

ADVANCE SYSTEM DESIGN

Back - of - the - envelope calculation.

Seconds in a day = $24h * 60m * 60s = 86400 = \sim 100,000$

$5 * 9.667 = 5 * 10 = 50$

Requests per second:
 Writes per day = 10 Millions.
 write to Read: 1:10
 Writes Reqs/sec: $1M / (24 \text{ hrs} * 3600 \text{ sec}) \sim 12 \text{ req/sec}$
 Reads Reqs/sec : $12 * 10 = \sim 120 \text{ req/sec.}$

Bandwidth (per second) = $10 \text{ GB per day} / (24 * 3600) = 115.740741 \text{ KB/s} = \sim 1 \text{ MB/s}$

Conversion factors:
 $B: \text{Byte} : 10^3$
 $K: \text{Kilo} : 10^3$
 $M: \text{Mega} : 10^6$
 $G: \text{Giga} : 10^9$
 $T: \text{Tera} : 10^{12}$
 $P: \text{Peta} : 10^{15}$
 $k * K = M$
 $M * K = G$
 $G * K = T$
 $T * K = P$

1 Byte = 8 Bits
 1 KB = 1000 Bytes
 1 MB = 1000 KB
 1 GB = 1000 MB
 1 TB = 1000 GB
 1 PB = 1000 TB

→ Latency numbers every programmer should know
 ↳ Byte by byte go → system design

→ Back of the envelope estimation.

Operation name	Time
L1 cache reference	0.5 ns
Branch mispredict	5 ns
L2 cache reference	7 ns
Mutex lock/unlock	100 ns
Main memory reference	100 ns
Compress 1K bytes with Zippy	10,000 ns = 10 μ s
Send 2K bytes over 1 Gbps network	20,000 ns = 20 μ s
Read 1 MB sequentially from memory	250,000 ns = 250 μ s
Round trip within the same datacenter	500,000 ns = 500 μ s
Disk seek	10,000,000 ns = 10 ms
Read 1 MB sequentially from the network	10,000,000 ns = 10 ms
Read 1 MB sequentially from disk	30,000,000 ns = 30 ms
Send packet CA (California) → Netherlands → CA	150,000,000 ns = 150 ms

→ Imp. points to note:-

Memory is fast but the disk is slow.

Avoid disk seeks if possible.

Simple compression algorithms are fast.

Compress data before sending it over the internet if possible.

Data centers are usually in different regions, and it takes time to send data between them.



Example: Estimate Twitter QPS and storage requirements

Please note the following numbers are for this exercise only as they are not real numbers from Twitter.

Assumptions:

- 300 million monthly active users.
- 50% of users use Twitter daily.
- Users post 2 tweets per day on average.
- 10% of tweets contain media.
- Data is stored for 5 years.

Estimations:

Query per second (QPS) estimate:

- Daily active users (DAU) = 300 million * 50% = 150 million
- Tweets QPS = 150 million * 2 tweets / 24 hour / 3600 seconds = ~3500
- Peak QPS = 2 * QPS = ~7000

We will only estimate media storage here.

- Average tweet size:
- tweet_id 64 bytes
- text 140 bytes
- media 1 MB
- Media storage: $150 \text{ million} * 2 * 10\% * 1 \text{ MB} = 30 \text{ TB per day}$
- 5-year media storage: $30 \text{ TB} * 365 * 5 = \sim 55 \text{ PB}$

Tips

Back-of-the-envelope estimation is all about the process. Solving the problem is more important than obtaining results. Interviewers may test your problem-solving skills. Here are a few tips to follow:

- Rounding and Approximation. It is difficult to perform complicated math operations during the interview. For example, what is the result of "99987 / 9.1"? There is no need to spend valuable time to solve complicated math problems. Precision is not expected. Use round numbers and approximation to your advantage. The division question can be simplified as follows: "100,000 / 10".
- Write down your assumptions. It is a good idea to write down your assumptions to be referenced later.
- Label your units. When you write down "5", does it mean 5 KB or 5 MB? You might confuse yourself with this. Write down the units because "5 MB" helps to remove ambiguity.
- Commonly asked back-of-the-envelope estimations: QPS, peak QPS, storage, cache, number of servers, etc. You can practice these calculations when preparing for an interview. Practice makes perfect.