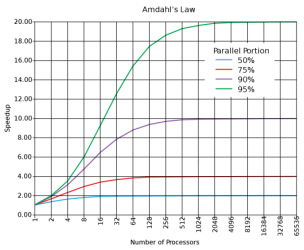
CS-E4640 Big Data Platform
CHEAT SHEET

Adam Ilyas 725819

December 20, 2018

```
'C-c C-s' \section{}
'C-c C-e' \begin{} \end{}
'C-c C-f C-b' \textbf{}
'C-c C-f C-i' \textit{}
'C-c C-f C-e' \emph{}
'C-c C-f C-t' \texttt{}
```



Amdahl's law
P: proportion of programs that can be parellelized
$1 - P$: proportion that remains serial
Maximum speedup that can achieved with N processors: $[(1 - P) + \frac{P}{N}]^{-1}$

Kryders Law Cost of storing a bit on a hard disk halves every 14 months

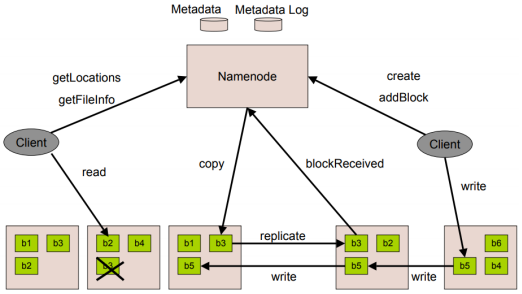
When the neeed for parellelism arises
Scaling up: A single powerful computer is added with more CPU cores, memory and hard disks
Scaling out: Task is divided between a large number of less powerful machines with relatively slow CPUs, moderate memory and moderate hard disks.

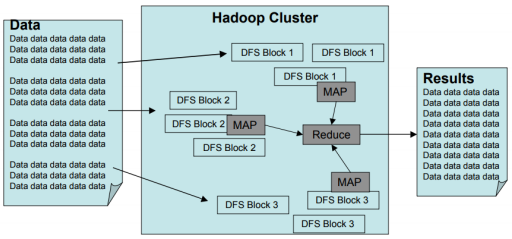
mapReduce framework that takes care of all issues related to parallelization, synchronization, load balancing, and fault tolerance.

Hadoop Distributed File System Open source implementation of the MapReduce framework.

Rack optimized. All data is replicated by default on three different data nodes (replicas) : 1. written locally 2. Same rack 3. Another rack

NameNode is a single computer that maintains metadata of the file system in memory, writes logs and does periodic snapshots to the disk
DataNodes handle block storage. Periodically sents block reports to NameNode.





Redundant Array of Independant Disks (RAID) Fault tolerance mechanism

Raid 1: All data is stored on 2 hard disks
Raid 5: Block-level striping w. distributed parity (error protection scheme)
Raid 6: Block-level striping w. double distributed parity
Raid 10: A nested RAID level: n stripes of mirrored disk pairs. Thus Data is stored on $2n$ hard disk.

RAID write hole problem A power failure during writes to a stripe can leave the Array in a corrupted state.

CAP Theorem It's impossible to create a distributed system that satisfies all three of the following:
Consistent: Every read receives the most recent write or an error
Availability: Every request receives a (non-error) response without the guarantee that it contains the most recent write
Partition Tolerance: The system continues to operate despite an arbitrary number of messages being dropped (or delayed) by the network between nodes

We have to choose between 2 of the CAPs
CA Consistent/ Available: Non-distributed (centralized) database system
CP Consistent/ Partition: A distributed system that cannot be modified
AP Available/ Partition: A distributed system that is inconsistent

Bloom Filters highly memory efficient probabilistic data structure to store sets.

```
def bloom_filter(d, k_hash_functions):
    """
    d: data item
    k_hash_functions: k independant hash functions
    Returns
        m bit vector
    """
    B = [0 for i in range(m)]
    for h in k_hash_functions:
        hash_value = h(d)
        B[hash_value] = 1 # update
    return B
```

Minimizing false positives
Probability of false positives
P(bit b is set to 1 by h_i) $= \frac{1}{m}$
P(bit b is NOT set to 1 by h_i) $= 1 - \frac{1}{m}$
P(bit b is NOT set to 1 all k h) $= (1 - \frac{1}{m})^k$
P(bit b is NOT set to 1 all k h after n items) $= (1 - \frac{1}{m})^{kn}$
P(bit b IS set to 1 all k h after n items) $= (1 - \frac{1}{m})^{kn}$
P(the k bit(s) IS set to 1 all k h after n items) $= ((1 - \frac{1}{m})^{kn})^k \approx$
p(False Positive) $= ((1 - \exp(-kn/m))^{kn})^k$
Optimal $k = \frac{m}{n} \ln(2) \approx \frac{m}{n} \times 0.693$
ACID/ BASE

Distributed Hash tables uses consistent hashing to Partition a keyspace amongs Distributed set of nodes, provide an overlay network such that the node responsible for any can be efficiently located.

Consistent Hashing Special Hashing that when a hash table is resized, only $\frac{K}{n}$ keys have to be remapped where K is the number of keys and n is the number of array slots.

In distributed systems, its a way to distribute the contents of a hash table over a distributed Hash Table (DHT). K keys distributed over n servers.

Idea:
- Key space uses 128 bits. Each computer node has a random unique node identifier n_i between 0 to $2^{128} - 1$
- All computer nodes are ordered clockwise to a virtual ring of servers with increasing node identifier order.
- A data item with a certain key k_j, is stored at the node with the smallest i such that $k_j \leq n_i$. Store k_j at n_i where $i = min\{i : k_j \leq n_i\}$
- if a new node k needs to join the virtual ring with identifier n_k, it will be allocated k_l for which n_k is the smallest identifier such that $k_l \leq n_k$