookeeper will help API servers locate the proper trie server(s) for getting the results.
- **Log**
  - Log is used to store searches and track their frequencies.
- **Map-Reduce**
  - Map-Reduce will process the logging data to update the copy of the old trie to a new trie.

Detailed design

- Data structure
  - Choice
    - Trie
      - General structure of Trie
        - Each node store one character.
        - Root node store an empty character.
        - The path from the root node to the leaf node can construct a word.



Additional features for our use case

- Each node stores the frequency of its prefix has been searched.
- Each node only keep top K frequent of all its children.

Update trie

- Basic idea
  - Update our trie offline after certain interval (every day or every week)
- Normal time
  - Put new searches into a log and track their frequencies.
  - Log every search or log every 1000th search (sampling)
- At the time to update the trie
  - Copy the old tries from servers
  - Use Map-Reduce to process the logging data to update the copy of the old tries to new tries.
  - Replace the old tries on the servers with the new tries.