What’s new in Hadoop 3?

image courtesy - Hortonworks

YARN Federation

- Enables applications to scale to **100k** of thousands of nodes
- Federation divides a large (10-100k nodes) cluster into smaller units called sub-clusters
- Federation negotiates with sub-clusters RM's and provide resources to the application
- Applications can schedule tasks on any node

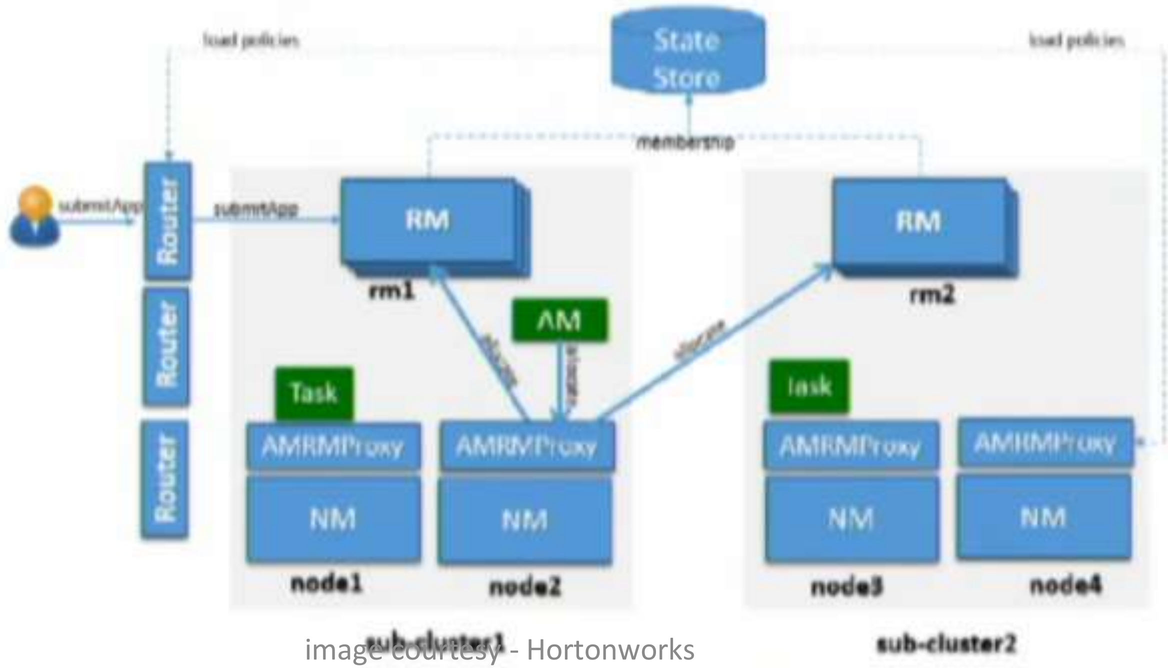


image courtesy - Hortonworks

Moving towards Global & Fast Scheduling

- **YARN-5139**
- **Problems**
  - Current design of one-node-at-a-time allocation cycle can lead to suboptimal decisions.
  - Several coarse grained locks.
- **With this, we improved to**
  - Look at several nodes at a time
  - Fine grained locks
  - Multiple allocator threads
  - YARN scheduler can allocate 3k+ containers per second ≈ 10 mil allocations / hour!
  - 10X throughput gains
  - Much better placement decisions

image courtesy - Hortonworks

Better placement strategies (YARN-6592)

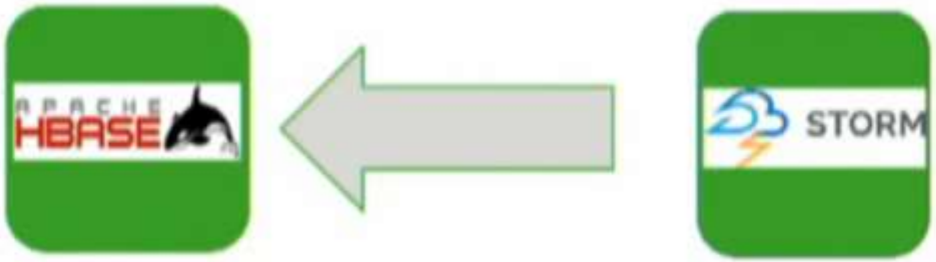
- **Past**
  - Supported constraints in form of Node Locality

- **Now YARN can support a lot more use cases**
  - Co-locate the allocations of a job on the same rack (**affinity**)
  - Spread allocations across machines (**anti-affinity**) to minimize resource interference
  - Allow up to a specific number of allocations in a node group (**cardinality**)

image courtesy - Hortonworks

Better placement strategies (YARN-6592)

- Affinity



- Anti-affinity

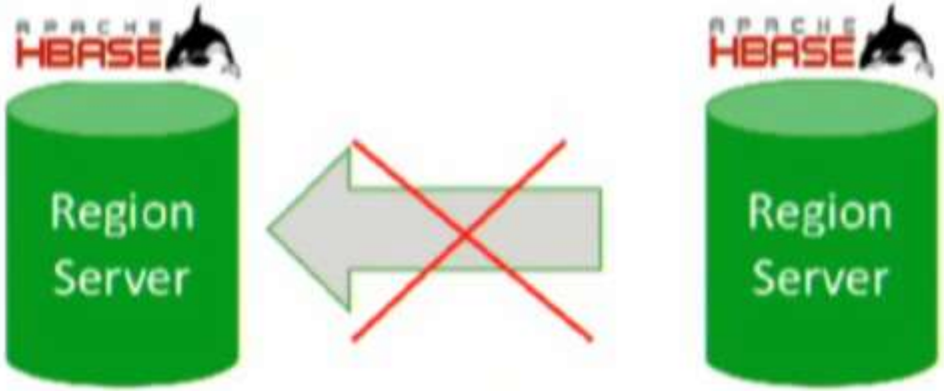
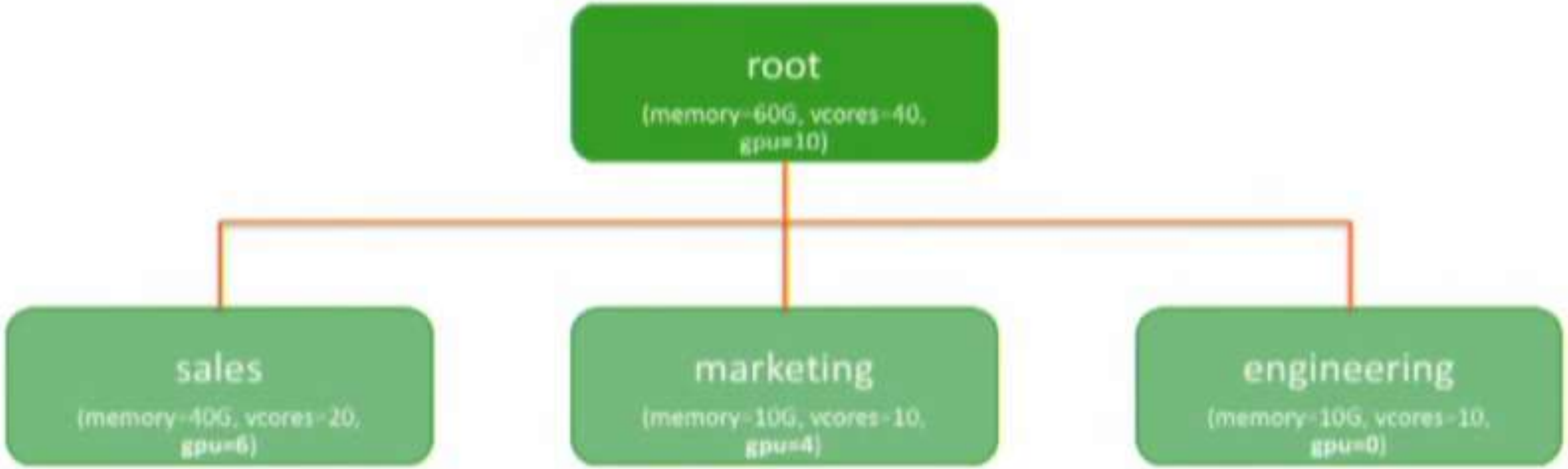


image courtesy - Hortonworks

Absolute Resources Configuration in CS – YARN-5881

- The cloud model! “Give me X resources, not X%”
- Gives ability to configure Queue resources as below
  <memory=24GB, vcores=20, yarn.io/gpu=2>
- Enables admins to assign different quotas of different resource-types
- No more **“Single percentage value limitation for all resource-types”**



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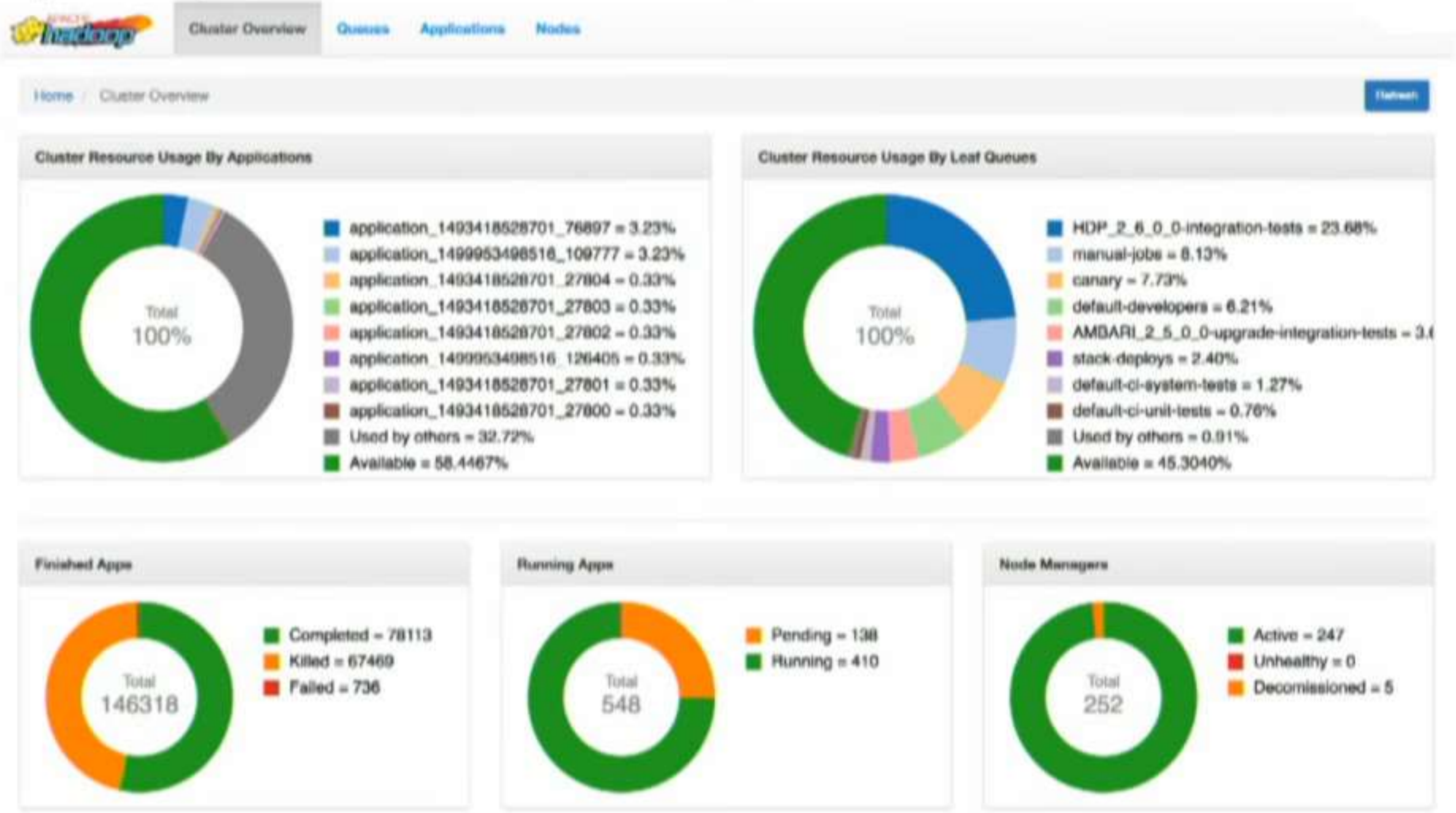
Auto Creation of Leaf Queues - YARN-7117

- **Easily map a queue** explicitly to user or group with out additional configs
- For e.g, User X comes in, automatically create a queue for user X with a templated capacity requirements
- **Auto created Queues** will be
  - created runtime based on user mapping
  - cleaned up after use
  - adhering to ACLs

image courtesy - Hortonworks

Usability: UI 1/2



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Timeline Service 2.0

- Understanding and Monitoring a Hadoop cluster itself is a BigData problem
  - Using **HBase as backend** for better scalability for read/write
  - More robust storage fault tolerance
  - Migration and compatibility with v.1.5

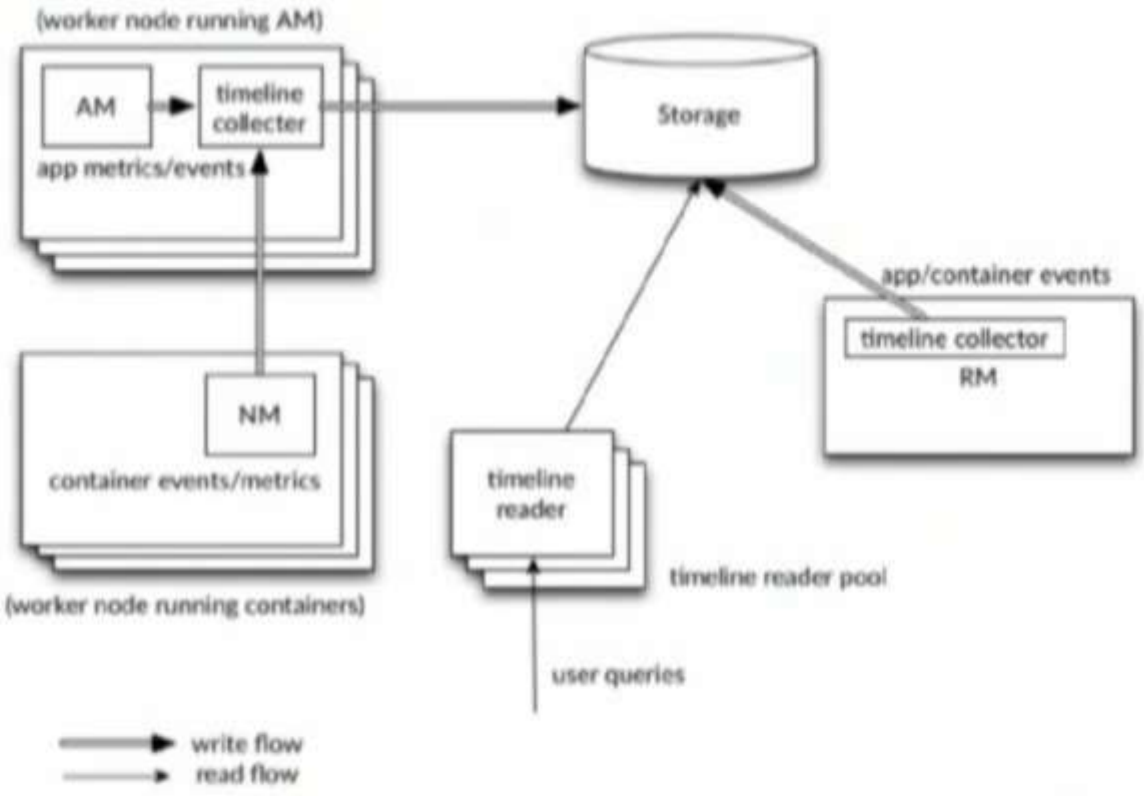


image courtesy - Hortonworks

Containers

- Better Packaging model
  - Lightweight mechanism for packaging and resource isolation
  - Popularized and made accessible by Docker
- Native integration ++ in YARN
  - Support for “Container Runtimes” in LCE: YARN-3611
  - Process runtime
  - Docker runtime

docker

image courtesy - Hortonworks

Containers

- Run both with and without docker on the same cluster
- Choose at run-time!

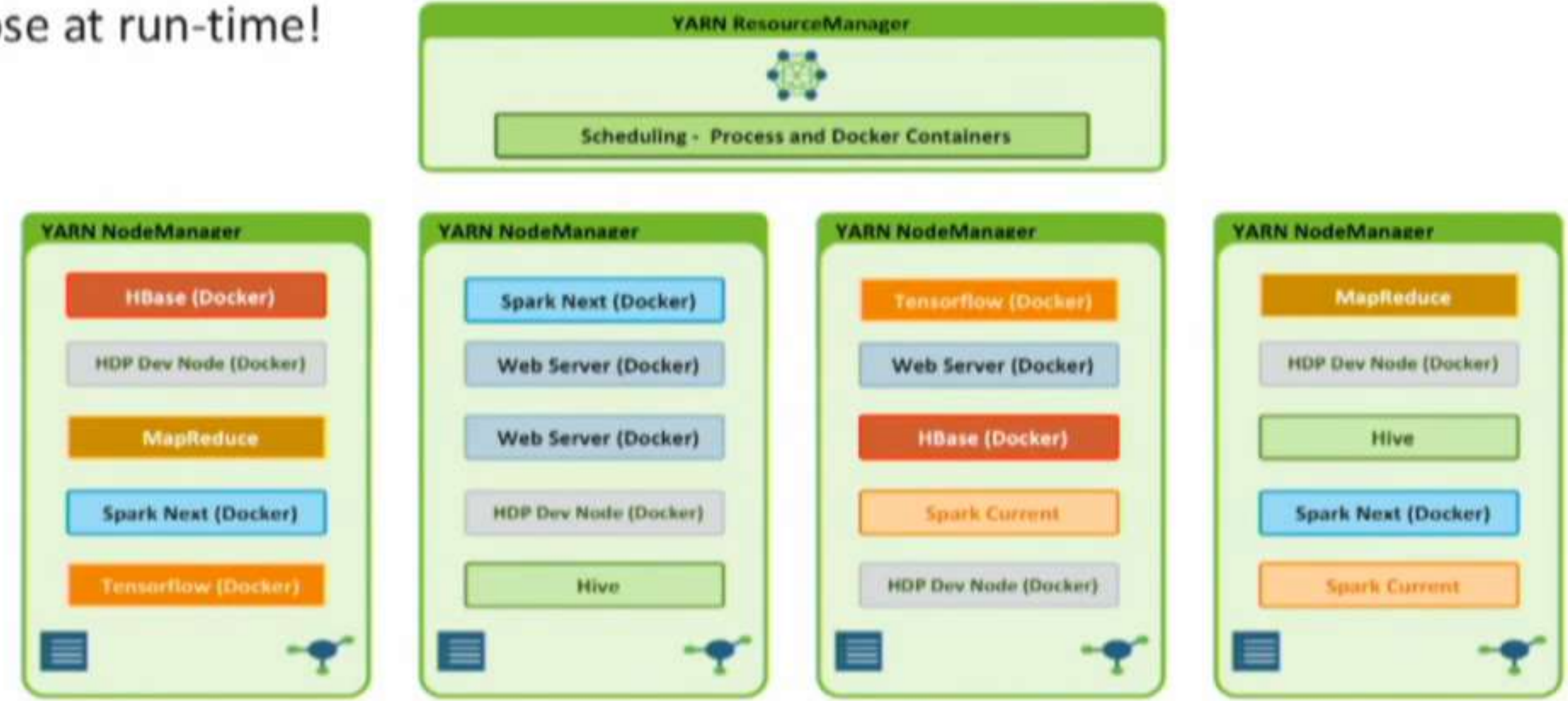


image courtesy - Hortonworks

Spark on Docker in YARN

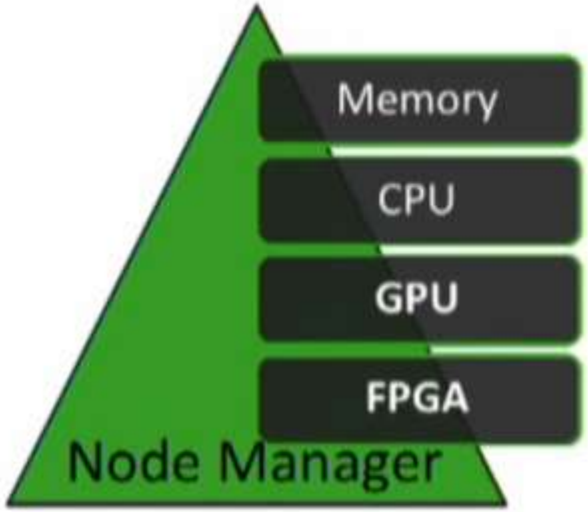
- **Apache Spark** applications have a complex set of required software dependencies
- Docker on YARN helps to solve Spark **package isolation issues with**
  - **PySpark** - Python versions, packages
  - **R** - packages

Containerized Spark on YARN: yarn-cluster mode

image courtesy - Hortonworks

Resource profiles and custom resource types

- **YARN** supported only **Memory** and **CPU**
- **Now**
  - A generalized vector for all resources
  - Admin could add arbitrary resource types!



- Ease of resource requesting model using profiles for apps

Profile	Memory	CPU	GPU
Small	2 GB	4 Cores	0 Cores
Medium	4 GB	8 Cores	0 Cores
Large	16 GB	16 Cores	4 Cores

image courtesy - Hortonworks

GPU support on YARN

- **Why?**
  - No need to setup separate clusters
  - Leverage shared compute!
- **Why need isolation?**
  - Multiple processes use the single GPU will be:
    - Serialized.
    - Cause OOM easily.
- **GPU isolation on YARN:**
  - Granularity is for per-GPU device.
  - Use cgroups / docker to enforce isolation.

image courtesy - Hortonworks

FPGA on YARN

- FPGA isolation on YARN: .
    - Granularity is for per-FPGA device.
    - Use Cgroups to enforce the isolation.
- Currently, only Intel OpenCL SDK for FPGA is supported. But implementation is extensible to other FPGA SDK.

image courtesy - Hortonworks

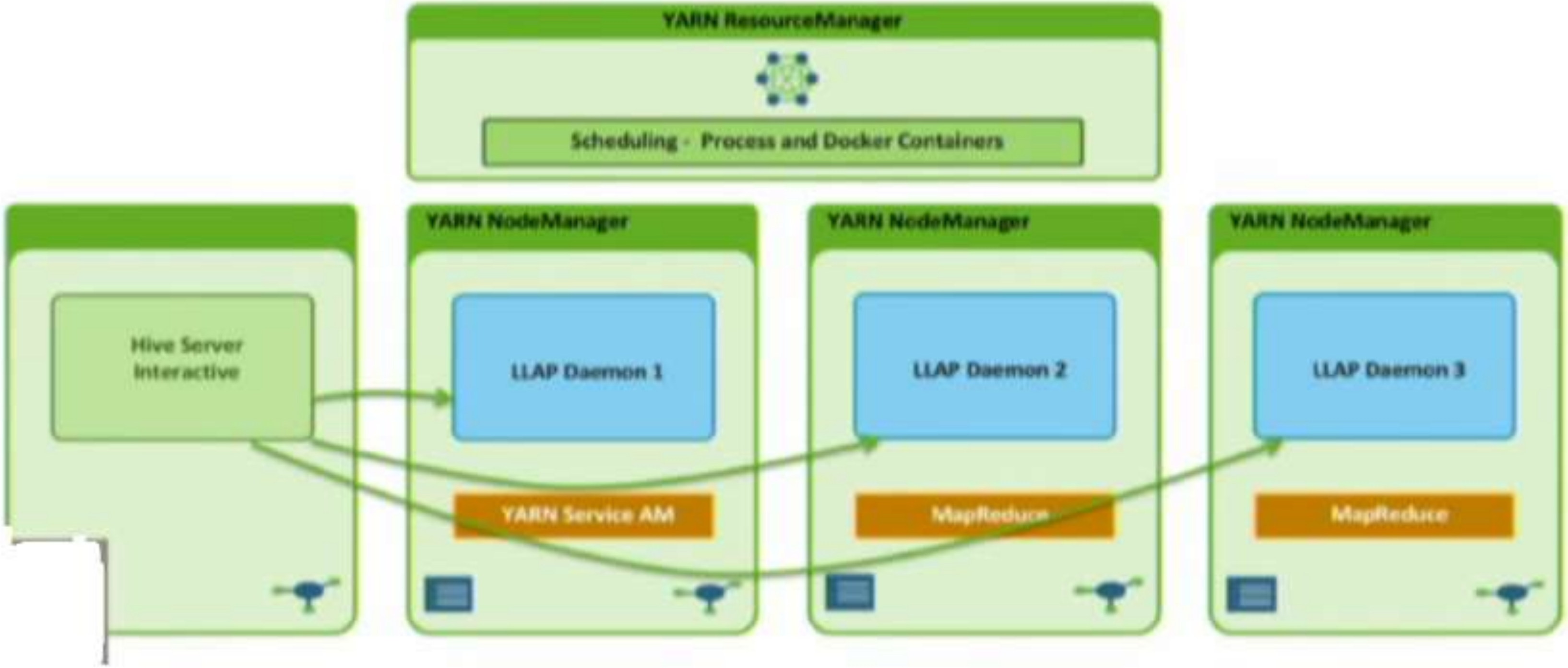
Services support in YARN

- A native **YARN services framework**
  - YARN-4692
  - [Umbrella] Native YARN framework layer for services and beyond
  - Apache Slider retired from Incubator – lessons and key code carried over to YARN
- Simplified discovery of services via **DNS mechanisms**: YARN-4757
  - ***regionserver-0.hbase-app-3.hadoop.yarn.site***
- **Application & Services upgrades**
  - "Do an upgrade of my HBase app with minimal impact to end-users"
  - YARN-4726

image courtesy - Hortonworks

LLAP on YARN

- **Apache Hive LLAP** is a key long running application
  - Used for query processing
  - Designed to run on a shared multi-tenant YARN cluster



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Application Timeout – YARN-3813

- Controlling running time of workloads in YARN
- Define lifetime for an application anytime for YARN to manage.
- “Give me resources for this app/service but kill it after 15 days”

image courtesy - Hortonworks

Node Attributes (YARN-3409)

- "Take me to a node with JDK 10"
- Node Partition vs. Node Attribute
- Partition:
  - One partition for one node
  - ACL
  - Shares between queues
  - Preemption enforced.
- Attribute:
  - For container placement
  - No ACL/Shares on attributes
  - First-come-first-serve

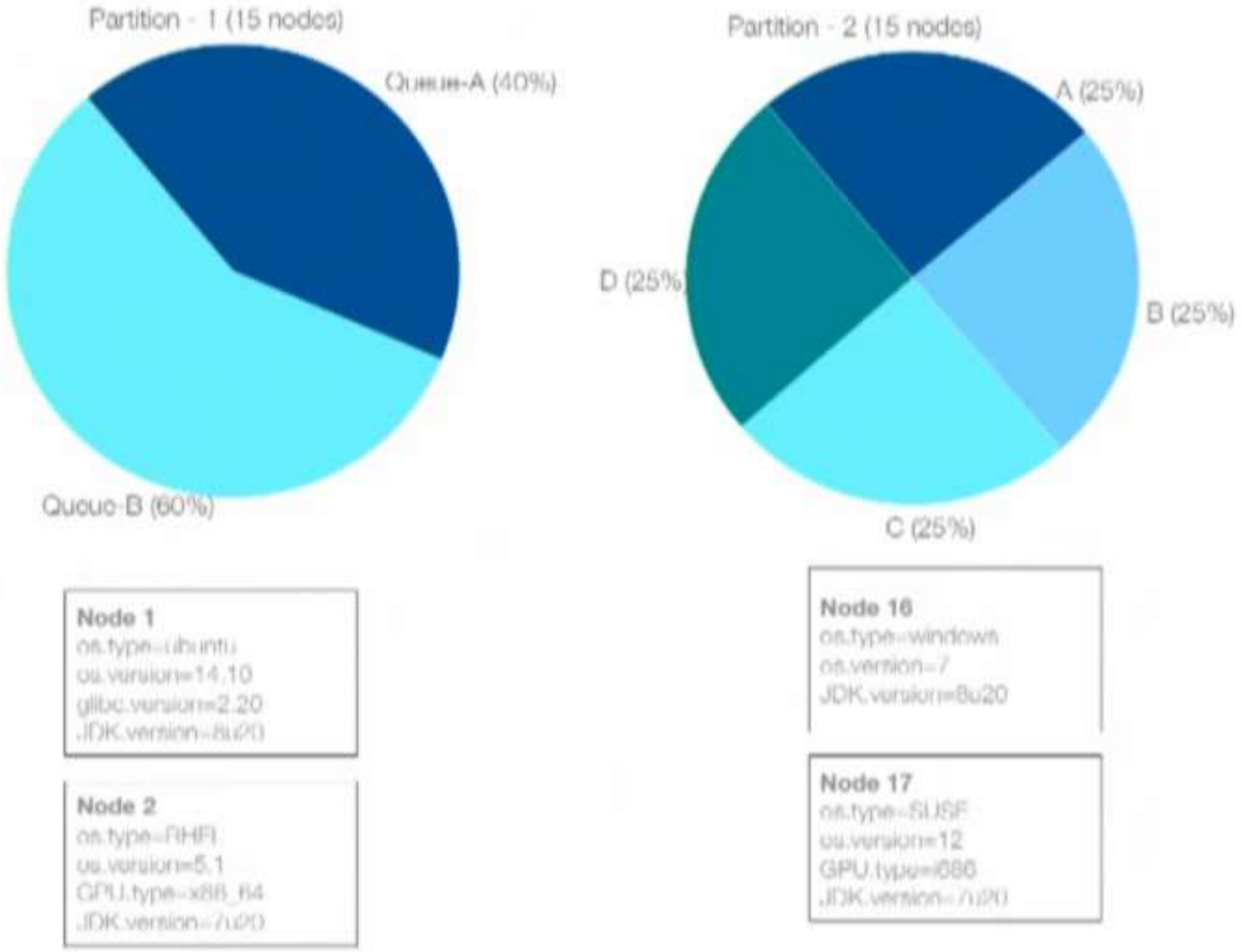


image courtesy - Hortonworks

TensorFlow on YARN: {Submarine} Project

- Run deep learning workloads on the same cluster as analytics, stream processing etc!
  - It allows jobs easy access data/models in HDFS and other storages.
  - Support run distributed Tensorflow jobs with simple configs.
  - Support run user-specified Docker images.
  - Support specify GPU and other resources.
  - Support launch tensorboard for training jobs if user specified.

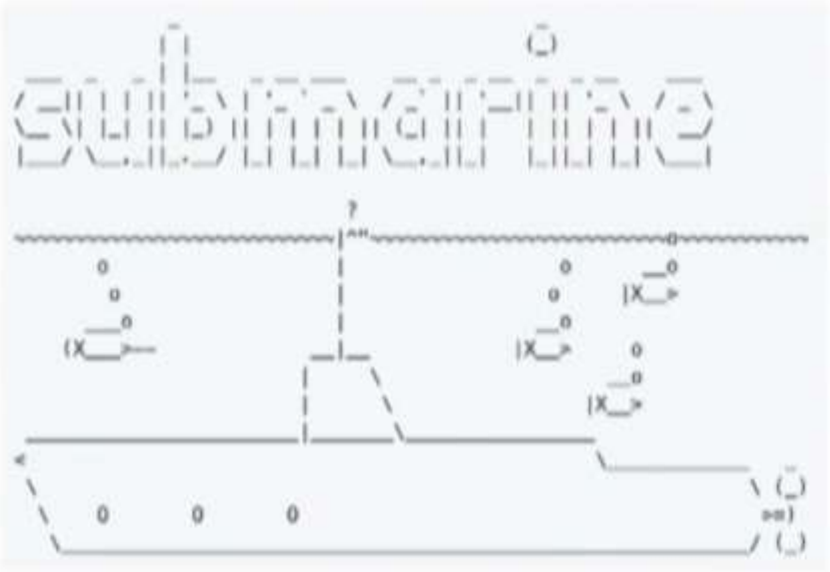
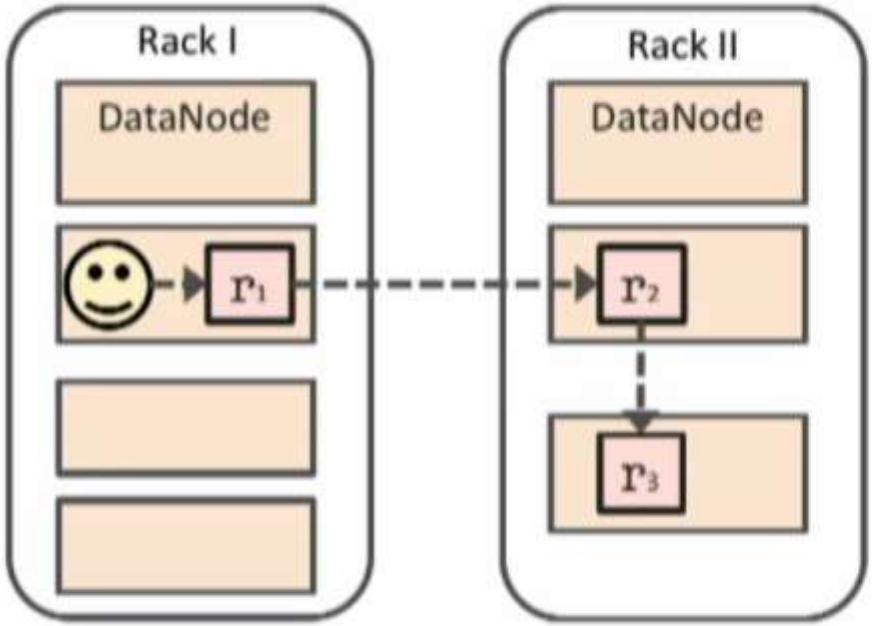


image courtesy - Hortonworks

Current HDFS Replication Strategy

- Three replicas by default
  - 1st replica on local node, local rack or random node
  - 2nd and 3rd replicas on the same remote rack
  - 3x storage overhead
- Reliability: tolerate 2 failures
- Good data locality
- Fast block recovery
- Expensive for
  - Massive data size e.g. cold data



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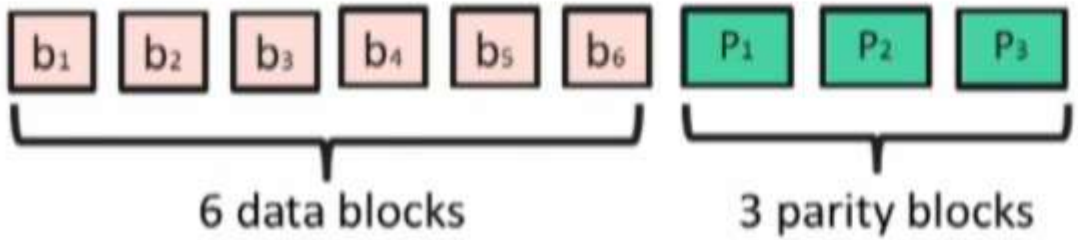
Erasure Coding

- k data blocks + m parity blocks $(k + m)$
  - Example: Reed-Solomon 6+3
- Reliability: tolerate m failures
- Save disk space
- Save I/O bandwidth on the write path



- 1.5x storage overhead
- Tolerate any 3 failures

image courtesy - Hortonworks

Erasure Coding on Striped Blocks

- Typical cell size – 1MB

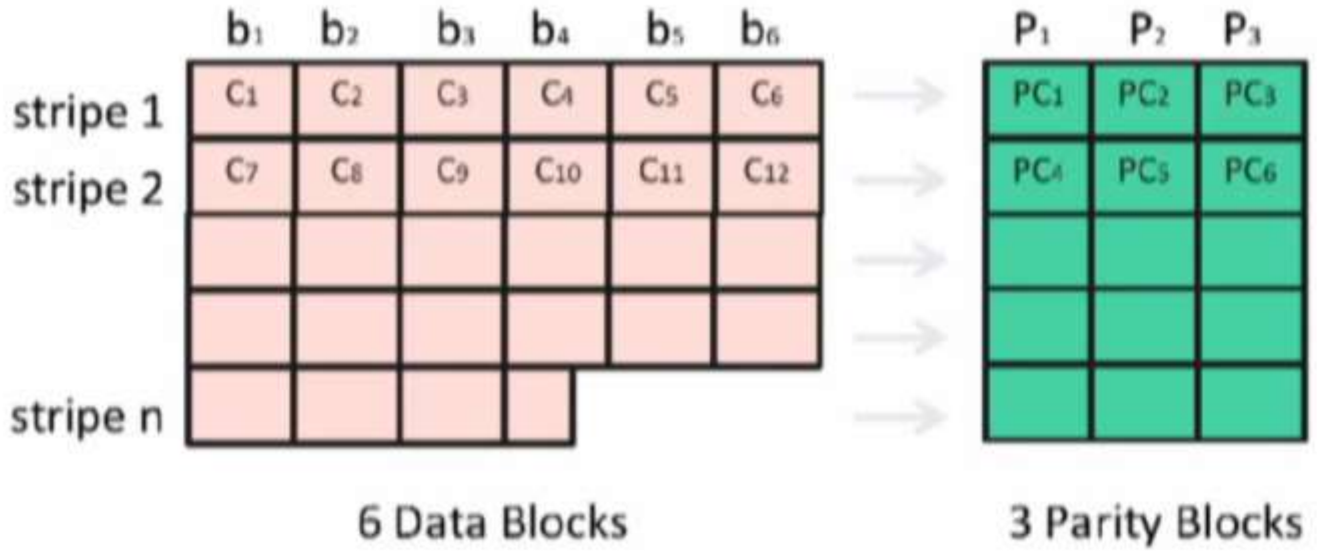


image courtesy - Hortonworks

Block Reconstruction

- Block reconstruction overhead
  - Higher network bandwidth cost
  - Extra CPU overhead

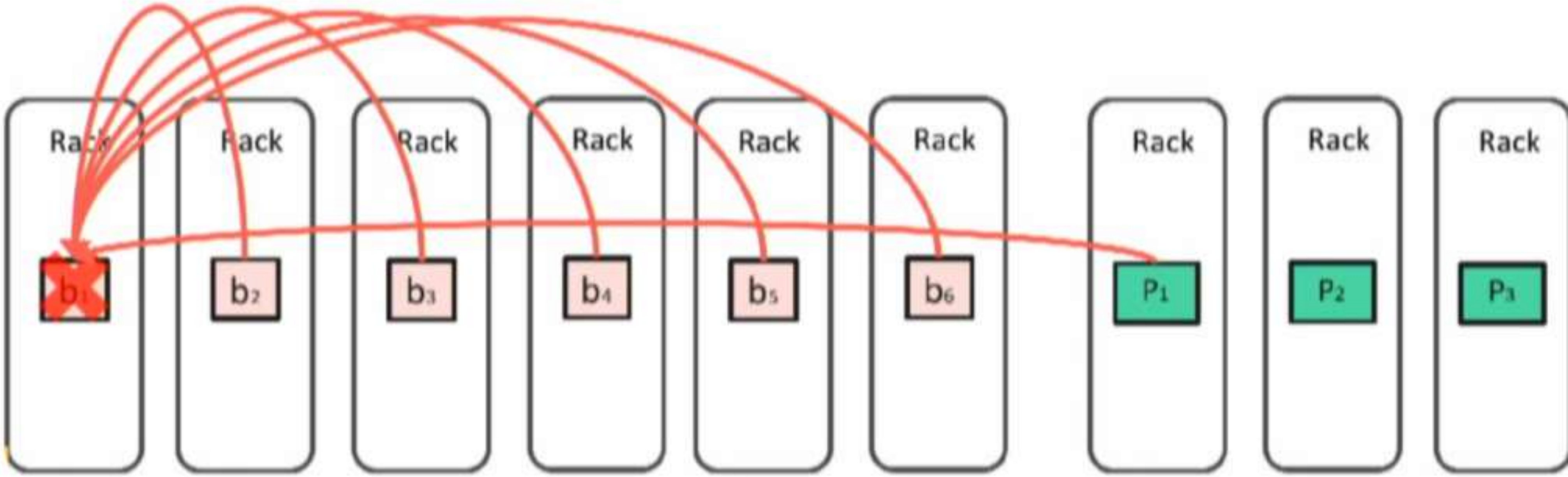


image courtesy - Hortonworks

Write Pipeline for Replicated Files

- Write to a datanode pipeline
- Durability: Use 3 replicas to tolerate maximum 2 failures
- Read is supported for being written files
- Consistency: Client can start reading from any replica and failover to any other replica to read the same data

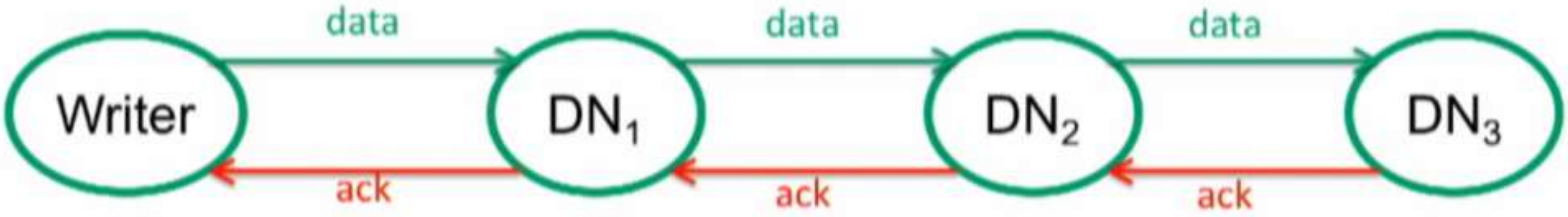


image courtesy - Hortonworks

Write Failure Handling

- Data Node failure
  - Client ignores the failed datanode and continues writing.
  - Able to tolerate up to 3 failures.
  - Need at least 6 datanodes.
  - Missing blocks will be reconstructed later.
  - Implications for slow writers

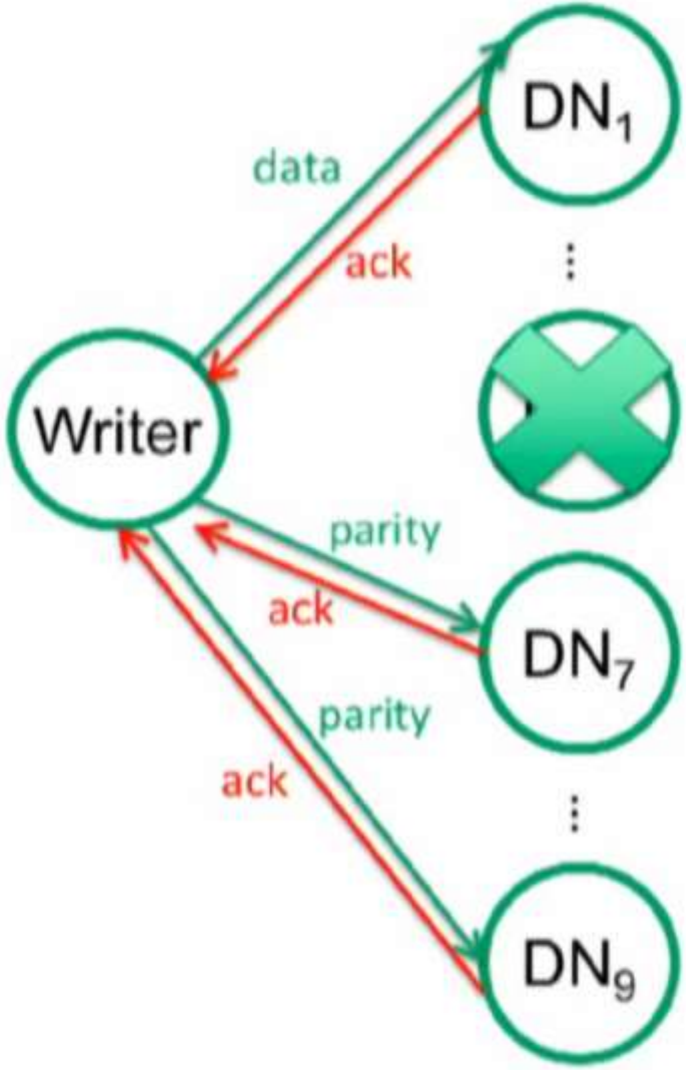


image courtesy - Hortonworks

EC policies

- Policy Naming Scheme
  - Codec – numDataBlocks(k) – NumParityBlocks(m) - CellSize
- Minimum cluster size is (k+m) nodes
- Some system supported policies
  - RS-6-3-1024k
  - RS-3-2-1024k
  - RS-10-4-1024k

image courtesy - Hortonworks

Erasure Coding - Caveats

- Loss of read locality (all reads use the network, no short-circuit reads)
- Not appropriate for smaller clusters
  - Recommend 9 or more racks for the RS-6-3-1024K policy
- Not appropriate for slow writers
  - Long write time increases probability of DataNode failure
  - EC write path cannot replace failed DataNodes (unlike the 3-replica write pipeline)
- Reads and writes are off-rack operations
  - Placement tries to provide tolerance from rack failures

image courtesy - Hortonworks

Erasure Coding – Current Technical Limitations

- No in-place encoding
- hflush/hsync are not supported
  - Cannot be used by HBase
- Append is not supported

image courtesy - Hortonworks

So when is Erasure Coding recommended?

- Larger clusters
- Lots of cold data
- Medium to Large files
  - At least as large as the stripe width - 9MB for **RS-6-3-1024K**

image courtesy - Hortonworks

Why Journal Node Sync?

- JNs can miss log segments and have gaps in the transaction history

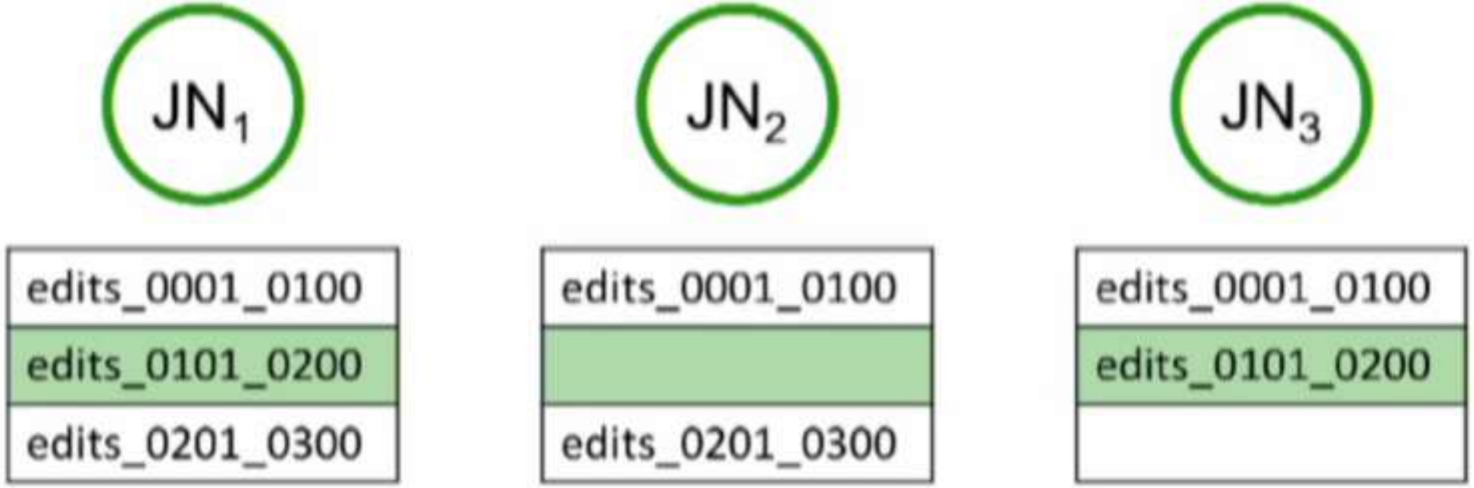


image courtesy - Hortonworks

3 NameNodes

- 1 Active NN, 1 Standby NN and 3 JNs can tolerate any one node failure
- 1 Active Namenode, 2 Standby Namenodes and 5 JNs
  - Node failure tolerance increases to two
- Configuration similar to 2 Namenode setup
- *dfs.ha.namenodes.mycluster = nn1, nn2, nn3*

image courtesy - Hortonworks