Interview Notes - Dropbox

Behavioural

Engineering Values

1. Relentlessly focus on impact. Iterate, prioritize, and build products that solve real user needs.
2. Own it. Do whatever it takes to see a project through to completion. Deliver on promises and own up to failure.
3. Pursue simplicity and sweat the details. Design and develop products anyone can use.
4. Build a culture you want to be part of ten years from now. Collaborate and help your team. Seek out feedback and provide constructive feedback to others.

> "Our hiring philosophy centers on our company values and candidates who can speak to them often do well. For example, we focus on teamwork and trust. Building a product useful to millions of people is truly a team effort — whether you're an engineer, designer, marketer, or anything else. Our users rely on Dropbox to help simplify their lives, and we take that trust seriously."

https://youtu.be/-ZuxQcp84o0

https://youtu.be/-ZuxQcp84o0

Algorithm

Allocate ID / Phone Directory

Things to consider:

- what happens if all IDs used up? throws Exception or return -1
- release invalid ID or release id that is not allocated, how to handle? just return or throw Exception??
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- release invalid ID or release id that is not allocated, how to handle? just return or throw Exception??

FreeList approach:

- Space is O(n), heavy, because of the data structure of queue and set too
- O(1) time in allocate and release

```
public class Allocator{
    private Queue<Integer> freeList;
    private Set<Integer> allocated;
    private final int MAX_ID;

    public Allocator(int maxId) {
        this.MAX_ID = maxId;
        this.freeList = new LinkedList<>();
        for(int i=0; i<maxId; i++) {
            freeList.offer(i);
        }
        this.allocated = new HashSet<>();
    }

    public int allocate() {
        if(freeList.isEmpty())
            return -1;
        int id = freeList.poll();
        allocated.add(id);
        return id;
    }

    public void release(int id) {
        if(id<0 || id>=MAX_ID || !allocated.contains(id)) retu
rn;
```

```
        allocated.remove(id);
        freeList.add(id);
    }

    public boolean check(int id) {
        // unnecessary check, the set contains can handle
        // if(id<0 || id>=MAX_ID) return false;
        return !allocated.contains(id);
    }

    public static void main(String[] args) {
        Allocator allocator = new Allocator(10);
        int id1 = allocator.allocate();
        int id2 = allocator.allocate();
        int id3 = allocator.allocate();
        System.out.println(id1+", "+id2+", "+id3);

        System.out.println(allocator.check(id1));
        System.out.println(allocator.check(id2));
        System.out.println(allocator.check(id3));
        System.out.println(allocator.check(11));
        System.out.println(allocator.check(-1));

        allocator.release(2);
        System.out.println(allocator.check(id3));

    }
}
```

*If no need to maintain a ordering allocation, can use just one set called available to achieve the above. Allocate is get and remove the first element in the set.

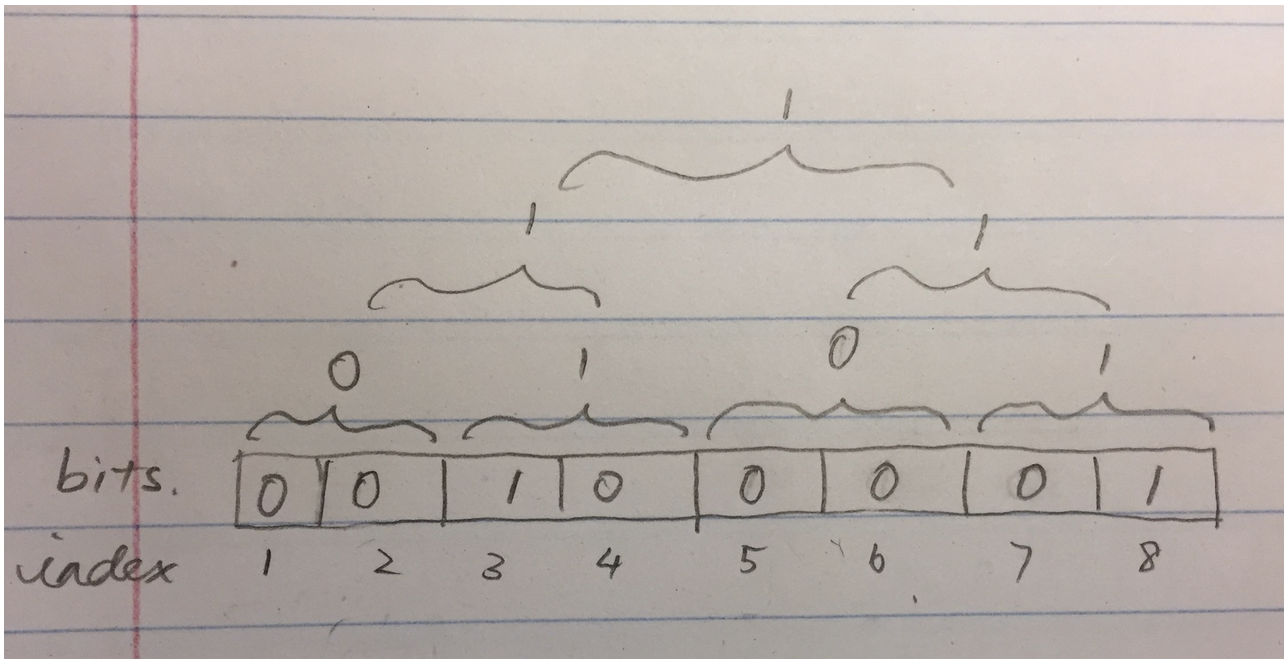
(available.iterator().first())

BitSet approach:
Space is much efficient: O(c), wouldn't say it is O(1) because we still need max_size number of bits
Time: **worst case O(n) in searching for next available id**

```
public class Allocator{
    private final int MAX_ID;
    private BitSet bitSet;
    private int nextAvailable;

    public Allocator(int maxId) {
        this.MAX_ID = maxId;
        this.bitSet = new BitSet(maxId);
        this.nextAvailable = 0;
    }

    public int allocate() {
       if(nextAvailable==MAX_ID) return -1;
       int num = nextAvailable;
       bitSet.set(num);
       nextAvailable = bitSet.nextClearBit(num);
       return num;
    }

    public void release(int id) {
        if(id<0 || id>=MAX_ID) return;
        if(bitSet.get(id)) {
            bitSet.clear(id);
            nextAvailable = Math.min(nextAvailable, id);
        }
```

```
    }

    public boolean check(int id) {
        if(id<0 || id>=MAX_ID) return false;
        return !bitSet.get(id);
    }
}
```

Using the idea of binary tree (in heap array representation in bitset):
Space: 2 * space used in bitset
Time: O(log n) time in **allocate and release**




```
public class Allocator{
    private final int MAX_ID;
    private BitSet bitSet;

    public Allocator(int maxId) {
        this.MAX_ID = maxId;
        this.bitSet = new BitSet(maxId*2-1);
```

```
    }

    public int allocate() {
        int index=0;
        while(index<MAX_ID-1) {
            if(!bitSet.get(index*2+1)) {
                index = index*2+1;
            } else if(!bitSet.get(index*2+2)) {
                index = index*2+2;
            } else {
                return -1;
            }
        }

        bitSet.set(index);
        updateTree(index);

        return index-MAX_ID+1;
    }

    public void updateTree(int index) {
        while(index>0) {
            int parent = (index-1)/2;
            if(index%2==1) { //left child
                if(bitSet.get(index) && bitSet.get(index+1)) {
                    bitSet.set(parent);
                } else {
                    bitSet.clear(parent); //it is required for
release id
                }
```

```
            } else {
                if(bitSet.get(index) && bitSet.get(index-1)) {
                    bitSet.set(parent);
                } else {
                    bitSet.clear(parent);
                }
            }
            index = parent;
        }
    }

    public void release(int id) {
        if(id<0 || id>=MAX_ID) return;
        if(bitSet.get(id+MAX_ID-1)) {
            bitSet.clear(id+MAX_ID-1);
            updateTree(id+MAX_ID-1);
        }
    }

    public boolean check(int id) {
        if(id<0 || id>=MAX_ID) return false;
        return !bitSet.get(id+MAX_ID-1);
    }
}
```

Download File - BitTorent

Things to consider:

- 增加一个显示下载百分比的功能 (use BitSet can do this)

If all chunks are given:

- just do something like interval merge

```
public boolean isFileDone(List<Chunk> chunks, int size) {
    if(chunks==null || chunks.size()==0) return false;

    Collections.sort(chunks, (a, b)-> a.start - b.start);
    if(chunks.get(0).start != 0) return false;

    int end = chunks.get(0).end;
    for(int i=1; i<chunks.size(); i++) {
        Chunk chunk = chunks.get(i);
        if(chunk.start>end)
            return false;
        else
            end = Math.max(end, chunk.end);
    }

    return end==size;
}
```

If chunks are coming in stream:

Using Priority Queue, addBlock is O(klog(m)) depending on the chunk arrivals and merging, but amortised worst case should be no more than O(logn).

```
class Downloader {
    private PriorityQueue<Chunk> chunks;
    int size;

    public Downloader(int size) {
        this.size = size;
        chunks = new PriorityQueue<>((a,b)->a.start-b.start);
```

```
    }

    public void addBlock(Chunk chunk) {
        chunks.offer(chunk);
        if(chunks.size()>1) {
            Chunk smallest = chunks.poll();
            //keep merging if there are continous chunks
            while(!chunks.isEmpty() && chunks.peek().start <=
smallest.end) {
                Chunk c = chunks.poll();
                smallest.end = Math.max(smallest.end, c.end);
            }
            chunks.offer(smallest);
        }
    }

    public boolean isDone() {
        if(!chunks.isEmpty() &&
            chunks.peek().start==0 && chunks.peek().end==size)
return true;
        return false;
    }
}
```

Using BitSet

```
class DownloaderBitSet {
    private BitSet chunksBitSet;
    int size;

    public DownloaderBitSet(int size) {
        this.size = size;
```

```
        chunksBitSet = new BitSet(size);
    }

    public void addBlock(Chunk chunk) {
        chunksBitSet.set(chunk.start, chunk.end);
    }

    public boolean isDone() {
        return chunksBitSet.cardinality()==size;
    }
}
```

TreeSet approach
https://www.programcreek.com/2014s/08/leetcode-data-stream-as-disjoint-intervals-java/

```
public class SummaryRanges {

    TreeSet<Interval> set;

    /** Initialize your data structure here. */
    public SummaryRanges() {
        set = new TreeSet<Interval>(new Comparator<Interval>()
{
            public int compare(Interval a, Interval b){
                return a.start-b.start;
            }
        });
    }

    public void addNum(int val) {
        Interval t = new Interval(val, val);
```

```
        Interval floor = set.floor(t);
        if(floor!=null){
            if(val<=floor.end){
                return;
            }else if(val == floor.end+1){
                t.start = floor.start;
                set.remove(floor);
            }
        }

        Interval ceil = set.higher(t);
        if(ceil!=null){
            if(ceil.start==val+1){
                t.end = ceil.end;
                set.remove(ceil);
            }
        }

        set.add(t);
    }


    public List<Interval> getIntervals() {
        return Arrays.asList(set.toArray(new Interval[0]));
    }
}
```

BST/Interval Tree??? how?

Duplicate Files

Things to consider:

1. Symbolic link, same file/dir with diff name, cannot detect cycle by visited...cycle? **use absolute path/ skip symbolic link (if we search the whole file system)**
2. invalid or malformed files e.g. permission or cannot read
3. compare file by hashing, MD5 false positive (due to hash collision), use SHA256/512 very very little chance of collision
4. ~~If dir depth is large: DFS might stack overflow, use BFS; the variable to store pathname might overflow.~~
5. Can ask question after interview how Dropbox solve this type of problem.
6. Most memory consuming: MD5, read in files etc
7. Race conditions?: someone is writing the file while you are reading etc
8. If error / hanging up in between: checkpoints, save states from time to time

```
import java.io.File;
import java.io.FileInputStream;
import java.io.FileNotFoundException;
import java.io.IOException;
import java.security.MessageDigest;
import java.security.NoSuchAlgorithmException;
import java.util.*;

public class FindDuplicateFiles {

    public List<List<String>> findDuplicates(String path) thro
ws Exception{
        List<List<String>> result = new ArrayList<>();
        if(path==null || path.length()==0) return result;

        List<String> filesPath = getAllFiles(path);
        Map<String, List<String>> dupFilesMap = new HashMap<>
();
```

```
        for(String filePath: filesPath) {
            File file = new File(filePath);
            String hashCode = hashFile(file, "MD5");

            if(!dupFilesMap.containsKey(hashCode)) {
                dupFilesMap.put(hashCode, new ArrayList<>());
            }
            dupFilesMap.get(hashCode).add(filePath);
        }

        for(List<String> dupFiles: dupFilesMap.values()) {
            if(dupFiles.size()>1)
                result.add(dupFiles);
        }

        return result;
    }

    private List<String> getAllFiles(String path) {
        List<String> filesPath = new ArrayList<>();
        Stack<String> s = new Stack<>();
        s.push(path); //DFS with Stack

        while(!s.isEmpty()) {
            String currPath = s.pop();
            File file = new File(currPath);

            if(file.isFile()) {
                filesPath.add(currPath);
            } else if(file.isDirectory()) {
```

```
                String[] subDir = file.list();
                for(String dir:subDir) {
                    s.push(currPath+"/"+dir);
                }
            }
        }

        return filesPath;
    }

    public List<List<String>> findDuplicatesOpt(String path) t
hrows Exception{
        List<List<String>> result = new ArrayList<>();
        if(path==null || path.length()==0) return result;

        Map<Long, List<String>> fileSizeMap = getAllFilesBySiz
e(path);
        Map<String, List<String>> dupFilesMap = new HashMap<>
();

        for(List<String> filePaths: fileSizeMap.values()) {
            if(filePaths.size()<2) continue;
            for(String filePath: filePaths) {
                File file = new File(filePath);
                String hashCode = hashFile(file, "MD5");

                if (!dupFilesMap.containsKey(hashCode)) {
                    dupFilesMap.put(hashCode, new ArrayList<>
());
                }
                dupFilesMap.get(hashCode).add(filePath);
```

```
            }
        }

        for(List<String> dupFiles: dupFilesMap.values()) {
            if(dupFiles.size()>1)
                result.add(dupFiles);
        }

        return result;
    }

    private Map<Long, List<String>> getAllFilesBySize(String p
ath) {
        Map<Long, List<String>> fileSizeMap = new HashMap<>();
        Stack<String> s = new Stack<>();
        s.push(path);

        while(!s.isEmpty()) { //DFS by stack
            String currPath = s.pop();
            File file = new File(currPath);

            if(file.isFile()) {
                long size = file.length();
                if(!fileSizeMap.containsKey(size))
                    fileSizeMap.put(size, new ArrayList<>());
                fileSizeMap.get(size).add(currPath);
            } else if(file.isDirectory()) {
                String[] subDir = file.list();
                for(String dir:subDir) {
                    s.push(currPath+"/"+dir);
```

```
                }
            }
        }

        return fileSizeMap;
    }

    private static String hashFile(File file, String algorith
m)
            throws Exception {
        try (FileInputStream inputStream = new FileInputStream
(file)) {
            MessageDigest digest = MessageDigest.getInstance(a
lgorithm);

            byte[] bytesBuffer = new byte[1024];
            int bytesRead = -1;

            while ((bytesRead = inputStream.read(bytesBuffer))
!= -1) {
                digest.update(bytesBuffer, 0, bytesRead);
            }

            byte[] hashedBytes = digest.digest();

            return convertByteArrayToHexString(hashedBytes);
        } catch (NoSuchAlgorithmException | IOException ex) {
            throw new Exception(
                    "Could not generate hash from file", ex);
        }
    }
```

```
    private static String convertByteArrayToHexString(byte[] a
rrayBytes) {
        StringBuffer stringBuffer = new StringBuffer();
        for (int i = 0; i < arrayBytes.length; i++) {
            stringBuffer.append(Integer.toString((arrayBytes
[i] & 0xff) + 0x100, 16)
                    .substring(1));
        }
        return stringBuffer.toString();
    }

    public static void main(String[] args) throws Exception{
        List<List<String>> dupFiles = new FindDuplicateFiles
().findDuplicatesOpt("./Resources/Dropbox");
        for(List<String> dup: dupFiles) {
            System.out.println(dup.toString());
        }

        //new FindDuplicateFiles().read1KBEachTime("./Resource
s/Dropbox/board.txt");
    }



}
```

How to check the file types in Linux:
Linux has different APIs e.g. is_regular_file(), is_block_file etc

How to hash 1KB each time:

```
  public void read1KBEachTime(String path)
            throws FileNotFoundException, IOException{
```

```
      File file = new File(path);
      FileInputStream fis = new FileInputStream(file);
      byte[] buffer = new byte[1024];
      int count;
      while((count=fis.read(buffer))!=-1) {
         // hash(buffer);
          System.out.print(buffer);
          count = fis.read(buffer);
      }
  }
```

```
    - • //Helper functions (need to be defined by you)
    - public List<String> getFiles(String directoryPath); //Returns all files directly under this directory
    - public List<String> getDirectories(String directoryPath); //Returns all directories directly under this directory
    - public String getFileContent(String filePath); //Returns content of a file
    - //Write this function (Interviewer just cared about this)
    - public List<String> findDuplicates(String rootDirectory) {
    -  ...
    -  ...
```

609. Find Duplicate File in System

Example 1:

```
Input:
["root/a 1.txt(abcd) 2.txt(efgh)", "root/c 3.txt(abcd)", "root/c/d 4.txt(efgh)", "root 4.txt(efgh)"]
Output:
```

```
[["root/a/2.txt","root/c/d/4.txt","root/4.txt"],["root/a/1.txt","root/c/3.txt"]]
```

```
class Solution {
    public List<List<String>> findDuplicate(String[] paths) {
        Map<String, List<String>> dupFilesMap = new HashMap<>();

        for(String dir: paths) {
            String[] fileAndContent = dir.split(" ");
            String dirPath = fileAndContent[0];
            for(int i=1; i<fileAndContent.length; i++) {

                String fileName = fileAndContent[i].substring(0, fileAndContent[i].indexOf("("));
                String fileContent = fileAndContent[i].substring(fileAndContent[i].indexOf("(")+1, fileAndContent[i].indexOf(")"));
                if(!dupFilesMap.containsKey(fileContent))
                    dupFilesMap.put(fileContent, new ArrayList<>());
                dupFilesMap.get(fileContent).add(dirPath+"/"+fileName);
            }
        }

        List<List<String>> result = new ArrayList<>();
        for(List<String> dupFiles: dupFilesMap.values()) {
            if(dupFiles.size()>1)
                result.add(dupFiles);
        }
```

```
        return result;
    }
}
```

Find Byte in File

Simple substring match

```
public boolean containBytes(byte[] pattern, byte[] text) {
    for(int i=0; i<=text.length-pattern.length; i++) {
        int j=0;
        while(j<pattern.length && pattern[j]==text[i+j]) {
           j++;
        }
        if(j==pattern.length) return true;
    }

    return false;
}
```

Use rolling hash to check substring match

- mod a large prime number to avoid overflow
- the parameters a and prime number determines the collision rate. We want the slot large enough, N*2 such that the expected collision for n elements is just 1/N, there are n numbers, so total expected collision is n* 1/n =1
- We need to check if this is really the substring match if the hash code is the same

```
public boolean containsBytesRollingHash(byte[] pattern, byte[]
text) {
    if(text.length<pattern.length)
        return false;

    int m = pattern.length, n=text.length;
    byte[] initialBytes = Arrays.copyOfRange(text, 0, m);
```

```
    RollingHash hashFun = new RollingHash(31, initialBytes);

    long patternHashVal = hashFun.hash(pattern);
    for(int i=0; i<=n-m; i++) {
        if(patternHashVal==hashFun.currHashValue) {
            //need to check byte by byte to ensure
            int j=0;
            while(j<m && pattern[j]==text[i+j]) j++;
            if(j==m) return true;
        }

        if(i<n-m){
            hashFun.recompute(text[i], text[i+m]);
        }
    }

    return false;
}

public boolean containsBytesFileRollingHash (byte[] pattern, F
ile file) throws FileNotFoundException, IOException {
    FileInputStream fis = new FileInputStream(file);

    try {
        byte[] initialBytes = new byte[pattern.length];

        if (fis.read(initialBytes) != pattern.length) return f
alse;

        RollingHash hashFun = new RollingHash(31, initialByte
s);
```

```
        long patternHashVal = hashFun.hash(pattern);
        if (patternHashVal == hashFun.currHashValue) return tr
ue;

        Queue<Byte> window = new LinkedList<>();
        for (int i = 0; i < initialBytes.length; i++) {
            window.offer(initialBytes[i]);
        }

        int b;
        while ((b = fis.read()) != -1) {
            System.out.println(b);

            hashFun.recompute(window.poll(), (byte) b);
            window.offer((byte) b);
            if (patternHashVal == hashFun.currHashValue) retur
n true;
        }

    }finally {
        fis.close();
    }

    return false;
}

class RollingHash {
    private final int LARGE_PRIME = 105613;
    private final int a;
    private int h=1;
```

```
    private final int WINDOW_LENGTH;

    private long currHashValue;

    public RollingHash(int a, byte[] initialBytes) {
        this.a = a;
        this.WINDOW_LENGTH = initialBytes.length;

        // The value of h would be "pow(a, WINDOW_LENGTH-1)%q
        for (int i = 0; i < WINDOW_LENGTH-1; i++) {
            //a^n % p = (a^n-1 % p * a%p)%p;
            h = (h*a)%LARGE_PRIME;
        }

        currHashValue = hash(initialBytes);

    }

    public long hash(byte[] bytes) {
        int hashVal=0;

        for(int i=0; i<bytes.length; i++) {
            hashVal = (a*hashVal + bytes[i])% LARGE_PRIME;
        }

        return hashVal;
    }

    public long recompute(byte removed, byte incoming) {
```

```
        //(a+b) %p = (a%p + b%p) %p
        //(a-b) %p = (a%p - b%p) %p might give negative
        //(a*b) %p = (a%p * b%p) %p
        currHashValue = (a*(currHashValue - removed*h) + incom
ing)%LARGE_PRIME;

        // We might get negative value of t, converting it to
positive
        if (currHashValue < 0)
            currHashValue += LARGE_PRIME;

        return currHashValue;
    }
}
```

Top K Photo ID

- counting the freq is O(n)
- use selection algorithm to select top k element is O(n) time, e.g. quick select; but it is not sorted, can be sorted in O(K log K) if needed. this approach runs in O(N) time, the constants hidden in the O-notation can be large. worst case of quick select is O(n^2)
- using min heap of size k (nlogk)
- using max heap of size n (n + klogn)

For non-streaming
approach 1:
Count freq + bucket sort
O(n), cons is the bucket is sparse, if there is **one extreme freq**, inefficient space usage

```
public List<Integer> topKViewPhoto(int[] photoIds, int k) {
    List<Integer> result = new ArrayList<>();
```

```
    if(photoIds==null || photoIds.length<1) return result;

    Map<Integer, Integer> freqMap = new HashMap<>();
    int maxFreq = 0;
    for(int id: photoIds) {
        int freq = freqMap.getOrDefault(id, 0)+1;
        maxFreq = Math.max(maxFreq, freq);
        freqMap.put(id, freq);
    }

    List[] freqBuckets = new List[maxFreq+1];
    for(Map.Entry<Integer, Integer> freqEntry: freqMap.entrySe
t()) {
        if(freqBuckets[freqEntry.getValue()]==null) {
            freqBuckets[freqEntry.getValue()] = new ArrayList<
>();
        }
        freqBuckets[freqEntry.getValue()].add(freqEntry.getKey
());
    }

    for(int i=freqBuckets.length-1; i>=0; i--) {
        if(freqBuckets[i]!=null) {
            List<Integer> ids = freqBuckets[i];
            if(k>=freqBuckets[i].size()) {
                result.addAll(ids);
                k -= freqBuckets[i].size();
            } else {
                for(int j=0; j<k; j++) {
                    result.add(ids.get(j));
                }
```

```
                break;
            }
        }

    }

    return result;

}
```

approach 2:
using k-min heap to maintain k most viewed. nlogk

```
public List<Integer> topKViewPhoto(int[] photoIds, int k) {
    List<Integer> result = new ArrayList<>();
    if(photoIds==null || photoIds.length<1) return result;

    Map<Integer, Integer> freqMap = new HashMap<>();
    for(int id: photoIds) {
        int freq = freqMap.getOrDefault(id, 0)+1;
        freqMap.put(id, freq);
    }

    PriorityQueue<View> topKView = new PriorityQueue<>((a,b)->
a.freq - b.freq);
    for(Map.Entry<Integer, Integer> freqEntry: freqMap.entrySe
t()) {
        View view = new View(freqEntry.getKey(), freqEntry.get
Value());
        if(topKView.size()<k) {
            topKView.add(view);
        } else {
```

```
            if(freqEntry.getValue()>topKView.peek().freq) {
                topKView.poll();
                topKView.offer(view);
            }
        }
    }

    while(!topKView.isEmpty()) {
        result.add(topKView.poll().id);
    }

    return result;

}

class View {
    int id;
    int freq;
    public View(int id, int freq) {
        this.id = id; this.freq = freq;
    }
}
```

For streaming:
The problem here is we cannot increase/ decrease value of priority queue, to remove it and re-add, the remove is O(k).
What we can do better is to implement the min heap ourselves, and do the keyAdjust heapify, which will be O(logk)
**check data structure heap

```
class PhotoView implements Comparable<PhotoView> {
    int id;
```

```
    int freq;

    public PhotoView(int id, int freq) {
        this.id = id; this.freq = freq;
    }

    @Override
    public int compareTo(PhotoView other) {
        if(this.freq == other.freq) {
            return other.id - this.id;
        }
        return this.freq - other.freq;
    }
}
public class MaxPhotoID {
    private PriorityQueue<PhotoView> kMostViewPhotos;
    private Map<Integer, PhotoView> photoViewFreqMap;
    private final int k;

    public MaxPhotoID(int k) {
        this.k = k;
        kMostViewPhotos = new PriorityQueue<>();
        photoViewFreqMap = new HashMap<>();
    }

    public void view(int id) {
        if(!photoViewFreqMap.containsKey(id)) {
            photoViewFreqMap.put(id, new PhotoView(id, 0));
        }
        PhotoView view = photoViewFreqMap.get(id);
```

```
        view.freq++;

        if (kMostViewPhotos.size()<k ||
                view.freq >= kMostViewPhotos.peek().freq ) {
            kMostViewPhotos.remove(view);
            kMostViewPhotos.offer(view);
            if(kMostViewPhotos.size()>k)
                kMostViewPhotos.poll();
        }
    }

    public List<Integer> getTopKViewPhoto() {
        PhotoView[] topK = kMostViewPhotos.toArray(new PhotoVi
ew[kMostViewPhotos.size()]);
        /*Arrays.sort(topK, (a, b)-> { //cannot sort it
            if(a.freq == b.freq) {
                return a.id - b.id;
            }
            return a.freq - b.freq;
        });*/
        List<Integer> result = new ArrayList<>();
        for(PhotoView photoView: topK) {
            result.add(photoView.id);
        }
        return result;
    }

    public static void main (String[] args) {
        MaxPhotoID solver = new MaxPhotoID(4);
        solver.view(1);
```

```
        solver.view(2);
        solver.view(1);
        System.out.println(solver.getTopKViewPhoto());
        solver.view(3);

        System.out.println(solver.getTopKViewPhoto());
        solver.view(2);
        solver.view(12);
        solver.view(31);
        solver.view(101);
        solver.view(11);
        solver.view(3);
        System.out.println(solver.getTopKViewPhoto());

        solver.view(31);
        solver.view(101);
        solver.view(31);
        solver.view(101);
        System.out.println(solver.getTopKViewPhoto());

    }

}
```

Some people's idea about HashMap + DD Linked List: (it is just bucket sort, but with dynamic buckets)
map <id, freq>
map<freq, DDLinkedListNode>
DDLinkedListNode <freq, set<id>>

view O(1); getTopK depends on the freq distribution, can be worst case O(k).

DD LL to maintain the buckets, if new bucket, just add it and update prev, next;; if after removing the element from old freq bucket, the bucket becomes empty, delete the node...

Phone Number & Dictionary

如果能得到词典的话。把词典的数据放到Trie tree里来达到自动过滤前缀的效果，每次DFS前用trie搜一下能减少DFS

Simple implementation:

```
public class PhoneNumberDict {

    private final static String[] KEYS = {"","","abc", "def", "ghi", "jkl", "mno", "pqrs", "tuv", "wxyz"};
    private static Set<String> dict;

    public List<String> letterCombinations(String digits) {
        List<String> combinations = new ArrayList<>();
        if(digits==null || digits.length()<1) return combinations;

        findCombinations(combinations, new StringBuilder(), digits, 0);

        return combinations;
    }

    public void findCombinations(List<String> combinations, StringBuilder sb, String digits, int i) {
        if(i==digits.length()) {
            String comb = sb.toString();
            if(isWord(comb))
```

```
                combinations.add(comb);
        } else {
            String keyLetters = KEYS[digits.charAt(i)-'0'];
            for(int k=0; k<keyLetters.length(); k++) {
                sb.append(keyLetters.charAt(k));
                findCombinations(combinations, sb, digits, i+
1);
                sb.setLength(sb.length()-1);
            }
        }
    }

    public boolean isWord(String word) {
        return dict.contains(word);
    }

    public static void main(String[] args) {
        dict = new HashSet<>();
        dict.add("drop");
        dict.add("box");
        dict.add("dropbox");

        List<String> combinations = new PhoneNumberDict().lett
erCombinations("3767269");
        for(String comb: combinations) {
            System.out.println(comb);
        }

    }
```

```
}
```

Follow up:

用TIRE当然不是说你已经凑好一个单词了，再去TRIE里搜索了，是带着TRIE NODE往下搜，遇到TRIE NODE CHILDREN里完全没有的，直接跳过，可以避免很多无意义的DFS，如果带着TRIE NODE往里搜，那么判断是不是单词也就O(1)，因为就CHECK一下那个ISWORD的BOOLEAN就行

Trie Tree

```
class Trie {

    private class Node {
        Map<Character, Node> children;
        boolean isWord;

        public Node() {
            children = new HashMap<Character, Node>();
            isWord = false;
        }
    }

    private Node root;

    /** Initialize your data structure here. */
    public Trie() {
        root = new Node();
    }

    /** Inserts a word into the trie. */
    public void insert(String word) {
        Node curr = root;
```

```
        for(int i=0; i<word.length(); i++) {
            Node temp = curr.children.get(word.charAt(i));
            if(temp==null) {
                temp = new Node();
                curr.children.put(word.charAt(i), temp);
            }
            curr = temp;
        }
        curr.isCompleteWord = true;
    }

    /** Returns if the word is in the trie. */
    public boolean search(String word) {
        Node curr = root;
        for(int i=0; i<word.length(); i++) {
            curr = curr.children.get(word.charAt(i));
            if(curr==null) return false;
        }

        return curr.isWord;
    }

    public Node search(Node trieNode, Character c) {
        return trieNode.children.get(c);
    }

    /** Returns if there is any word in the trie that starts w
ith the given prefix. */
    public boolean startsWith(String prefix) {
        Node curr = root;
```

```
        for(int i=0; i<prefix.length(); i++) {
            curr = curr.children.get(prefix.charAt(i));
            if(curr==null) return false;
        }
        return true;
    }
}
```

Game of Life

- performance bottleneck: disk read/write
- In distributed computing, can use MapReduce, key: top left and bottom right coordinates to represent the rectangle.

Memory full:s

- linux cannot allocate memory, kill the current task
- Windows start use disk as virtual memory and speed down significantly

Linux commands to check memory:

```
top //check memory and cpu usage per process, but also reports total memory usage
free -m
```

Sharpness Values

Things to consider:

- Ask questions to clarify and let interviewer know you understand the problem before coding
- Explain the concept how it is DP = min(max(..,..,..), self)
- Space optimization, tell the interviewer the observation it just depends on prev column result. we will do space opt later.

```
public class SharpnessValue {
```

```
    public int findSharpnessValue(int[][] matrix) {
        if(matrix==null || matrix.length<1 || matrix[0].length
<1) return -1;

        int m = matrix.length, n = matrix[0].length;
        int[][] sharpness = new int[m][n];

        for(int i=0; i<m; i++) {
            sharpness[i][0] = matrix[i][0];
        }

        for(int j=1; j<n; j++) {
            for(int i=0; i<m; i++) {
              //find the max sharpness from the left, upper le
ft, and lower left path
                int pathPrev = sharpness[i][j-1];
                if(i>0) {
                    pathPrev = Math.max(pathPrev, sharpness[i-
1][j-1]);
                }
                if(i<m-1) {
                    pathPrev = Math.max(pathPrev, sharpness[i+
1][j-1]);
                }

                sharpness[i][j] = Math.min(pathPrev, matrix[i]
[j]);
            }
        }
```

```
        int maxSharpness = Integer.MIN_VALUE;
        for(int i=0; i<m; i++) {
            maxSharpness = Math.max(maxSharpness, sharpness[i]
[n-1]);
        }

        return maxSharpness;

    }

    public static void main(String[] args) {
        int[][] matrix = {{1}, {2}, {3}};

        SharpnessValue solver = new SharpnessValue();
        assert solver.findSharpnessValue(matrix)==3;

        int[][] matrix2 = {{1,2,3}};
        assert solver.findSharpnessValue(matrix2)==1;

        int[][] matrix3 = {{3}};
        assert solver.findSharpnessValue(matrix3)==3;

        int[][] matrix4 = {{5,7,2},{7,5,8},{9,1,5}};
        System.out.println(solver.findSharpnessValue(matrix
4));

    }
}
```

Space Optimised:

```
for(int j=1; j<n; j++) {
```

```
    int prev = sharpness[0];
    for(int i=0; i<m; i++) {
        //find the max sharpness from the left, upper left, an
d lower left path
        int maxPath = sharpness[i];
        if(i>0) {
            maxPath = Math.max(maxPath, prev);
        }
        if(i<m-1) {
            maxPath = Math.max(maxPath, sharpness[i+1]);
        }

        prev = sharpness[i];
        sharpness[i] = Math.min(maxPath, matrix[i][j]);
    }
}
```

Follow-up:
If the matrix is very large:
*cannot process rectangle by rectangle, because the boundary of the rect depends on the next row of the prev, and the next row prev is depends on the doundary of ... recursive...!
*The same reason, cannot do it 3 rows by 3 rows each time.

1. Read it column by column each time (**many disk seek() because of the way array is stored**)
2. Transpose the file: same if read row, output col, many disk seek() when write; if read col, output row, many disk seek() when read
    - we can according to the memory size, each time read a square matrix, and do the transpose of it. (need RandomAccessFile, seek() etc)
    - Then do the processing row by row.
3. Divide the matrix into many smaller blocks (divide & conquer) s.t. each block can fit into memory and do the transpose in memory; transpose each block & output to a file with id; reconstruct the final matrix by read in the blocks according to the transpose order of those smaller blocks.

follow up是要你算page swap次数，给了假设是一个4T的文件。要你算出一个数字出来。
然后优化是行列转一下，再算一次需要swap的次数。比较一下性能提高了多少。
总之基本都要算出来具体的数字而不是给个大概的表达式。
memory和disk都是按page为单位存的。
假设matrix太大不能存进memory，只能存进disk。那么每次从matrix中间读(i,j)就要从disk中访问，就会把(i,j)所在的page swap进memory。
如果按行存，dp的时候按列dp，每次读都要swap一个新页进memory，就很慢。

Buy Soda/ Coin Change - Combination Sum

```
Given a set of candidate numbers (C) (without duplicates) and a target number (T), find all unique combinations in C where the candidate numbers sums to T.

The same repeated number may be chosen from C unlimited number of times.

Note:
    - All numbers (including target) will be positive integers.
    - The solution set must not contain duplicate combinations.

For example, given candidate set [2, 3, 6, 7] and target 7,
A solution set is:
[
  [7],
  [2, 2, 3]
]
```

Recursive:
complexity在 (sizes.length)^n 级别，因为n可以非常大，所以很容易指数爆炸，但是一般来说pack sizes只有那么几种，所以她想让我写 n^(sizes.length) 级别的解法

Recursive time complexity: each level there is a loop, the branching factor could up to m, the depth could up to O(T), so M^T (*it is not 2^n as the element can be used

more than one, if the element can use only once, actually we are considering all combination, 2^n such combinations)
Space: just use the result array and one list for backtracking.

```
class Solution {
    public List<List<Integer>> combinationSum(int[] candidate
s, int target) {
        List<List<Integer>> result = new ArrayList<>();
        Arrays.sort(candidates);
        combinationSum(result, new ArrayList(), candidates, ta
rget, 0);
        return result;
    }

    public void combinationSum(List<List<Integer>> result, Lis
t<Integer> list, int[] candidates, int target, int index) {
        if(target<0) return;
        if(target==0) {
            result.add(new ArrayList<Integer>(list)); return;
        }

        for(int i=index; i<candidates.length && candidates[i]<
=target; i++) {
            list.add(candidates[i]);
            combinationSum(result, list, candidates, target-ca
ndidates[i], i);
            list.remove(list.size()-1);
        }
    }
}
```

DP:
Time complexity: T*mk, where k is the partial solution set size*

Space: use up much more space as we stored so many partial solutions

```
class Solution {
    public List<List<Integer>> combinationSum(int[] candidates, int target) {
        List<List<List<Integer>>> dp = new ArrayList<>();//be careful, 0 base index
        Arrays.sort(candidates);

        for(int t=1; t<=target; t++) {
            ArrayList<List<Integer>> newList = new ArrayList<>();
            for(int i=0; i<candidates.length && candidates[i]<=t; i++) {
                if(t==candidates[i]) {
                    newList.add(Arrays.asList(candidates[i]));
                } else {
                    for(List<Integer> list: dp.get(t-candidates[i]-1)) {
                        //this is to pick the list seq which is monotonic increasing
                        //this can avoid duplicates
                        if(candidates[i]>=list.get(0)) {
                            List<Integer> cumList = new ArrayList<>();
                            cumList.add(candidates[i]); cumList.addAll(list);
                            newList.add(cumList);
                        }
                    }
                }
            }
            dp.add(newList);
```

```
        }

        return dp.get(target-1);
    }
}
```

Word Pattern

Given pattern and a list of words:

- bijection mapping, so need to check if the word is already mapped.

```
class Solution {
    public boolean wordPattern(String pattern, String str) {
        String[] patternStrMap = new String[258];
        Set<String> mapped = new HashSet<>();

        String[] words = str.split(" ");
        if(pattern.length()!=words.length)
            return false;

        for(int i=0; i<pattern.length(); i++) {
            char c = pattern.charAt(i);
            if(patternStrMap[c]==null) {
                if(mapped.contains(words[i]))
                    return false;
                patternStrMap[c] = words[i];
                mapped.add(words[i]);
            } else {
                if(!patternStrMap[c].equals(words[i]))
```

```
                    return false;
            }
        }

        return true;
    }
}
```

The given input is not a list of words

```
public class WordPatternMatch {
    public boolean wordPatternMatch(String pattern, String st
r) {
        Map<Character, String> charStrMap = new HashMap<>();
        Set<String> usedStr = new HashSet<>();
        return isMatch(charStrMap, usedStr, pattern, 0, str,
0);
    }

    public boolean isMatch(Map<Character, String> charStrMap,
Set<String> usedStr, String pattern, int i, String str, int j)
{
        //System.out.println(i + "  "+j);
        if(pattern.length()==i && str.length()==j) return true
;
        if(pattern.length()==i || str.length()==j) return fals
e;

        char c = pattern.charAt(i);
        if(charStrMap.containsKey(c)) {
            String mappedStr = charStrMap.get(c);
            if(str.startsWith(mappedStr, j)) {
```

```
                return isMatch(charStrMap, usedStr, pattern, i
+1, str, j+mappedStr.length());
            } else {
                return false;
            }
        } else {
            for(int k=j; k<str.length(); k++) {
                String word = str.substring(j, k+1);
                //System.out.println(word);
                if(usedStr.contains(word)) continue;
                usedStr.add(word);
                charStrMap.put(c, word);
                if(isMatch(charStrMap, usedStr, pattern, i+1,
str, k+1))
                    return true;
                usedStr.remove(word);
                charStrMap.remove(c);
            }
            return false;
        }

    }

    public static void main(String[] args) {
        System.out.println(new WordPatternMatch().wordPatternM
atch("abba", "dogcatcatdog"));
    }
}
```

Word Break /Word Break II

Given a **non-empty** string *s* and a dictionary *wordDict* containing a list of **non-empty** words, determine if *s* can be segmented into a space-separated sequence of one or more dictionary words. You may assume the dictionary does not contain duplicate words.

For example, given

s = "leetcode",

dict = ["leet", "code"].

Return true because "leetcode" can be segmented as "leet code".

```
class Solution {
    public boolean wordBreak(String s, List<String> wordDict) {
        boolean[] dp = new boolean[s.length()+1];
        dp[0]=true;

        for(int i=1; i<=s.length(); i++) {
            for(int j=0; j<i; j++) {
                if(dp[j] && wordDict.contains(s.substring(j, i))) {
                    dp[i] = true; break; //here dp[i] refers to prev 0..i-1 chars can be wordbreak
                }

            }
        }

        return dp[s.length()];
    }
}
```

If we need to output the solution:

```
class Solution {
    public List<String> wordBreak(String s, List<String> wordD
ict) {
        Map<String, List<String>> lookup = new HashMap<>();
        return wordBreak(s, wordDict, lookup);
    }

    public List<String> wordBreak(String s, List<String> wordD
ict,
                                  Map<String, List<String>>
lookup) {
        if(lookup.get(s)!=null) return lookup.get(s);

        List<String> result = new ArrayList<>();
        if(s.length()==0) {
            result.add("");
            return result;
        }

        for(String word: wordDict) {
            if(s.startsWith(word)) {
                List<String> partialResult = wordBreak(s.subst
ring(word.length()) ,
                      wordDict, lookup);
                for(String str: partialResult) {
                    result.add(word + (str.equals("")? "":" "+
str));
                }
            }
```

```
        }
        lookup.put(s, result);

        return result;
    }

}
```

Number of Islands

Given a 2d grid map of `'1'`s (land) and `'0'`s (water), count the number of islands. An island is surrounded by water and is formed by connecting adjacent lands horizontally or vertically. You may assume all four edges of the grid are all surrounded by water.

Example 1:

```
11110
11010
11000
00000
```

```
class Solution {
    public static final char ISLAND_MARK = '1';
    public static final char WATER_MARK = '0';

    public int numIslands(char[][] grid) {
        int counter = 0;
        if(grid==null || grid.length<1) return counter;
        for(int i=0; i<grid.length; i++) {
            for(int j=0; j<grid[i].length; j++) {
                if(grid[i][j]==ISLAND_MARK) {
                    counter++;
```

```
                    mark(grid, i,j);
                }
            }
        }
        return counter;
    }

    public void mark(char[][] grid, int i, int j) {
        if(i>=0 && i<grid.length && j>=0 && j<grid[i].length &
& grid[i][j] == ISLAND_MARK) {
            grid[i][j] = WATER_MARK;
            mark(grid, i-1, j);
            mark(grid, i+1, j);
            mark(grid, i, j-1);
            mark(grid, i, j+1);
        }
    }
}
```

If file very large, read row by row, using Union Find:

305. Number of Islands II

A 2d grid map of `m` rows and `n` columns is initially filled with water. We may perform an *addLand* operation which turns the water at position (row, col) into a land. Given a list of positions to operate, **count the number of islands after each *addLand* operation**. An island is surrounded by water and is formed by connecting adjacent lands horizontally or vertically. You may assume all four edges of the grid are all surrounded by water.

Example:

Given `m = 3, n = 3`, `positions = [[0,0], [0,1], [1,2], [2,1]]`.

Initially, the 2d grid `grid` is filled with water. (Assume 0 represents water and 1 represents land).

```
0 0 0
0 0 0
0 0 0
```

Operation #1: addLand(0, 0) turns the water at grid[0][0] into a land.

```
1 0 0
0 0 0   Number of islands = 1
0 0 0
```

```
class Solution {
    private static final int[][] directions = {{0, 1}, {1, 0}, {-1, 0}, {0, -1}};

    public List<Integer> numIslands2(int m, int n, int[][] positions) {
        List<Integer> result = new ArrayList<>();
        if(m==0 || n==0 || positions==null || positions.length<1) return result;

        int[] root = new int[m*n]; //id = n*i+j
        int[] rank = new int[m*n];
        Arrays.fill(root, -1);

        int numIslands = 0;
        for(int[] position: positions) {
            int id = position[0]*n + position[1];
            root[id] = id; rank[id] = 1;
            numIslands++;
            for(int k=0; k<directions.length; k++) {
                int i = position[0] + directions[k][0];
                int j = position[1] + directions[k][1];
```

```
                if(i>=0 && i<m && j>=0 && j<n && root[i*n+j]!=
-1) {
                    numIslands = union(root, rank, id, i*n+j,
numIslands);
                }

            }

            result.add(numIslands);
        }

        return result;
    }

    public int union(int[] root, int[] rank, int x, int y, int
numIslands) {
        int parent1 = find(root, x);
        int parent2 = find(root, y);
        if(parent1!=parent2) { //union
            numIslands--;
            if(rank[parent1]< rank[parent2]) {
                root[parent1] = parent2;
                rank[parent2] += rank[parent1];
            } else {
                root[parent2] = parent1;
                rank[parent1] += rank[parent2];
            }
        }
        return numIslands;
    }
```

```
    public int find(int[] root, int id) {
        while(root[id]!=id) {
            root[id] = root[root[id]];
            id = root[id];
        }
        return root[id];
    }

}
```

Folder Access

Given child-parent folder relationships, and user has access to folders in the access set. Find if user has access to particular folder.
/A
|_ _ /B
    |__ /C <-- access
    |__ /D
|__ /E <-- access
    |__ /F
|__ /G
folders = [[br] ('A', None),
('B', 'A'),
('C', 'B'),
('D', 'B'),
('E', 'A'),
('F', 'E'),
]
access = set(['C', 'E'])
has_access(String folder_name) -> boolean
has_access("B") -> false
has_access("C") -> true
has_access("F") -> true
~~has_access("G") -> true (this is probably wrong)~~

Things to consider:

- The child-parent relationships are given in HashMap?
- can a folder has more than one parent? If so, how is it represented?

Linux command to create symbolic link to folder:

```
ln -s path-to-actual-folder name-of-link
ls -ld name-of-link
```

- Would it be possible a circular child-parent relationship? if so, mark visited.
- Need to return false if you are checking a folder non-exiting.

```
package DropBox;
import java.util.*;

public class FolderAccess {
    private Map<String, String> foldersParent;
    private Set<String> access;

    public FolderAccess(Map<String, String> foldersParent, Set
<String> access) {
        this.foldersParent = foldersParent;
        this.access = access;
    }

    public boolean hasAccess(String folderName) {
        String currFolder = folderName;
        while(currFolder!=null) {
            if(access.contains(currFolder)) {
                return true;
            } else {
                currFolder = foldersParent.get(currFolder);
            }
        }
        return false;
```

```
    }

    public Set<String> simplifyAccess() {
      Set<String> simplifiedAccess = new HashSet<>();

      for(String folder: access) {
          String currFolder = foldersParent.get(folder);
          boolean shouldDelete = false;
          while(currFolder!=null && !shouldDelete) {
              if(access.contains(currFolder)) {
                  shouldDelete = true;
              } else {
                  currFolder = foldersParent.get(currFolder);
              }
          }

          if(!shouldDelete)
              simplifiedAccess.add(folder);
      }

      return simplifiedAccess;
    }

    public static void main(String[] args) {
        Map<String, String> foldersParent = new HashMap<>();
        foldersParent.put("B", "A");
        foldersParent.put("C", "B");
        foldersParent.put("D", "B");
        foldersParent.put("E", "A");
        foldersParent.put("F", "E");
```

```
        Set<String> access = new HashSet<>();
        access.add("C");
        access.add("E");

        FolderAccess solver = new FolderAccess(foldersParent,
access);
        assert solver.hasAccess("B") == false;
        assert solver.hasAccess("C") == true;
        assert solver.hasAccess("F") == true;
        assert solver.hasAccess("G") == false; //G is not in t
he folders structure
    }
}
```

http://www.1point3acres.com/bbs/thread-445904-1-1.html
followup说可访问set里有重复，比如C，B，A同时出现，要求只留一个A。
写一个fixRedundantAccess来优化，解与之前类似，往上如果parent 已经存在就删。写完问runtime，答O(mlogn)，m为可访问set的大小。
被要求继续优化，于是每次往上的时候把路径存下来，最后一起删掉（类似剪枝）。结果跑完发现不对，把最顶层也删了，于是debug。

我的思路是dfs，从set里的每个点出发，找到target folder返回true，否则一直搜到最底层的folder，搜索过程维持一个visited的set，避免以后重复搜索

Count And Say

```
class Solution {
    public String countAndSay(int n) {
```

```
        String curr = "1";
        StringBuilder sb = new StringBuilder();
        for(int i=2; i<=n; i++) {
            sb.setLength(0);
            int count = 1;
            for(int j=0; j<curr.length(); j++) {
                if(j==curr.length()-1 || curr.charAt(j)!=curr.
charAt(j+1)) {
                    sb.append(count).append(curr.charAt(j));
                    count=1;
                } else
                    count++;
            }
            curr = sb.toString();
        }

        return curr;
    }
}
```

Folders And Cows

Grid Illumination

Multi-threading

Web Crawler

http://scrumbucket.org/tutorials/neo4j-site-crawler/part-2-create-multi-threaded-crawl-manager/

Multithreading Things to consider:

1. which part is most time-consuming. The part that the thread knows the url to be visited and getting back list of URLs. Network latency, webpage content parser and processing.
2. Should visit URL? e.g. define the depth of crawling, type of urls e.g. the one without ending in .pdf, size of the result set etc.
3. Crawler failed, will throws ExecutionException
4. Sleep the master thread a little bit each time after the checking of futures... manager thread will not use all the resources

Simple single thread DFS, BFS

```
public List<String> crawlBFS(String url) {
    Set<String> result = new HashSet<>();
    Queue<String> q = new LinkedList<>();
    q.add(url); result.add(url);

    while(!q.isEmpty()) {
        String currUrl = q.poll();

        List<String> childrenUrls = getUrls(currUrl);
        if(childrenUrls!=null) {
            for(String childUrl: childrenUrls) {
                if(!result.contains(childUrl)) {
                    q.offer(childUrl);
                    result.add(childUrl);
                }
            }
        }
    }
```

```
    return new ArrayList<>(result);
}

public List<String> crawlDFS(String url) {
    Set<String> result = new HashSet<>();

    crawlDFSHelper(result, url);

    return new ArrayList<>(result);
}

public void crawlDFSHelper(Set<String> result, String url) {
    if(url==null || result.contains(url)) return;

    result.add(url);
    List<String> childrenUrls = getUrls(url);
    if(childrenUrls!=null) {
        for(String childUrl: childrenUrls) {
            crawlDFSHelper(result, childUrl);
        }
    }

}
```

Multithread version:

1. since the most time consuming part is the getUrls(url) function, we can use a Master/slave approach to parallel processing the getUrls(url),
2. The benefit of also making the read write of result set parallel doesn't justify synch overhead. So, prefer just the master thread to do it.

```
import java.util.*;
import java.util.concurrent.*;

/*
    http://scrumbucket.org/tutorials/neo4j-site-crawler/part-2-create-multi-threaded-crawl-manager/
 */
public class CrawlerManager {
    public static final int THREAD_COUNT = 10;
    private static final long PAUSE_TIME = 1000;

    private Set<String> result = new HashSet<>();
    private List<Future<List<String>>> futures = new ArrayList<>();
    private ExecutorService executor = Executors.newFixedThreadPool(THREAD_COUNT);

    private static Map<String, List<String>> connectedUrls;


    public static List<String> getUrls(String url) {
        return connectedUrls.getOrDefault(url, new ArrayList<String>());
    }

    public List<String> crawl(String startUrl) {
        submitNewUrl(startUrl);

        try{
            while(checkCrawlerResults());
        } catch (InterruptedException e) {
```

```
        }
        executor.shutdown();
        return new ArrayList<>(result);
    }

    public boolean checkCrawlerResults() throws InterruptedExc
eption {
        Thread.sleep(PAUSE_TIME);
        Iterator<Future<List<String>>> iterator = futures.iter
ator();
        List<String> newUrls = new ArrayList<>();

        while(iterator.hasNext()) {
            Future<List<String>> future = iterator.next();
            if(future.isDone()) {
                iterator.remove();
                try {
                    newUrls.addAll(future.get());
                } catch (ExecutionException e) {

                }
            }
        }

        // do this after the while iterator because submitNewU
rl will change the futures array list,
        // will cause concurrent modification error
        for(String url: newUrls) {
            submitNewUrl(url);
        }
```

```
        return futures.size()>0;
    }

    public void submitNewUrl(String url) {
        if(!result.contains(url)) {
            result.add(url);

            Crawler crawler = new Crawler(url);
            Future<List<String>> future = executor.submit(craw
ler);
            futures.add(future);
        }
    }

    private class Crawler implements Callable<List<String>> {
        private String url;

        public Crawler(String url) {
            this.url = url;
        }

        @Override
        public List<String> call() {
            List<String> urls = getUrls(url);
            return urls;
        }
    }

    public static void main(String[] args) {
```

```
        connectedUrls = new HashMap<>();
        List<String> aChildren = new ArrayList<>();
        aChildren.add("b");
        aChildren.add("c");
        aChildren.add("d");
        aChildren.add("e");
        List<String> bChildren = new ArrayList<>();
        bChildren.add("k");
        bChildren.add("m");
        bChildren.add("d");
        bChildren.add("z");
        List<String> kChildren = new ArrayList<>();
        kChildren.add("o");
        kChildren.add("j");
        kChildren.add("e");
        kChildren.add("z");

        connectedUrls.put("a", aChildren);
        connectedUrls.put("b", bChildren);
        connectedUrls.put("k", kChildren);

        CrawlerManager crawlerManager = new CrawlerManager();
        System.out.println(crawlerManager.crawl("a"));

    }
}
```

How the urls are gathered:

```
public List<String> getUrls(String urlStr) {
        List<URL> urlList = new ArrayList<>();
```

```
        URL url = new URL(urlStr);
        Document doc = Jsoup.parse(url, TIMEOUT);

        Elements links = document.select("a[href]");
        for(Element link: links) {
                String href = link.attr("href");
                if(StringUtils.isBlank(href) || href.startsWit
h("#")) {
                        continue;
                }
                try {
                        URL nextUrl = new URL(url, href);
                        urlList.add(nextUrl);
                } catch (MalformedURLException e) {

                }
        }

        return urlList;

}
```

Read Write Lock

http://tutorials.jenkov.com/java-concurrency/read-write-locks.html#java_lock

- Grant Read access when there is no writers (can be many readers at the same time)
- Grant Write access when there is no readers and no writers (only one writer can write at the same time)

Why notifyAll()?

- all threads waiting for read access are granted read access at once - not one by one.
- Inside the ReadWriteLock there are threads waiting for read access, and threads waiting for write access. If a thread awakened by notify() was a read access thread, it would be put back to waiting because there are threads waiting for write access. However, none of the threads awaiting write access are awakened, so nothing more happens. No threads gain neither read nor write access. By calling noftifyAll() all waiting threads are awakened and check if they can get the desired access.

Starvation

Consider the situation more write or more read, we need to prioritise the read/write to avoid starvation. To do this, we can add additional count call writeRequests/readRequest. If read/write more or less the same, no need prioritise

Simple Version w/o Reentrant

```
public class ReadWriteLock{
  private int readers       = 0;
  private int writers       = 0;
  private int writeRequests = 0;

  public synchronized void lockRead() throws InterruptedExcept
ion{
    while(writers > 0 || writeRequests > 0){
      wait();
    }
    readers++;
  }

  public synchronized void unlockRead(){
    readers--;
    notifyAll();
```

```
  }

  public synchronized void lockWrite() throws InterruptedExcep
tion{
    writeRequests++;
    while(readers > 0 || writers > 0){
      wait();
    }
    writeRequests--;
    writers++;
  }

  public synchronized void unlockWrite() throws InterruptedExc
eption{
    writers--;
    notifyAll();
  }
}
```

Reentrant

If no reentrant and the writer tries to acquire read access before releasing write access, will cause infinite lock. 😖

Read -> Read

The thread holding the read access should be able to reenter if there is no writer writing.

Write -> Write

Currently holding write lock

Read -> write

if it i**s the only reader**

Write -> read

should always granted for writer

```
public class ReadWriteLock{
```

```
  private Map<Thread, Integer> readingThreads =
       new HashMap<Thread, Integer>();

  private int writeAccesses    = 0;
  private int writeRequests    = 0;
  private Thread writingThread = null;

  public synchronized void lockRead() throws InterruptedExcept
ion{
    Thread callingThread = Thread.currentThread();
    while(! canGrantReadAccess(callingThread)){
      wait();
    }

    readingThreads.put(callingThread,
     (getReadAccessCount(callingThread) + 1));
  }

  private boolean canGrantReadAccess(Thread callingThread){
    if( isWriter(callingThread) ) return true;
    if( hasWriter()             ) return false;
    if( isReader(callingThread) ) return true;
    if( hasWriteRequests()      ) return false;
    return true;
  }

  public synchronized void unlockRead(){
    Thread callingThread = Thread.currentThread();
    if(!isReader(callingThread)){
```

```
      throw new IllegalMonitorStateException("Calling Thread d
oes not" +
        " hold a read lock on this ReadWriteLock");
    }
    int accessCount = getReadAccessCount(callingThread);
    if(accessCount == 1){ readingThreads.remove(callingThrea
d); }
    else { readingThreads.put(callingThread, (accessCount -
1)); }
    notifyAll();
  }

  public synchronized void lockWrite() throws InterruptedExcep
tion{
    writeRequests++;
    Thread callingThread = Thread.currentThread();
    while(! canGrantWriteAccess(callingThread)){
      wait();
    }
    writeRequests--;
    writeAccesses++;
    writingThread = callingThread;
  }

  public synchronized void unlockWrite() throws InterruptedExc
eption{
    if(!isWriter(Thread.currentThread()){
      throw new IllegalMonitorStateException("Calling Thread d
oes not" +
        " hold the write lock on this ReadWriteLock");
    }
```

```
    writeAccesses--;
    if(writeAccesses == 0){
      writingThread = null;
    }
    notifyAll();
  }

  private boolean canGrantWriteAccess(Thread callingThread){
    if(isOnlyReader(callingThread))    return true;
    if(hasReaders())                   return false;
    if(writingThread == null)          return true;
    if(!isWriter(callingThread))       return false;
    return true;
  }

  private int getReadAccessCount(Thread callingThread){
    Integer accessCount = readingThreads.get(callingThread);
    if(accessCount == null) return 0;
    return accessCount.intValue();
  }

  private boolean hasReaders(){
    return readingThreads.size() > 0;
  }

  private boolean isReader(Thread callingThread){
    return readingThreads.get(callingThread) != null;
  }

  private boolean isOnlyReader(Thread callingThread){
```

```
    return readingThreads.size() == 1 &&
           readingThreads.get(callingThread) != null;
  }

  private boolean hasWriter(){
    return writingThread != null;
  }

  private boolean isWriter(Thread callingThread){
    return writingThread == callingThread;
  }

  private boolean hasWriteRequests(){
      return this.writeRequests > 0;
  }
}
```

- If the code might cause Exceptions, **put .unlock in the finally block.**

Token Bucket

https://konghq.com/blog/how-to-design-a-scalable-rate-limiting-algorithm/

```
public class TokenBucket {
    private final int MAX_CAPACITY;
    private final int FILL_RATE;

    private List<Integer> bucket;
    private long lastFillTimeStamp;

    final Lock lock = new ReentrantLock();
    final Condition notFull = lock.newCondition();
```

```
    final Condition notEmpty = lock.newCondition();

    public TokenBucket(int maxCapacity, int fillRate) {
        this.MAX_CAPACITY = maxCapacity;
        this.FILL_RATE = fillRate;
        lastFillTimeStamp = System.currentTimeMillis();

        bucket = new ArrayList<>();
    }

    public void fill() throws InterruptedException {
        lock.lock();
        while (bucket.size() == MAX_CAPACITY) {
            System.out.println("Bucket is filled now.");
            notFull.await();
        }
        long now = System.currentTimeMillis();
        //System.out.println((now - lastFillTimeStamp)/1000 *
FILL_RATE);
        long numTokensToAdd = Math.min(MAX_CAPACITY - bucket.s
ize(), (now - lastFillTimeStamp)/1000 * FILL_RATE);
        lastFillTimeStamp = now;
        //System.out.pritln(numTokensToAdd);
        for(int i=0; i<numTokensToAdd; i++) { //add tokens
            bucket.add((int) (Math.random() * 100) + 1);
        }
        notEmpty.signalAll();
        lock.unlock();

    }
```

```
    public List<Integer> get(int n) throws InterruptedExceptio
n{
        //System.out.println(n);
        if(n<=0)
            throw new IllegalArgumentException("Cannot get zer
o or negative number of tokens.");
        if(n>MAX_CAPACITY)
            throw new IllegalArgumentException("Cannot get tok
ens more than max capacity.");
        List<Integer> result = new ArrayList<>();

        int tokenAcquired = 0;
        while(tokenAcquired<n) { //this can ensure fair compet
ition
            lock.lock();
            while(bucket.size()<1) {
                System.out.println("Bucket is not enough now."
);
                notEmpty.await();
            }
            result.add(bucket.get(bucket.size()-1));
            bucket.remove(bucket.size()-1);
            tokenAcquired++;
            notFull.signalAll();
            lock.unlock();

        }

        return result;
    }
```

```
    public static void main(String[] args) {
        TokenBucket bucket = new TokenBucket(100, 8);
        Runnable filler = () -> {
            while(true) {
                try {
                    bucket.fill();
                    Thread.sleep(1000);
                } catch (InterruptedException e) {
                    e.printStackTrace();
                }
            }
        };

        Runnable consumer = () -> {
            while(true) {
                try {
                    List<Integer> result = bucket.get((int) (M
ath.random() * 5) + 1);
                    System.out.println(result.toString());
                    Thread.sleep(3000);
                } catch (InterruptedException e) {
                    e.printStackTrace();
                }
            }
        };

        new Thread(filler).start();
        new Thread(consumer).start();
    }
```

```
}
```

3. 类似Token Bucket, 换成了水龙头往桶里滴水。get/put 多线程。在跟面试官的讨论和提示下写出来了，最后说了句good job，但是不知道是不是口是心非

Design

Hit Counter

Things to consider:

- If a lot of hits within given time window / per sec
- If it keeps hit() for a long time only then call getHit(), memory problem (clear outdated also when hit() is called)
- Multi-threading, if multiple threads report hit() // if a webpages, multiple clients click the hit

Simple version using queue:
Space: varies, depends on number of hits in given time window
Time: varies, depends on number of outdated hits

```
public class HitCounter {
  private static final int WINDOW = 5*60; // 5 minutes
  private Queue<Integer> timeStamps;

  public HitCounter() {
    timeStamps =  new LinkedList<>();
  }

  public void hit() {
    int currTime = getCurrTimeSec();
    timeStamps.offer(currTime);
  }
```

```
  public void getHits() {
    int currTime = getCurrTimeSec();
    while(!timeStamps.isEmpty() && timeStamps.peek() <= currTi
me - WINDOW) {
      timeStamps.poll();
    }
    return timeStamps.size();
  }

  public int getCurrTimeSec() {
    return System.currTimeMillis()/1000;
  }
}
```

Circular Array approach:

- think about it as assigning the hits to buckets, 300 buckets, next time you put hits into the bucket, the previous hits are already outdated, you can safely overwrite it.

Space: O(WINDOW_LENGTH)
Time: O(WINDOW_LENGTH)

```
//circular array

//|--------------------|--------------------|
public class HitCounter {
  private final int WINDOW_LENGTH; // in sec
  private Hit[] hitRecords;

  public HitCounter(int windowLength) {
    this.WINDOW_LENGTH = windowLength;
    hitRecords = new Hit[windowLength];
  }
```

```
  public void hit() {
    int currTime = getCurrTimeSec();
    int index = currTime % WINDOW_LENGTH;
    if(hitRecords[index]!=null && hitRecords[index].timeStamp==currTime) {
      hitRecords[index].count++;
    } else {
      hitRecords[index] = new Hit(currTime, 1);
    }
  }

  public int getHits() {
    int currTime = getCurrTimeSec();
    int count=0;
    for(Hit hit: hitRecords) {
      if (hit!=null && hit.timeStamp>currTime-WINDOW_LENGTH)
        count += hit.count;
    }
    return count;
  }

  public int getCurrTimeSec() {
    return (int)System.currentTimeMillis()/1000;
  }

  private class Hit {
    int timeStamp;
    int count;
```

```
    public Hit(int timeStamp, int count) {
      this.timeStamp = timeStamp;
      this.count = count;
    }
  }
}
```

We can avoid storing the timestamp attribute by storing the lastHitTime, and clear those since lastHitTime till currentHitTime / getHitTime to avoid invalid counts.

```
public void clearBucketFromLastHit(int currTime) {
    if(lastHitTime!=-1) {
        for(int i=lastHitTime+1; i<=currTime; i++) {
            hitRecords[i%WINDOW_LENGTH] = 0;
        }
    }
}
```

Multi-threading:

1. use BlockingQueue, **Linked**BlockingQueue is not bounded
2. synchronised the modification and reading from queue
3. Use ConcurrentHashMap, **it is not blocking on the whole collection when write**, so can have multiple writes at the same time, read is non blocking, using volatile... This is achieved by partitioning Map into different parts based on concurrency level and locking only a portion of Map during updates.

Testing:

1. Use Thread.sleep() to wait which is stupid! can change the methods to accept timestamps.
2. Use mockito to mock the System.currentTimeMillis().

Test cases:

1. No hits within pass 300 sec
2. Boundary case getHits()
3. Multiple hits within a sec
4. Consecutive getHits()

counter.getHits(0);
counter.hit(1);
counter.hit(2);
counter.hit(2);
counter.hit(2);
counter.hit(300);
counter.getHits(300);
counter.getHits(300);
counter.getHits(301);

Space Panorama

```
import java.io.*;
import java.util.*;


/**
* NASA selects Dropbox as its official partner, and we’re tasked with managing
* a panorama for the universe. The Hubble telescope (or some other voyager we
* have out there) will occasionally snap a photo of a sector of the universe,
* and transmit it to us. You are to help write a data structure to manage this.
* For the purpose of this problem, assume that the observable universe has been .
* divided into 2D sectors. Sectors are indexed by x- and y-coordinates.
*/
public File {
    public File(String path) {}
    public Boolean exists() {}
    public byte[] read() {}
```

```
    public void write(bytes[] bytes) {}
}

public Image {
    public Image(byte[] bytes) {}
    byte[] getBytes() {} // no more than 1MB in size
}

public Sector {
    public Sector(int x, int y) {}
    int getX() {}
    int getY() {}

    @Override
    public boolean equals(Object o) {
        if(o==this) return true;

        if(!(o instanceof Sector)){
            return false;
        }

        Sector that = (Sector) o;

        return this.x == that.getX() && this.y == that.getY();
    }

    @Override
    public int hashCode() {
        int prime = 31;
        int result = 1;
```

```
        result = prime*result + this.x;
        result = prime*result + this.y;
        return result;
    }
}

/**
* row-major indexing to be consistent.
*/
if
    public void removeHead() {
        locMap.put(head.next.key, null);
        head.next = head.next.next;
        head.next.prev = head;
    }

    public void addTail(int key, int value) {
        DLinkedList newEle = new DLinkedList(key, value);
        moveToTail(newEle);
        locMap.put(key, newEle);
    }

    public void moveToTail(DLinkedList e) {
        e.prev = tail.prev;
        tail.prev.next = e;
        tail.prev = e;
        e.next = tail;
    }
}
```

LRU

```
class LRUCache {
    private int capacity;
    private LinkedHashMap<Integer, Integer> leastRecentUsedLis
t;

    public LRUCache(int capacity) {
        this.capacity = capacity;
        leastRecentUsedList = new LinkedHashMap<>();
    }

    public int get(int key) {
        if(leastRecentUsedList.containsKey(key)) {
            int value = leastRecentUsedList.get(key);
            leastRecentUsedList.remove(key);
            leastRecentUsedList.put(key, value);
            return value;
        }

        return -1;

    }

    public void put(int key, int value) {
        if(leastRecentUsedList.containsKey(key)) {
            leastRecentUsedList.remove(key);
        } else if(leastRecentUsedList.size()==capacity) {
            leastRecentUsedList.remove(leastRecentUsedList.key
Set().iterator().next());
        }
        leastRecentUsedList.put(key, value);
```

```
    }


}
/*class LRUCache {
    class DLinkedList {
        int key, val;
        DLinkedList prev, next;

        public DLinkedList(int _key, int _val) {
            key = _key; val = _val;
        }
    }

    private int capacity, count = 0;
    private DLinkedList head, tail;
    private Map<Integer, DLinkedList> locMap = new HashMap<Int
eger, DLinkedList>();

    public LRUCache(int capacity) {
        this.capacity = capacity;
        head = new DLinkedList(-1, -1);//dummy for easier poin
ter manipulation
        tail = new DLinkedList(-1, -1);
        head.next = tail;
        tail.prev = head;
    }

    public int get(int key) {
        DLinkedList e = getNode(key);
```

```
        return  e == null? -1: e.val;
    }

    public DLinkedList getNode(int key) {
        if(locMap.get(key)!=null) {
            DLinkedList e = locMap.get(key);
            e.next.prev = e.prev;
            e.prev.next = e.next;
            moveToTail(e);
            return e;
        } else {
            return null;
        }
    }

    public void put(int key, int value) {
        DLinkedList e = getNode(key);
        if(e!=null) {
           e.val = value;
        } else {
            if(count==capacity) { // remove LRU
                removeHead();
            }
            addTail(key, value);
            count++;
        }

    }

    public void removeHead() {
```

```
        locMap.put(head.next.key, null);
        head.next = head.next.next;
        head.next.prev = head;
        count--;
    }

    public void addTail(int key, int value) {
        DLinkedList newEle = new DLinkedList(key, value);
        moveToTail(newEle);
        locMap.put(key, newEle);
    }

    public void moveToTail(DLinkedList e) {
        e.prev = tail.prev;
        tail.prev.next = e;
        tail.prev = e;
        e.next = tail;
    }
}*/

/**
 * Your LRUCache object will be instantiated and called as suc
h:
 * LRUCache obj = new LRUCache(capacity);
 * int param_1 = obj.get(key);
 * obj.put(key,value);
 */
```

个人觉得用两级Hash table做貌似overhead要小一些，第一级只hash row，找到该行对应的hash table，第二级hash column取图片

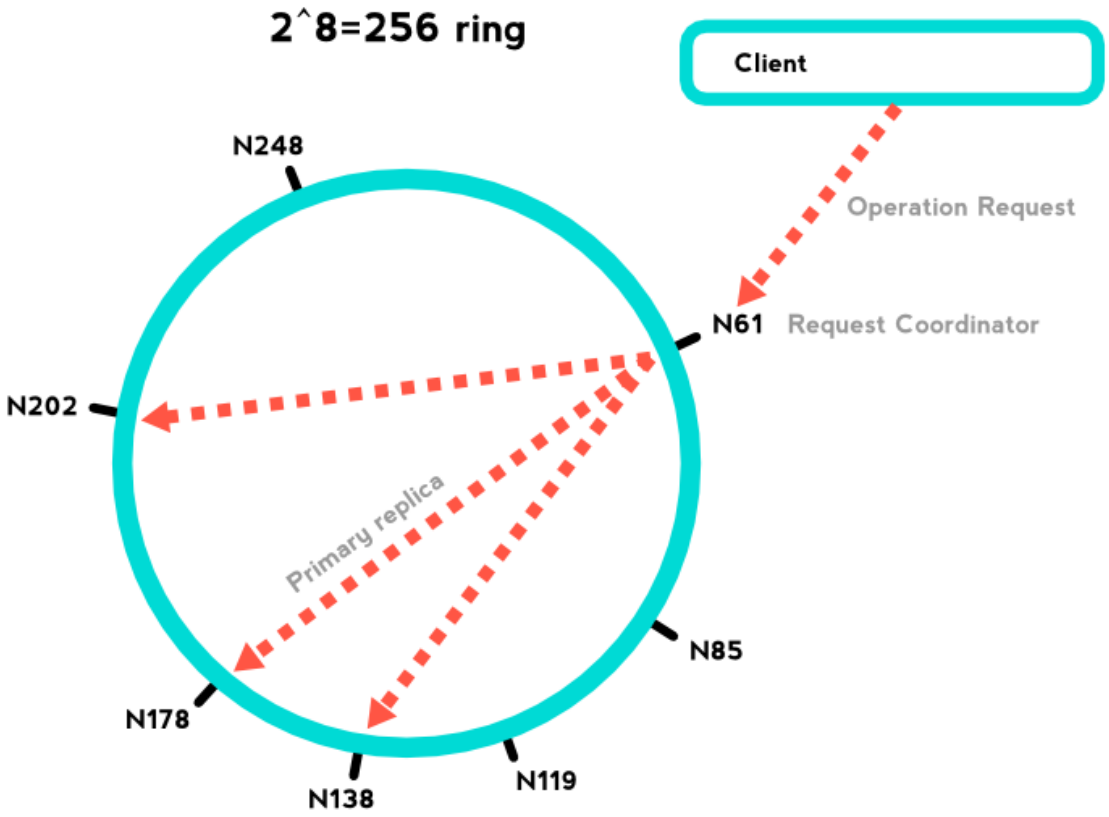
KV Store Transaction

https://youtu.be/rnZmdmlR-2M

https://youtu.be/rnZmdmlR-2M
Single Machine:
Hash Table:

- Compress your data. This should be the first thing to think about and often there are a bunch of stuff you can compress. For example, you can store reference instead of the actual data. You can also use float32 rather than float64. In addition, using different data representations like bit array (integer) or vectors can be effective as well.
- Storing in a disk. When it's impossible to fit everything in memory, you may store part of the data into disk. To further optimize this, you can think of the system as a cache system. Frequently visited data is kept in memory and the rest is on a disk.

Distributed key-value storage:
split the data into multiple machines by some rules and a coordinator machine can direct clients to the machine with requested resource.
Sharding algorithm: keys are distributed randomly & evenly. important to balance the traffic
system availability: replica
consistency:
Inside Cassandra
http://blog.fourthbit.com/2015/04/12/building-a-distributed-fault-tolerant-key-value-store
Cassandra uses a Distributed Hash-Table-like ring



Cassandra Ring

Design Logging System (Distributed)

这一轮是设计 log monitor，面试官规定了log 的format，

{action: "view"，
page: "www.dropbox.com",
location: "GB",
time stamp: xxxx}
{action: "download",
file: "hello.txt",
time stamp: xxxx}

在log里面，一定会有action和time stamp，然后其他的不分根据action是什么来决定，你会怎么设计interface来 create log, 需要哪些function，之后就是讨论moniter service和web server这两个不分怎么交互，怎么存log，会有什么bottleneck ，怎么样improve，怎

么样scale，然后又问了如果让设计个metrics来监测你的monitor service的健康状况，你会收集哪些数据。大概就是这些。

他没有让我具体计算需要多少存储，多少server，只是后面scale up的时候大概说了说可以怎么sharding这些的。
moniter service和web server交互，moniter主要是怎么接收拿过来的log data，拿过来之后需要做一些怎样的aggregation，然后更新moniter数据。

Design Twitter

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Message Queue

queue里面每个节点需要哪些内容？如果message queue这个service down了怎么办？consumer花太多时间working on one task怎么办？consumer掉线了怎么办？.