# 系统设计

## Crawler, Typeahead

欧阳锋 老师



**扫描二维码关注微信/微博**
**获取最新面试题及权威解答**

微信: ninechapter
知乎专栏:http://zhuanlan.zhihu.com/jiuzhang
微博: http://www.weibo.com/ninechapter
官网: www.jiuzhang.com

# 本节重点

九章算法

## Design a web crawler

Dropbox, Google, Turn, Alibaba

## Design thread-safe producer and consumer

Google, Amazon, TripAdvisor, Microsoft, Snapchat

## Design a Typeahead

LinkedIn, Uber, Hulu

# 你会掌握

1. Producer consumer pattern
2. How to design distributed web crawler
3. How search engine works
4. How to design Google Suggestion

# Design a web crawler

Interviewer: How to design a web crawler?

# Design a web crawler



How to design a web crawler?

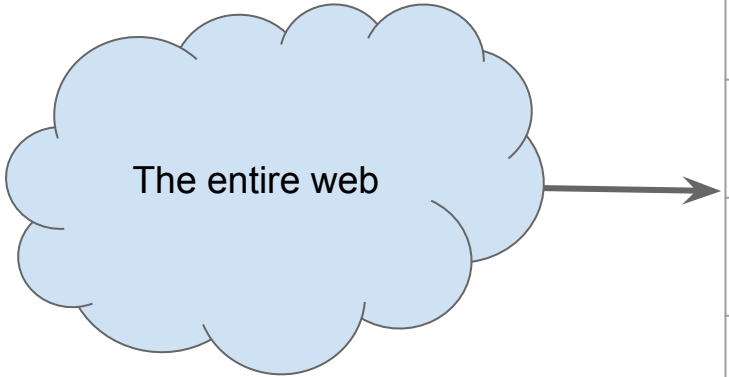
- multi-threading
- system design

What is a web crawler?

- For collecting data/information from the web

# Design a web crawler

## What does Google's crawler do?

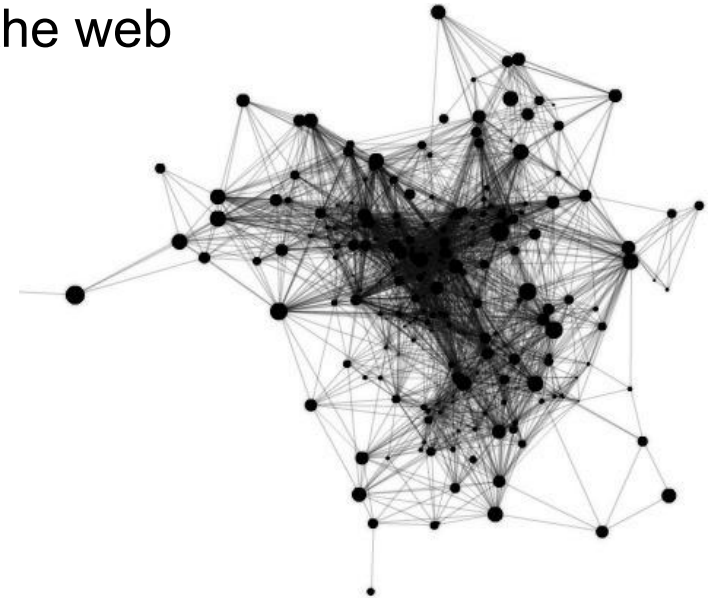



| url | page_content |
|---|---|
| "https://www.wikipedia.org/" | "<!DOCTYPE html><html>...</html>" |
| "http://www.sina.com/" | "<!DOCTYPE html><html>...</html>" |
| ... | ... |
| "http://www.bbc.co.uk/" | "<!DOCTYPE html><html>...</html>" |
| ... | ... |

# Design a web crawler

Scenario

Given seeds, crawl the web



# Design a web crawler

九章算法

Needs: How many web pages? how long? how large?

1. crawl **1.6m web pages per second**
    - 1 trillion web pages
    - crawl all of them every week
2. 10p (petabyte) web page storage
    - average size of a web page: 10k

# Design a web crawler

九章算法

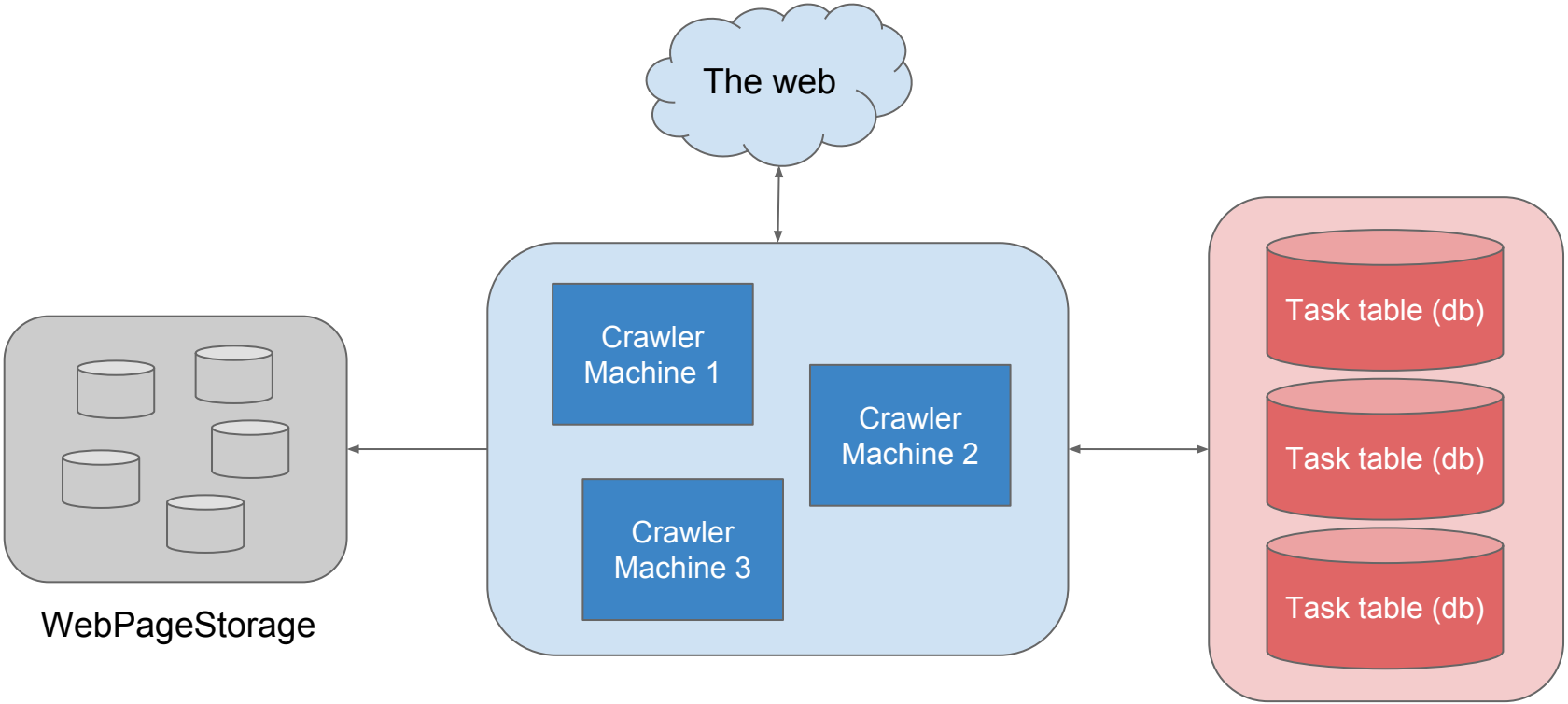
**S**cenario: Given seeds, crawl the web

**N**eeds: How many web pages? how long? how large?

**A**pplication: Crawler, TaskService, StorageService

**K**ilobyte: Use db to store tasks, BigTable to store web pages

# Design a web crawler



# Design a web crawler

九章算法

A simplistic news crawler

A simplistic web crawler

A single-threaded web crawler

A multi-threaded web crawler

Dropbox interview question:

Program a web crawler, then make it multi-threaded

# A Simplistic News Crawler

九章算法

How a simplistic news crawler works

- given the URL of news list page

1. Send an HTTP request and grab the content of the news list page
2. Extract all the news titles from the news list page

# A Simplistic News Crawler

Input: URL of the news list page

http://tech.163.com/it

# A Simplistic News Crawler

Grab the content of the page

```
import urllib2
url = ‘http://tech.163.com
request = urllib2.Reques
response = urllib2.urlope
page = response.read()
```

```
>>> request = urllib2.Request('http://www.baidu.com')
>>> response = urllib2.urlopen(request)
>>> response.read()
'<!DOCTYPE html><!--STATUS OK--><html><head><meta http-equiv="content-type" cont
ent="text/html;charset=utf-8"><meta http-equiv="X-UA-Compatible" content="IE=Edg
e"><meta content="always" name="referrer"><meta name="theme-color" content="#293
2e1"><link rel="shortcut icon" href="/favicon.ico" type="image/x-icon" /><link r
el="search" type="application/opensearchdescription+xml" href="/content-search.x
ml" title="\xe7\x99\xbe\xe5\xba\xa6\xe6\x90\x9c\xe7\xb4\xa2" /><link rel="icon"
sizes="any" mask href="//www.baidu.com/img/baidu.svg"><link rel="dns-prefetch" h
ref="//s1.bdstatic.com"/><link rel="dns-prefetch" href="//t1.baidu.com"/><link r
el="dns-prefetch" href="//t2.baidu.com"/><link rel="dns-prefetch" href="//t3.bai
du.com"/><link rel="dns-prefetch" href="//t10.baidu.com"/><link rel="dns-prefetc
h" href="//t11.baidu.com"/><link rel="dns-prefetch" href="//t12.baidu.com"/><lin
k rel="dns-prefetch" href="//b1.bdstatic.com"/><title>\xe7\x99\xbe\xe5\xba\xa6\x
e4\xb8\x80\xe4\xb8\x8b\xef\xbc\x8c\xe4\xbd\xa0\xe5\xb0\xb1\xe7\x9f\xa5\xe9\x81\x
93</title>\n<style index="index"  id="css_index">html,body{height:100%}html{over
flow-y:auto}body{font:12px arial;text-align:;background:#fff}body,p,form,ul,li{m
argin:0;padding:0;list-style:none}body,form,#fm{position:relative}td{text-align:
left}img{border:0}a{color:#00c}a:active{color:#f60}input{border:0;padding:0}#wra
```

# A Simplistic News Crawler

Extract all the news URLs from the news list page

Regular Expression

```
<h3[^>]*><a[^>]*>(.*?)<\/a><\/h3>
```

# A Simplistic News Crawler

九章算法

Output: a list of news titles

[

“富士康或将收购夏普交易推迟到下周”,

“美的董事长回应董明珠:怎么能说我们是骗子”,

“终于来了 亚马逊招开发经理打造VR平台”,

…

“Skylake Mac mini?小众用户也想要更强性能”

]

# Design a web crawler

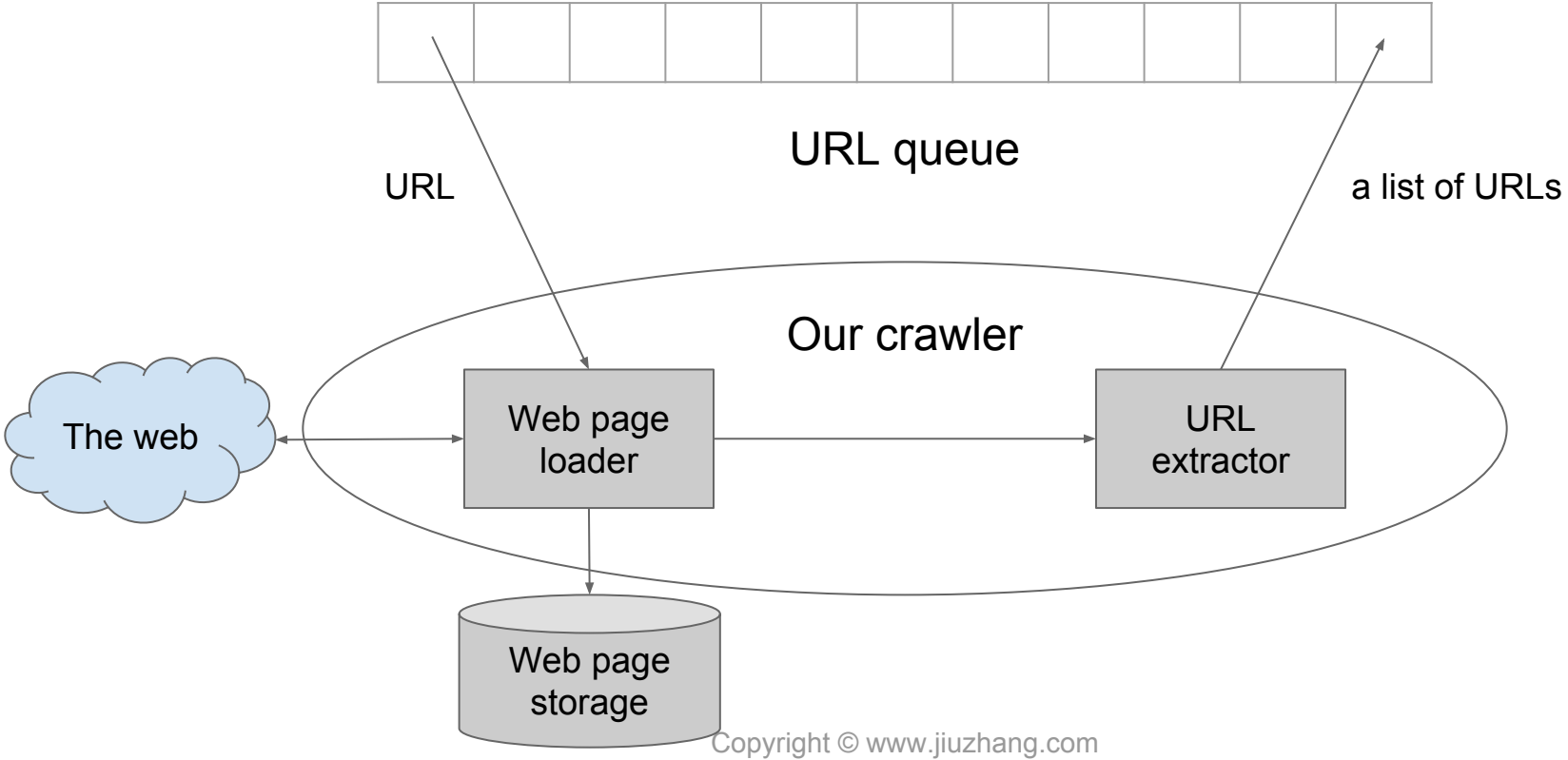
Dropbox interview question:

Program a web crawler, then make it multi-threaded

Input: url seeds

Output: list of urls

# A Single-threaded Web Crawler



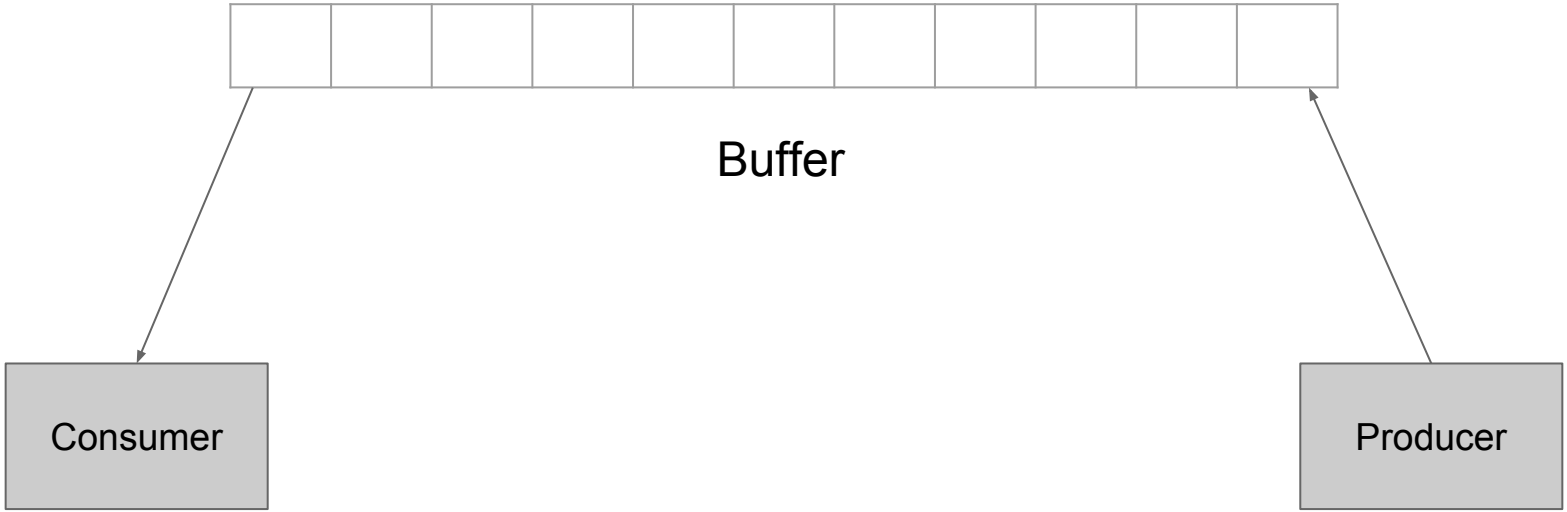
# A Single-threaded Web Crawler

九章算法

```
thread crawler
    function run
        while (url_queue not empty)
            url = url_queue.dequeue()
            html = web_page_loader.load(url) // consume
            url_list = url_extractor.extract(html) // produce
            url_queue.enqueue_all(url_list)
        end
```

# A Single-threaded Web Crawler

## Producer Consumer Pattern



# A Single-threaded Web Crawler

九章算法

Snapchat: write producer consumer

# A Single-threaded Web Crawler

http://agiliq.com/blog/2013/10/producer-consumer-problem-in-python/

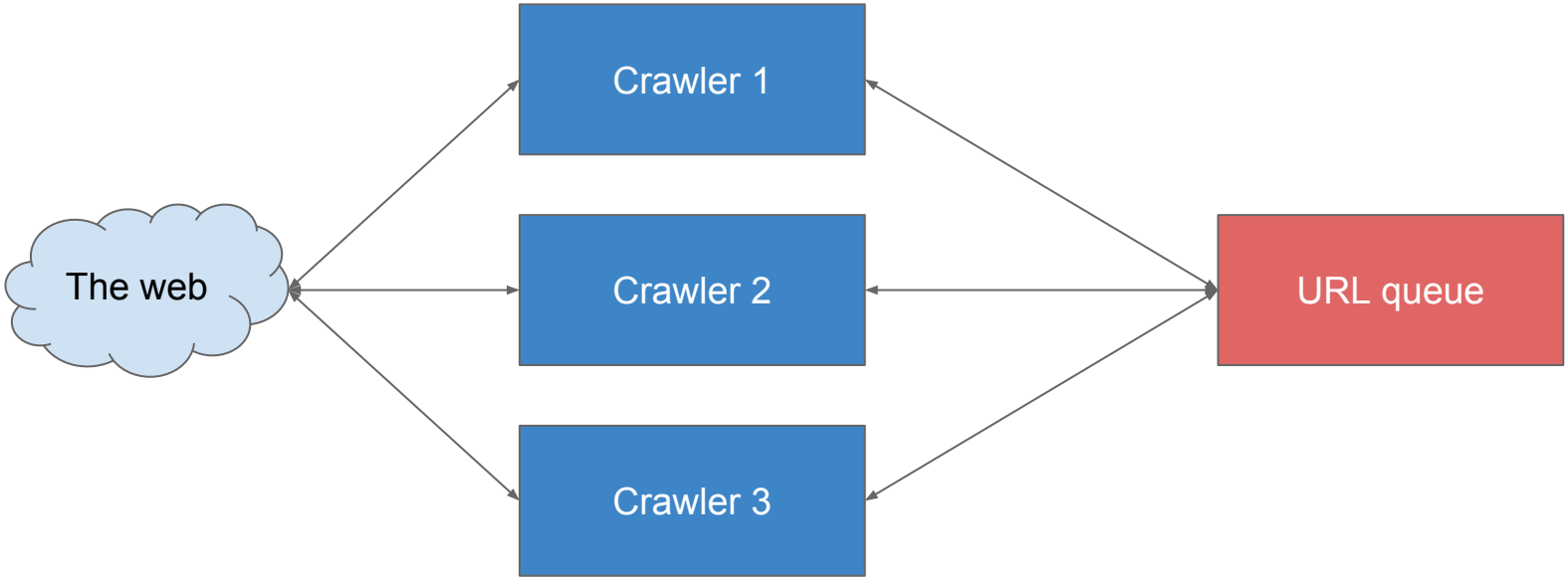
# A Single-threaded Web Crawler

九章算法

What’s the problem of single thread?

Too slow?

# A Multi-threaded Web Crawler



# A Multi-threaded Web Crawler

九章算法

How different threads work together?

Three approaches:

1. sleep
2. condition variable
3. semaphore

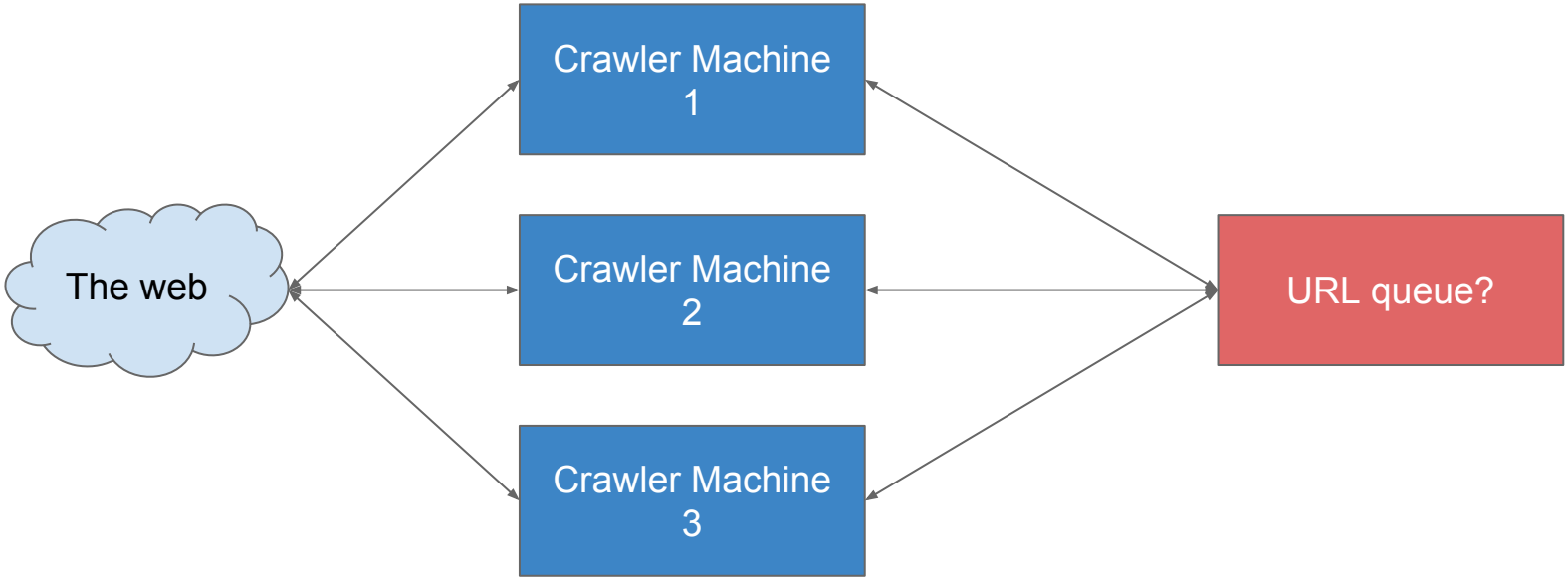
# A Distributed Web Crawler

九章算法

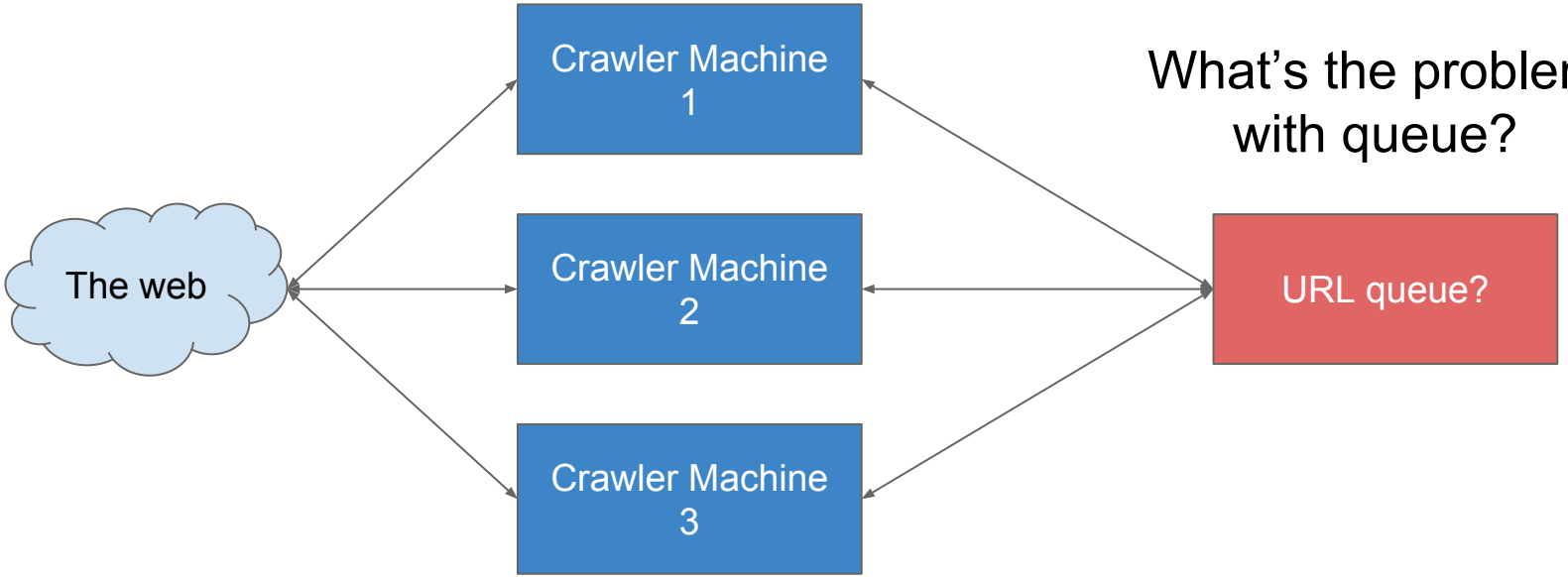
Why distributed?

- CPU number (context switch cost)
- thread (port) number limitation
- network bottleneck for single machine

# A Distributed Web Crawler



# A Distributed Web Crawler




What's the problem with queue?

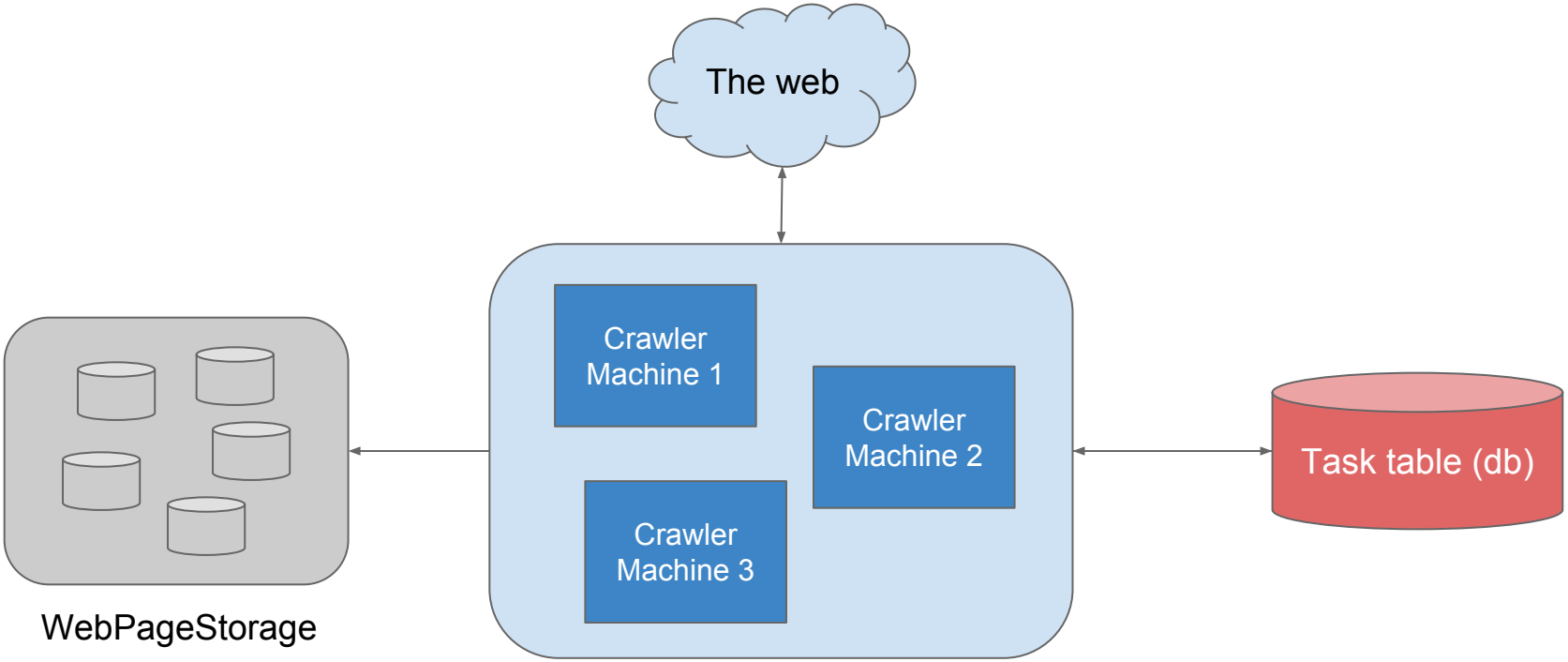
# A Distributed Web Crawler

九章算法

## How to design the task table

| id | url | state | priority | available_time |
|---|---|---|---|---|
| 1 | “http://www.sina.com/” | “idle” | 1 | “2016-03-04 11:00 am” |
| 2 | “http://www.sina1.com/” | “working” | 1 | “2016-03-04 12:00 am” |
| 3 | “http://www.sina2.com/” | “idle” | 0 | “2016-03-14 02:00 pm” |
| 4 | “http://www.sina3.com/” | “idle” | 2 | “2016-03-12 04:25 am” |
| ... | ... | ... | ... | ... |

# A Distributed Web Crawler



# A Distributed Web Crawler

九章算法

Now we have a work solution!

**S**cenario: Given seeds, crawl the web

**N**eeds: How many web pages? how long? how large?

**A**pplication: Crawler, TaskService, StorageService

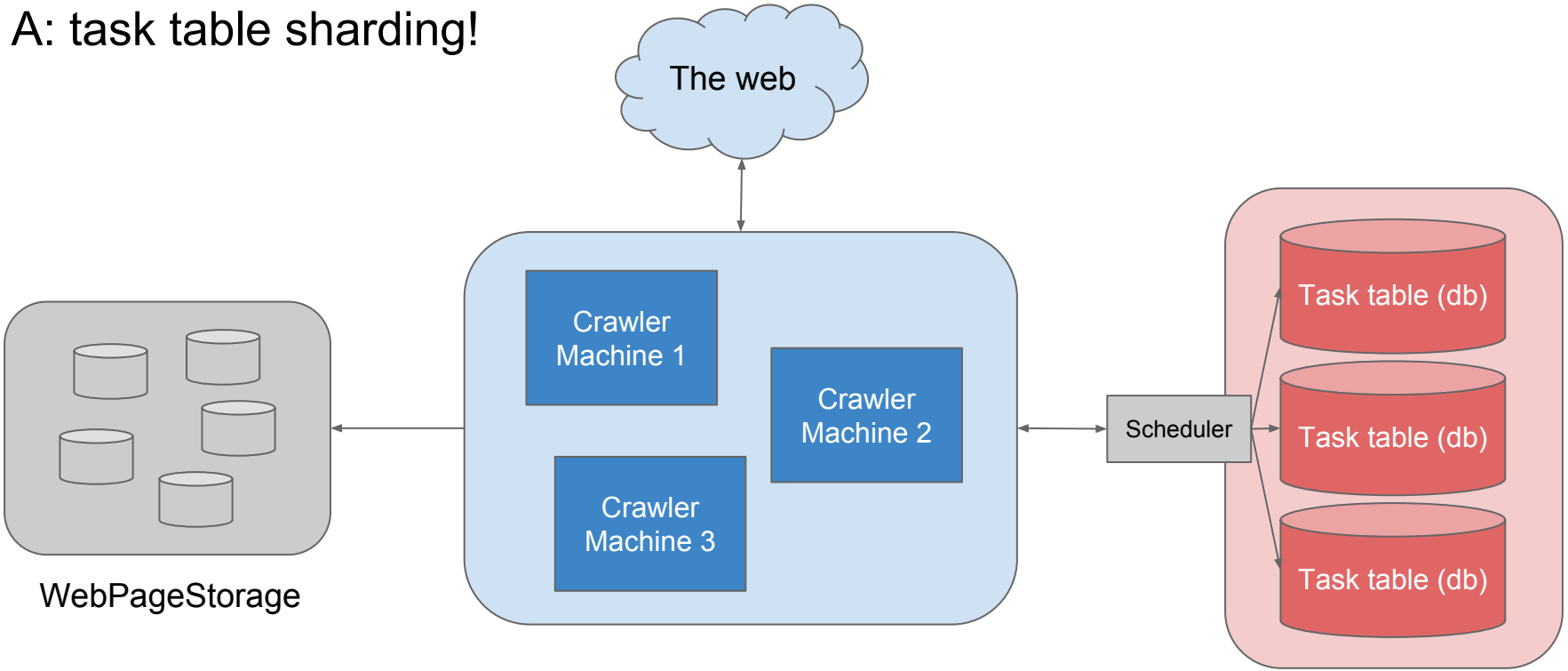
**K**ilobyte: Use db to store tasks, BigTable to store web pages

Let’s see how to evolve!

Interviewer: How to handle slow select?

# A Distributed Web Crawler

A: task table sharding!



Interviewer: How to handle update for failure?

(i.e. content update, crawl failure)

# A Distributed Web Crawler

Answer: Exponential back-off!

success: crawl after 1 week

no.1 failure: crawl after 2 week

no.2 failure: crawl after 4 weeks

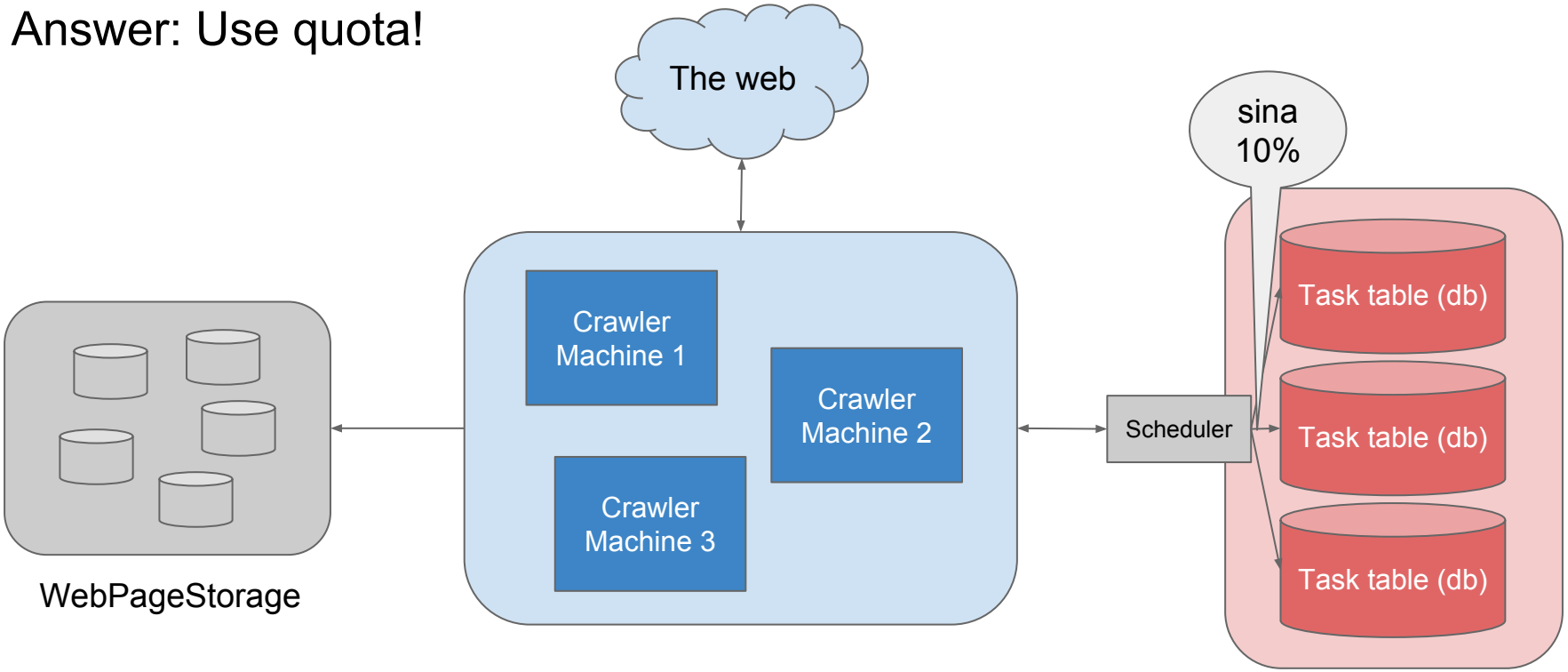
no.3 failure: crawl after 8 weeks ...

# Interviewer: How to handle dead cycle?

(Too many web pages in sina.com, the crawler keeps crawling sina.com and don’t crawl other websites)

# A Distributed Web Crawler

Answer: Use quota!



# A Distributed Web Crawler

九章算法

**S**cenario: Given seeds, crawl the web

**N**eeds: How many web pages? how long? how large?

**A**pplication: Crawler, TaskService, StorageService

**K**ilobyte: Use db to store tasks, BigTable to store web pages

**E**volve: single -> multi, multi -> distributed, queue -> table, slow select (db sharding), crawl failure/update handle, dead cycle (sina.com -> quota), multi-region

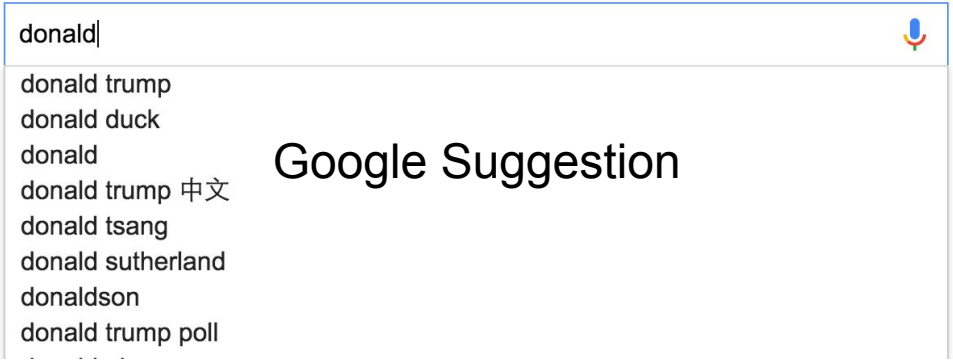
# Design a Typeahead

Interviewer: How to design a Typeahead?

# Design a Typeahead

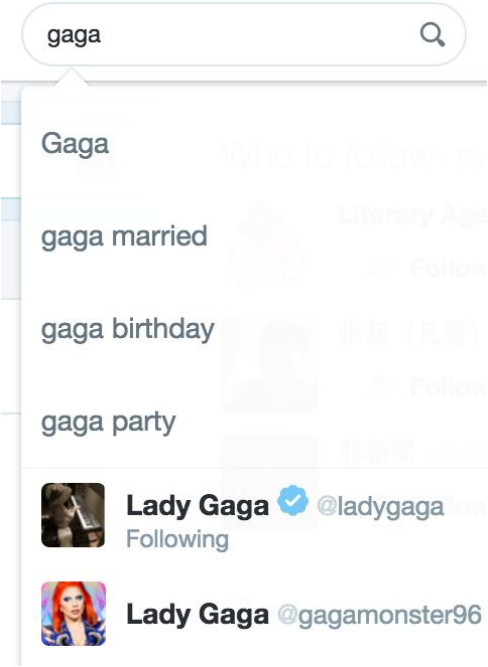
九章算法

## What is Typeahead?



# Design a Typeahead

## Twitter Typeahead



# Design a Typeahead

Google suggestion

- prefix -> top n hot key words

Twitter typeahead

- suggestion + user + hashtag

# Design a Typeahead

Google Suggestion

Scenario

prefix -> top n search keywords

# Design a Typeahead

Google Suggestion

Needs

DAU: 500m

Search: 6 * 6 * 500m = 18b

QPS = 18b / 86400 ≈ 200k

Peak QPS = QPS * 2 ≈ 400k

# Design a Typeahead

Google Suggestion

Application (service):

What service(s) do we need?

# Design a Typeahead

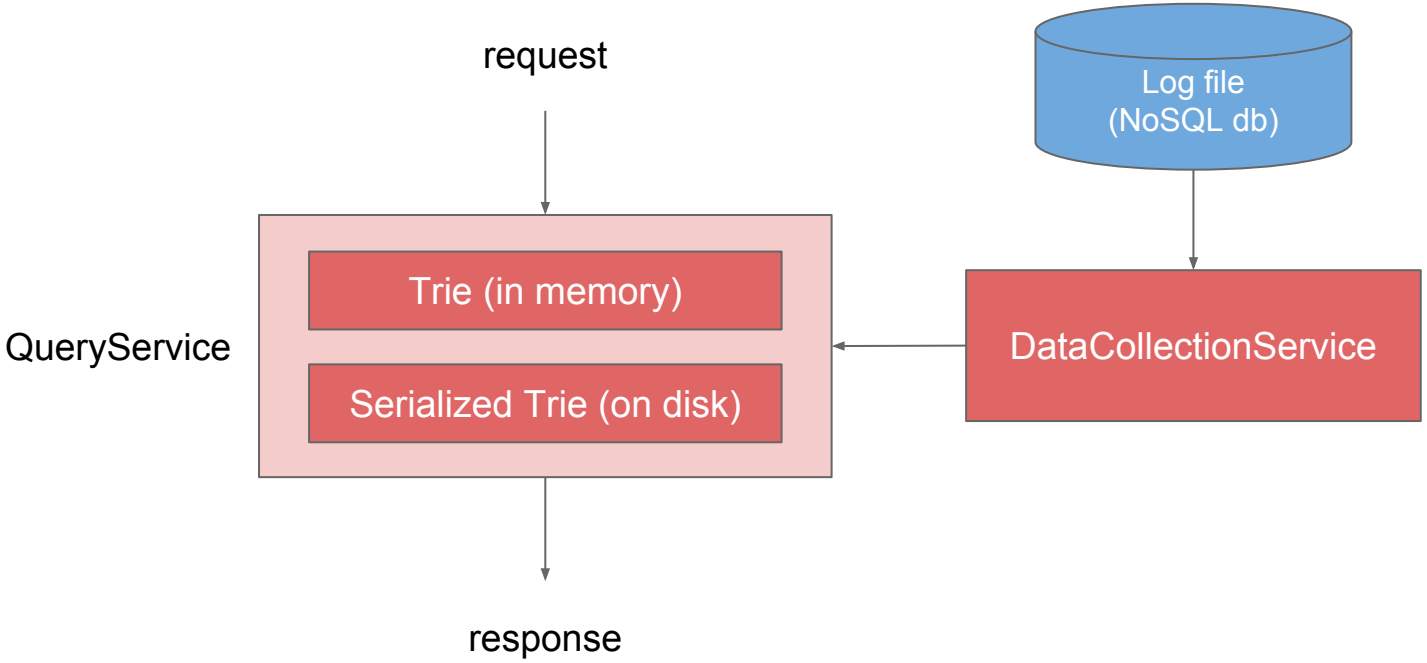
Google Suggestion

Application (service):

1. QueryService
2. DataCollectionService

# Design a Typeahead

## Google Suggestion



# Design a Typeahead

Google Suggestion

Kilobyte

1. QueryService

# Design a Typeahead

Google Suggestion

Kilobyte

1. QueryService

   what kind of data

   do we need to store?

   The naive way

| keyword | hit_count |
|---|---|
| “amazon” | 20b |
| “apple” | 15b |
| “adidas” | 7b |
| “airbnb” | 3b |
| ... | ... |

# Design a Typeahead

How to query on the db?

Query payload: { key }

Query SQL:

```
SELECT * FROM hit_stats
WHERE keyword LIKE `${key}%`
ORDER BY hit_count DESC
LIMIT 10
```

| keyword | hit_count |
|---|---|
| “amazon” | 20b |
| “apple” | 15b |
| “adidas” | 7b |
| “airbnb” | 3b |
| ... | ... |

hit_stats

# Design a Typeahead

Interviewer: What’s the problem with this approach?

# Design a Typeahead

九章算法

```
SELECT * FROM hit_stats
WHERE keyword LIKE `${key}%`
ORDER BY hit_count DESC
LIMIT 10
```

LIKE operation is expensive!

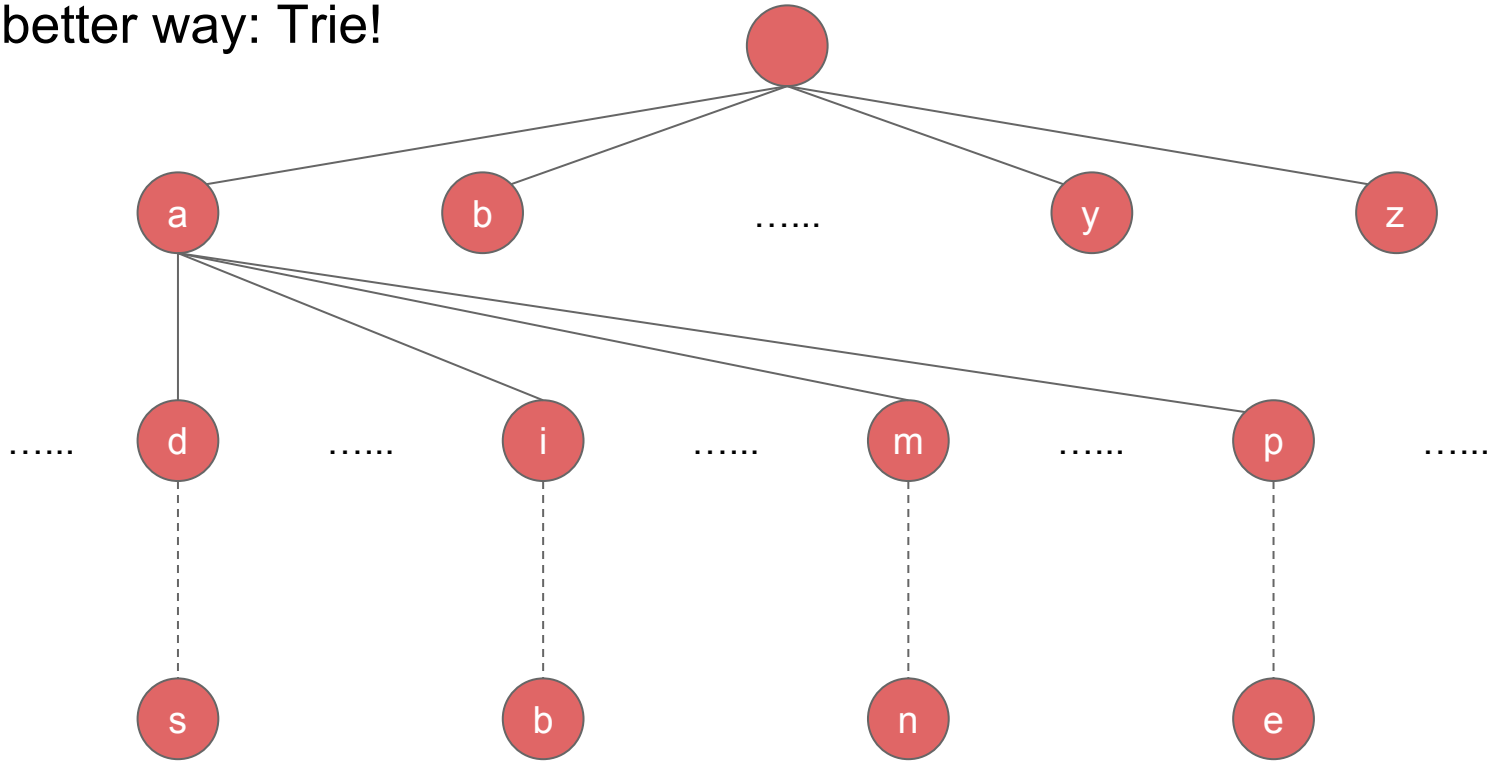
# Design a Typeahead

To reduce query time

| prefix | keywords |
|---|---|
| “a” | [“amazon”, “apple”, ...] |
| “am” | [“amazon”, “amc”, ...] |
| “ad” | [“adidas”, “adobe”, ...] |
| “don” | [“don’t have”, “donald trump”, ...] |
| ... | ... |

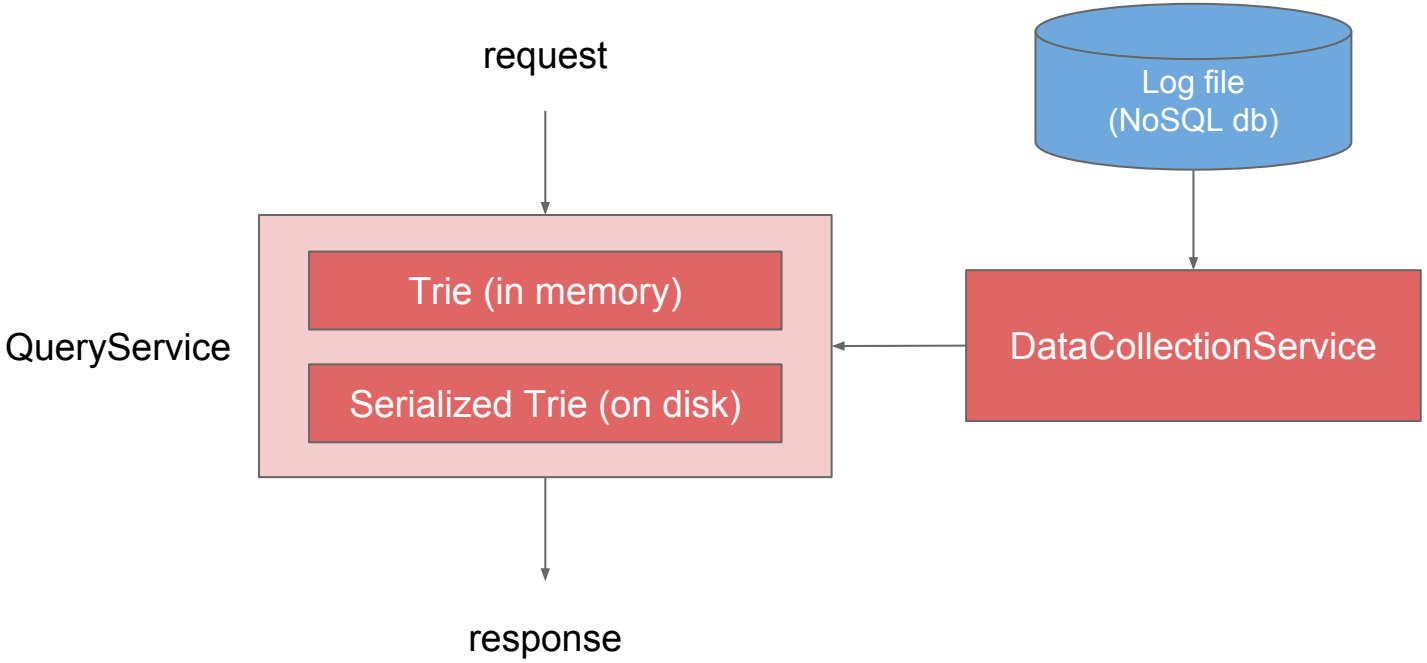
# Design a Typeahead

A better way: Trie!



# Design a Typeahead

## Google Suggestion



# Design a Typeahead

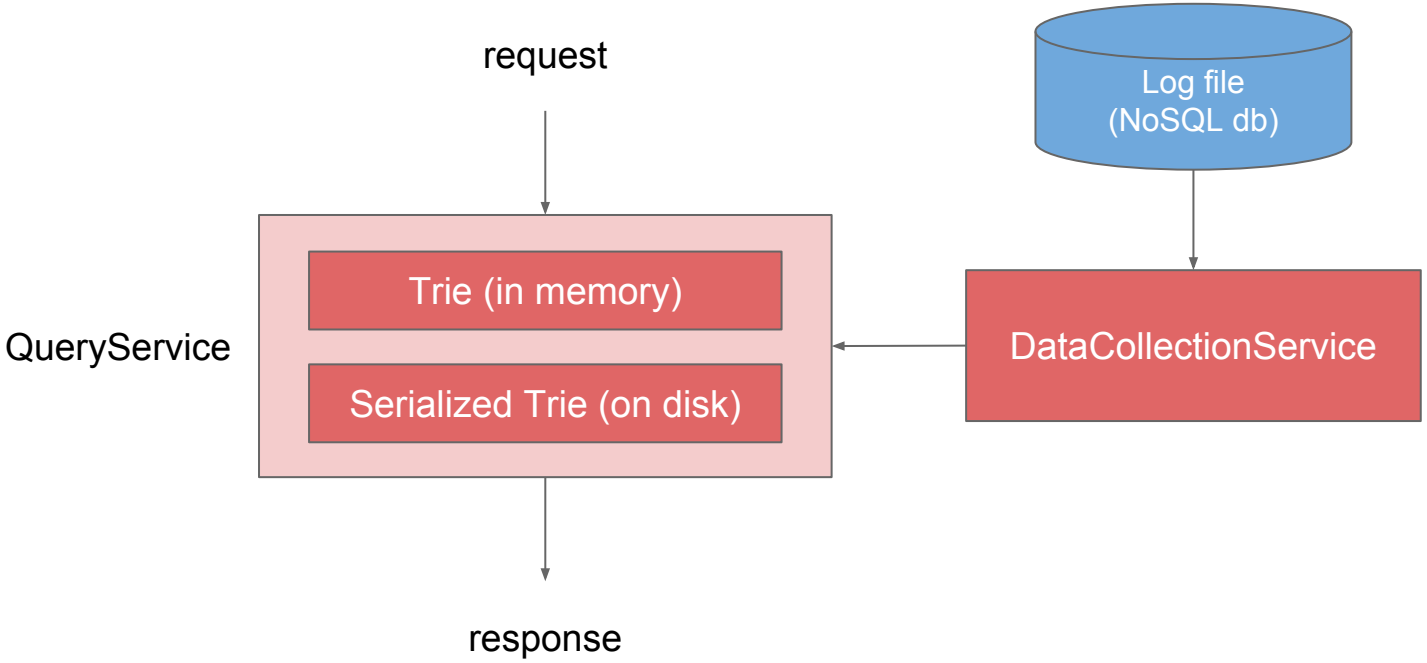
Google Suggestion

Kilobyte

1. QueryService
2. DataCollectionService

# Design a Typeahead

## Google Suggestion



# Design a Typeahead

Now we have a work solution!

# Design a Typeahead

Evolve:

Interviewer: How to qualify this system?

# Design a Typeahead

Evolve:

How to qualify this system?

Hi-pri: response time

Low-pri: result quality

# Design a Typeahead

Evolve:

Interviewer: How to reduce reponse time

# Design a Typeahead

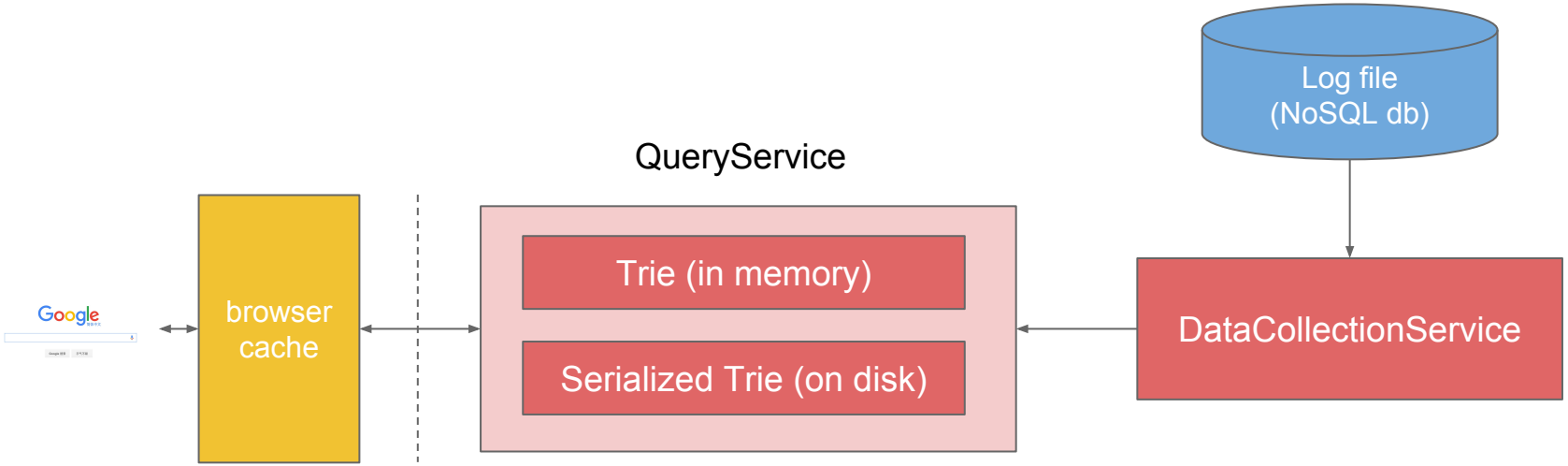


How to reduce reponse time **in front-end (browser)**

1. cache result
2. pre-fetch

# Design a Typeahead

How to reduce reponse time **in front-end**



# Design a Typeahead

Evolve:

Interviewer: How to reduce the size of log file?

# Design a Typeahead

九章算法

How to reduce the size of log file

Probabilistic logging

Log with 1 / 10,000 probability

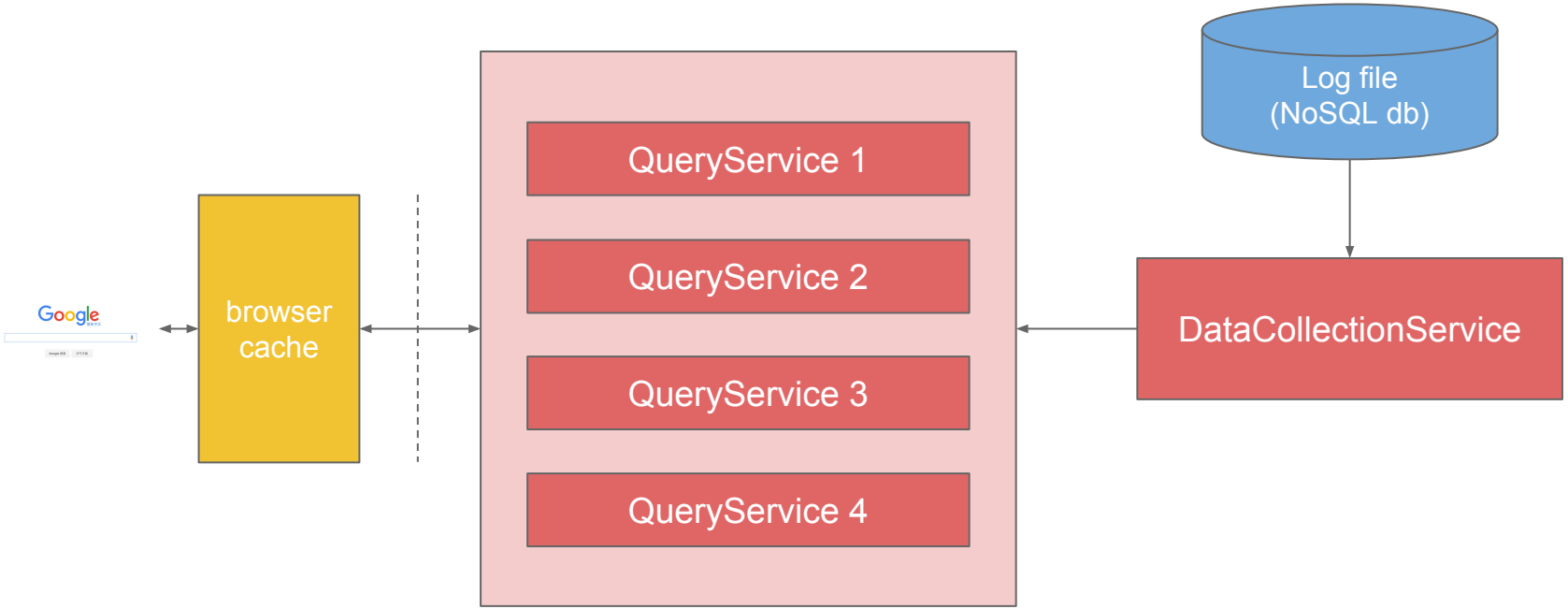
# Design a Typeahead

Evolve:

Interviewer: What if the trie gets too large for one machine?

# Design a Typeahead

What if the trie gets too large for one machine



# Appendix

课后练习

http://www.lintcode.com/en/problem/url-parser/

http://www.lintcode.com/en/problem/implement-trie/

http://www.lintcode.com/en/problem/trie-serialization/

http://www.lintcode.com/en/problem/typeahead/

http://www.lintcode.com/en/problem/webpage-crawler/

# 谢谢大家