Tuning & Hardening Trellis for Large Scale Deployment

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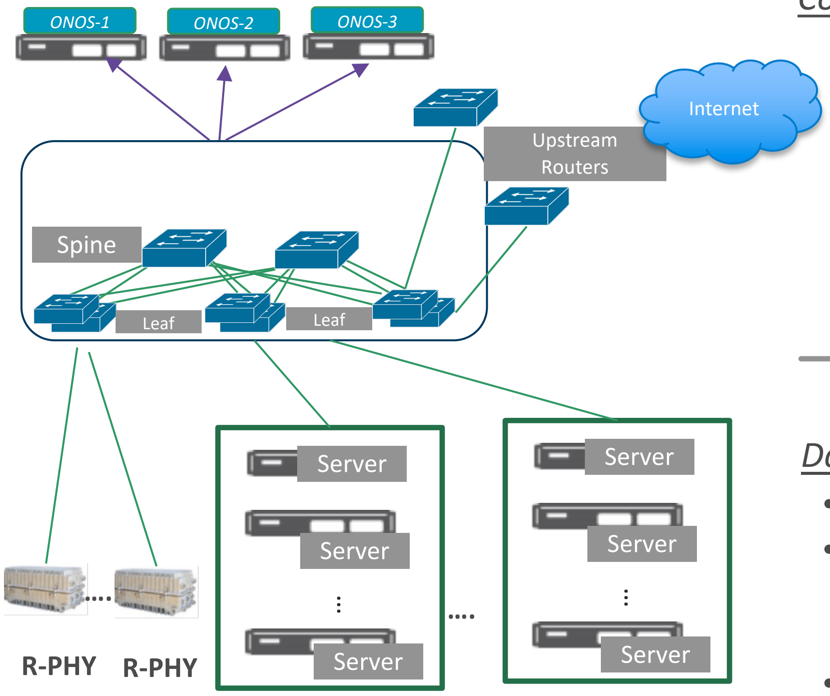
Tuning & Hardening

What do you do to your stock tires if you want to drive to Lake Tahoe in Winter??…

Defaults are like stock tires…

* Understanding the environment and product capability is extremely important to arrive at right tuning of parameters and hardening features

Deployment Topology



Control Plane

- *3 Node ONOS cluster.*
- *The ONOS Cluster uses Distributed stores to reflect the network state in terms of Link store, Host store, Route store, Flow & Group stores etc.,*
- *Each instance may assume a role of device master or distributed store partition leader and have corresponding back-up/Follower instances*

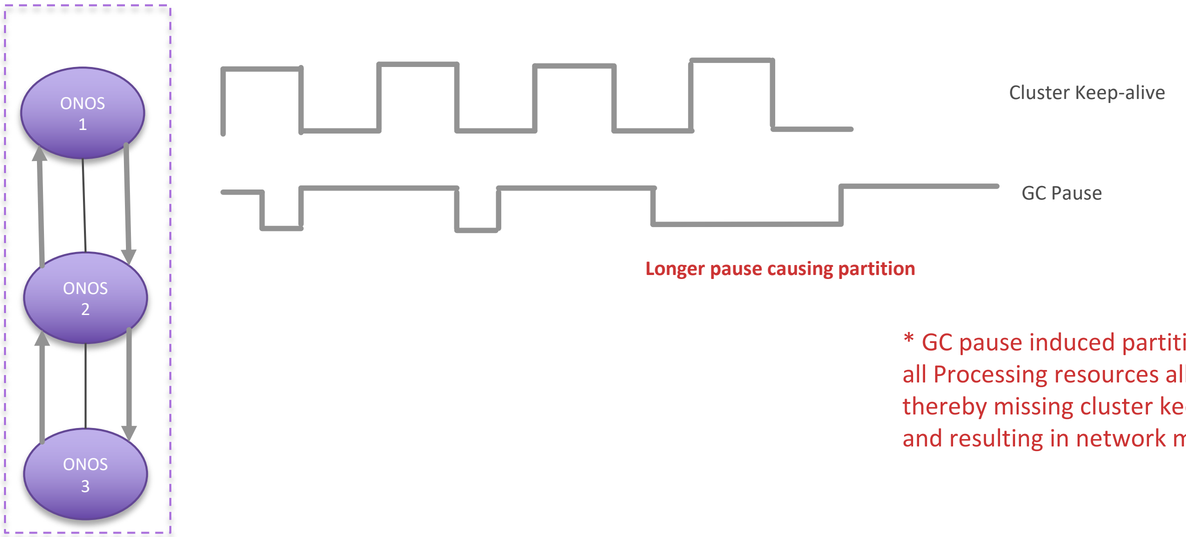
Data Plane

- *Leaf-Spine-Leaf network Topology*
- *One leaf layer connected to Servers running CMTS VNFs and other leaf layer connected to the R-Phy devices, with the fabric interconnecting them.*
- *End services(CM & CPEs) connect through the R-Phy device and get tunneled to the CMTS VNFs and reach the Internet through the upstream routers.*
- *R-Phy, CM, CPEs use DHCP for IP assignment*

Tuning Parameters

GC & Distributed Cluster Timers Tuning

- ONOS Distributed Cluster Keep-alive, Election timers play a crucial role in keeping the cluster up and preventing network meltdown.
- The GC stop the world pause whenever it goes beyond cluster timeout, causes network partition that can result in network meltdown depending on the volume of data to be synced.



* GC pause induced partition happens due to all Processing resources allocated for GC thereby missing cluster keep-alive processing and resulting in network meltdown

GC & Distributed Cluster Timers Tuning

- Tune the cluster timers and the GC parameters to avoid the longer Pause!

* GC Pause < Heart Beat Timer < Election Timer

- CMS (Concurrent Mark Sweep) doesn’t provide much flexibility with controlling pause timers so changed GC mechanism to G1GC, that has control up to 200ms of pause.

* G1GC almost reduced all the network partitions with a **200ms pause** timer which is lesser than the cluster communication timeout.

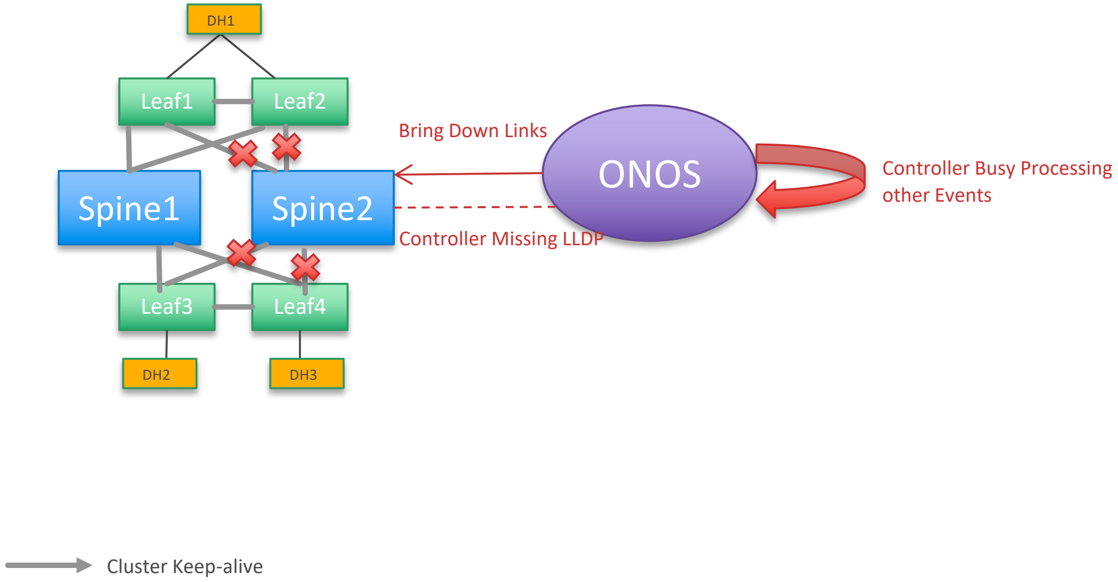
- However with increased scale more tuning of G1GC parameters and Java JVM heap size was required to achieve route scale of 150k. Tuning Explained comprehensively here:

https://docs.google.com/document/d/1bY6dyl57GqqXFVYPaIcQPyu74eeU9B1nofcnbJ1EdLk/edit?usp=sharing

* G1GC parameter Tuning(**G1HeapRegionSize, ParallelGCThreads, ConcGCThreads etc.,)**
and **JVM heap size** changes made it possible to achieve **120 to 150K Route scale with stable soak testing**

LLDP StaleLinkAge Tuning

- When the controller doesn’t see LLDP messages on a link within the StaleLinkAge time, the link is marked as broken. When controller is busy with other processing including GC, it can cause wrong StaleLinkAge timeout and link removal.
- Multiple false link removals at scale can result in total topology re-convergence computation which can cause Network meltdown.



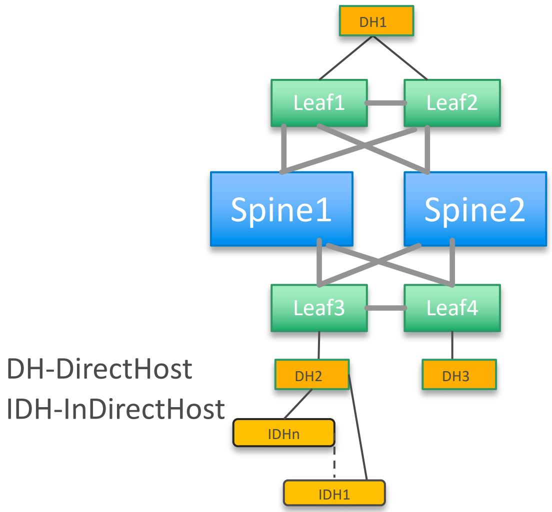
* Increase LLDP StaleLinkAge more than known controller processing tolerance at scale

Hardening Features

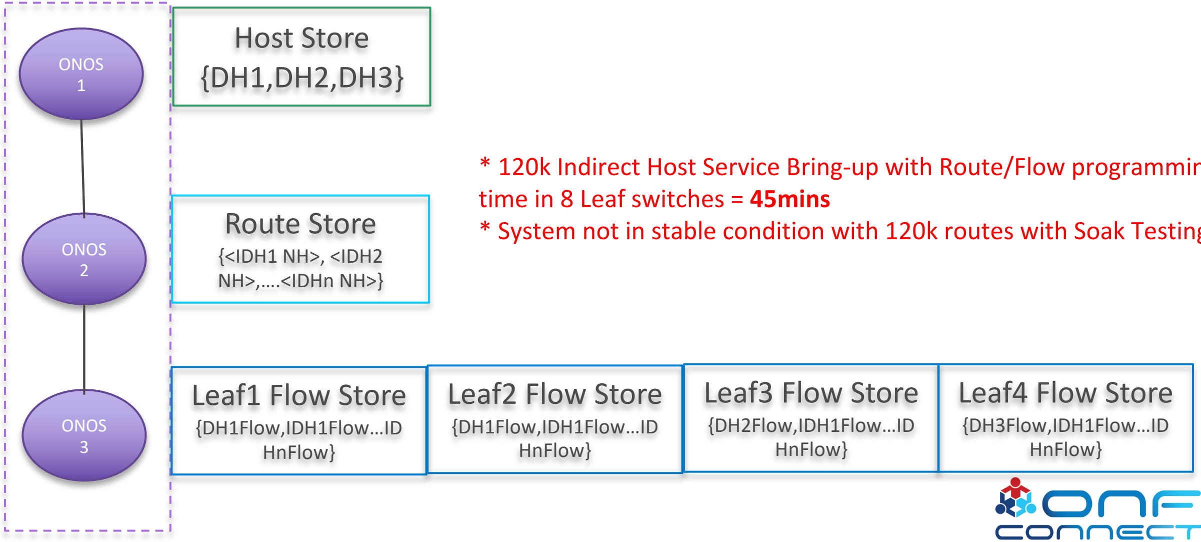
Route/Flow Store Explosion

When the number of indirect hosts keep increasing with scale, it causes route/flow store explosion and also increases switch processor utilization, costly service bring-up and topology convergence.

Leaf-Spine-Leaf Data Plane



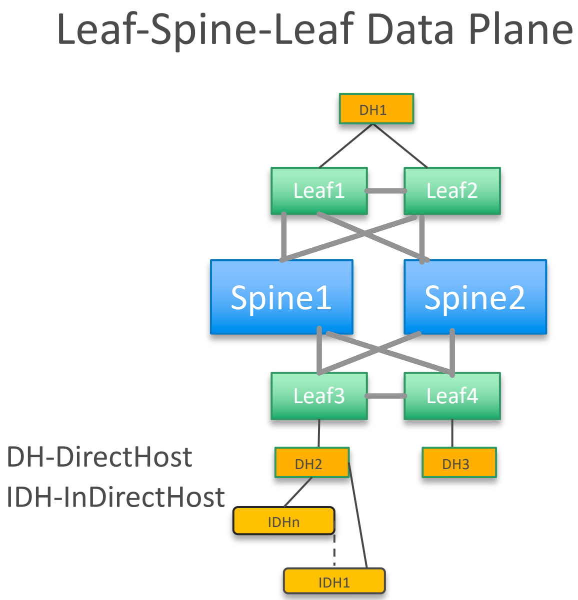
3 Node ONOS Cluster Control Plane

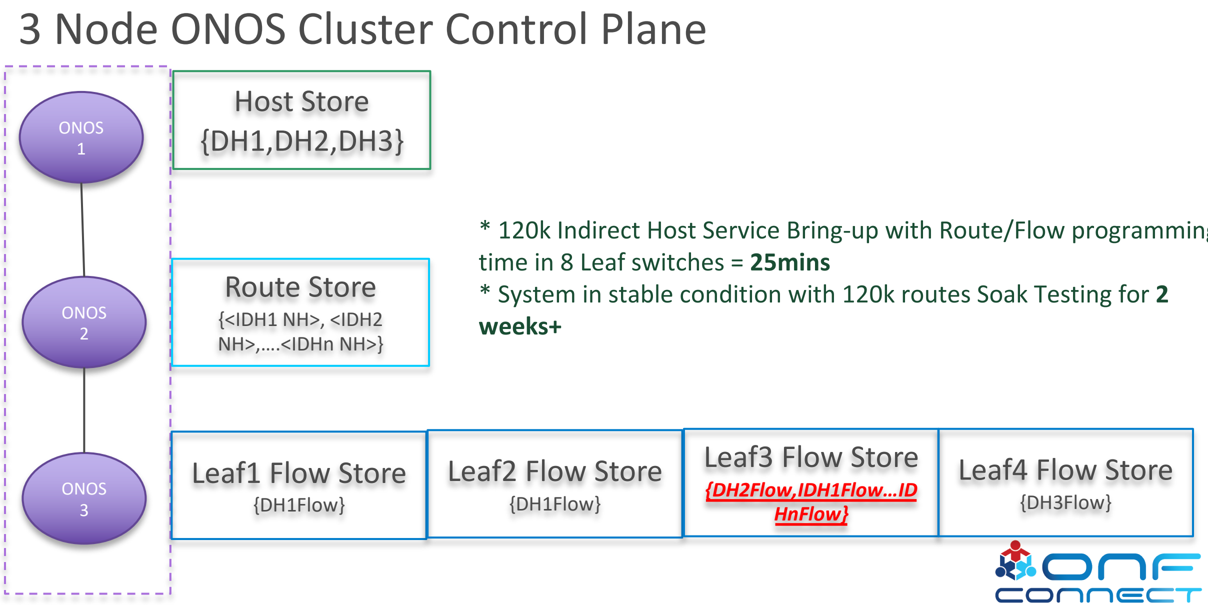


* 120k Indirect Host Service Bring-up with Route/Flow programming time in 8 Leaf switches = **45mins**
* System not in stable condition with 120k routes with Soak Testing

Route/Flow Store Explosion

Route Simplification – Program Indirect hosts only where the next hop resides!

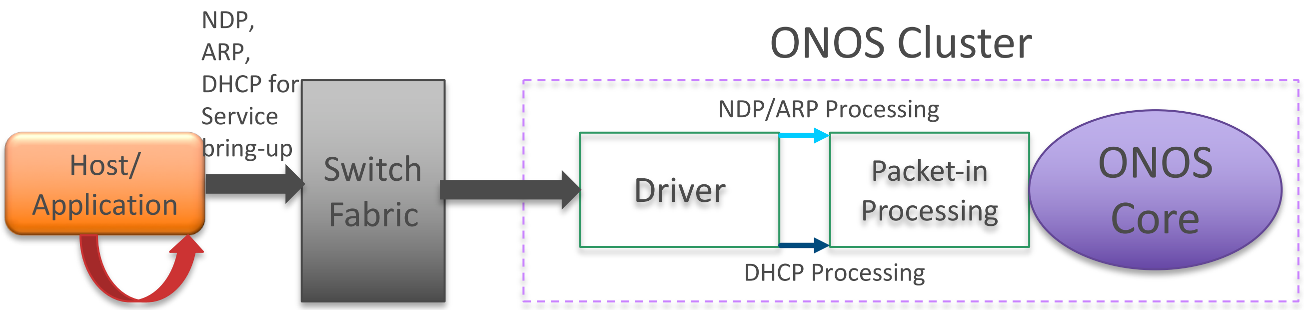




* 120k Indirect Host Service Bring-up with Route/Flow programming time in 8 Leaf switches = **25mins**
* System in stable condition with 120k routes Soak Testing for **2 weeks+**

Critical Event Prioritization

- As scale increases critical Service bring-up events which depends on Packet-in Processing requires prioritization
- Without prioritization time taken for bringing up all services becomes underwhelming and can cause the overlay applications to trigger retries resulting in a choked bottle-neck situation.

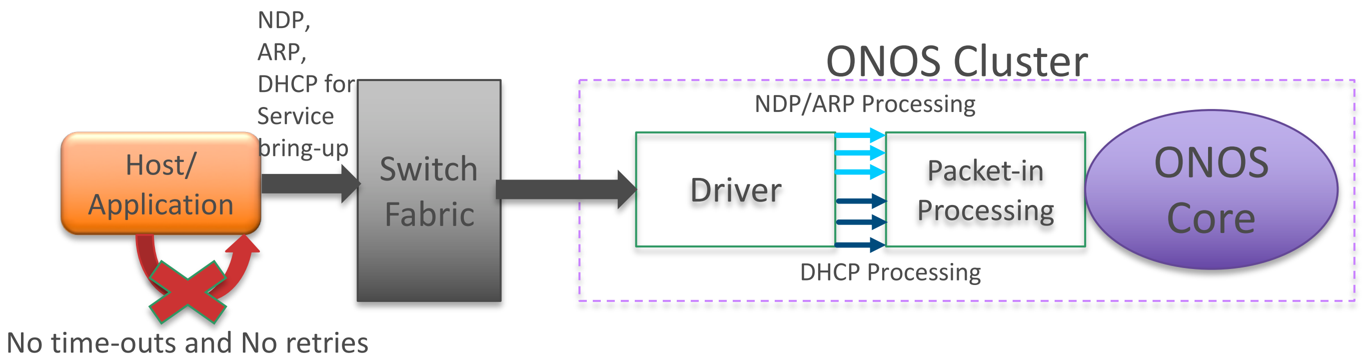


Timeout due to slower processing results in re-tries that pumps even more packets that further slows

* DHCP based customer Service bring-up delayed up to **2 hours +** and further worsens due to re-tries with **20K** customers coming online at the same time

Critical Event Prioritization

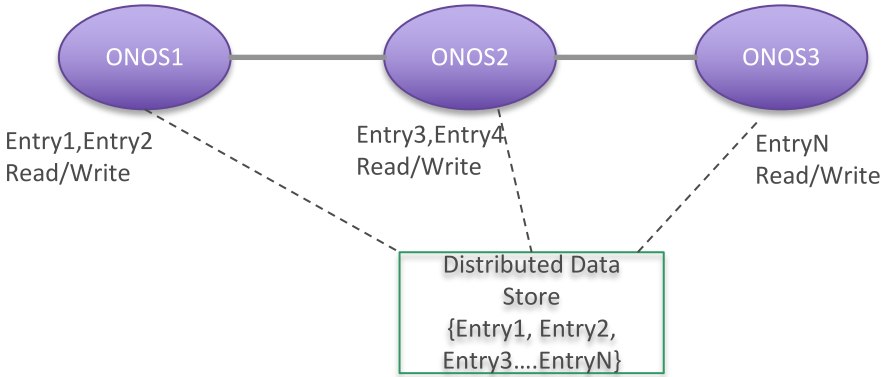
- Multi-Threading! Helps fasten packet-in processing thereby indirectly achieving prioritization for service bring-up event.
- The solution avoids time-outs and resulting retries on the application side!



* DHCP based customer Service bring-up taken care smoothly up to **120k** customers coming only at the same time due to multi-threaded processing

Distributed Store Operation for Non-Critical Data

- Storing non-critical data using distributed store implementing strong/eventual consistency is costly at large scale and causes performance degradation.
- Especially in a critical event processing cycle, store operations and locks will cause noticeable performance throughput variations.



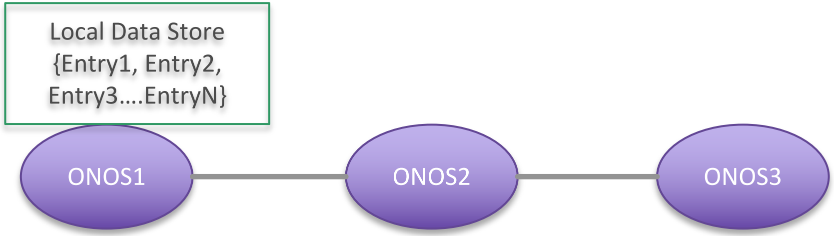
* DHCP based customer Service bring-up delayed up to **2 hours +** even after multi-threading due to consistent store based dhcp counter processing

Distributed Store Operation for Non-Critical Data

Call Tree	Time (ms)		Samples	
<All threads>	54,840	100 %	433	100 %
java.lang.Thread.run()	54,840	100 %	433	100 %
Thread.java:748 java.util.concurrent.ThreadPoolExecutor$Worker.run()	54,840	100 %	433	100 %
ThreadPoolExecutor.java:624 java.util.concurrent.ThreadPoolExecutor.runWorker(ThreadPoolExecutor$Worker)	54,840	100 %	433	100 %
ThreadPoolExecutor.java:1149 org.onosproject.dhcprelay.DhcpRelayManager$DhcpRelayPacketProcessor$$Lambda$1705.run()	28,144	51 %	320	74 %
org.onosproject.dhcprelay.DhcpRelayManager$DhcpRelayPacketProcessor.lambda$process$0(PacketContext)	28,144	51 %	320	74 %
DhcpRelayManager.java:496 org.onosproject.dhcprelay.DhcpRelayManager$DhcpRelayPacketProcessor.processInternal(PacketContext)	28,144	51 %	320	74 %
DhcpRelayManager.java:510 java.util.Optional.ifPresent(Consumer)	28,144	51 %	320	74 %
Optional.java:159 org.onosproject.dhcprelay.DhcpRelayManager$DhcpRelayPacketProcessor$$Lambda$1739.accept(Object)	28,144	51 %	320	74 %
org.onosproject.dhcprelay.DhcpRelayManager$DhcpRelayPacketProcessor.lambda$processInternal$2(PacketContext, DHCP6)	28,144	51 %	320	74 %
DhcpRelayManager.java:511 org.onosproject.dhcprelay.Dhcp6HandlerImpl.processDhcpPacket(PacketContext, BasePacket)	28,144	51 %	320	74 %
Dhcp6HandlerImpl.java:547 org.onosproject.dhcprelay.Dhcp6HandlerImpl.processDhcp6PacketFromServer(PacketContext, Ethernet, Set)	9,216	17 %	125	29 %
Dhcp6HandlerImpl.java:1297 org.onosproject.dhcprelay.Dhcp6HandlerImpl.addHostOrRoute(boolean, ConnectPoint, DHCP6, DHCP6, MacAddress, Int	8,140	15 %	115	27 %
Dhcp6HandlerImpl.java:996 org.onosproject.dhcprelay.store.DistributedDhcpRelayCountersStore.incrementCounter(String, String)	5,648	10 %	61	14 %
Dhcp6HandlerImpl.java:938 org.onosproject.routeservice.store.RouteStoreImpl.replaceRoute(Route)	1,476	3 %	47	11 %
Dhcp6HandlerImpl.java:923 org.onosproject.dhcprelay.Dhcp6HandlerImpl.getFirstIpByHost(Boolean, MacAddress, VlanId)	436	1 %	3	1 %

* Distributed store operation for DHCP counters for every DHCP transaction slows down the processing speed of each service bring-up

- Local Stores! Store non-critical data using local stores. This will greatly avoid the number of store operations across instances and deliver better throughput.

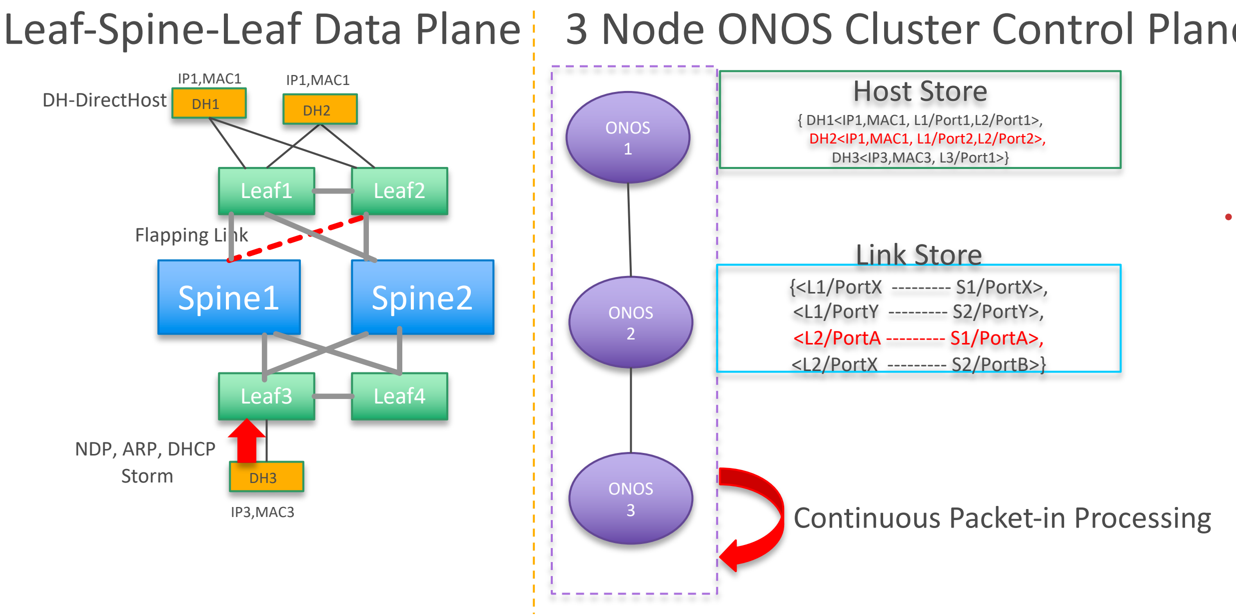


* DHCP based customer Service bring-up taken care smoothly up to **120k** customers coming only at the same time due to multi-threaded processing and converting dhcp counters to local stores achieving a turn around time within **25mins**

Resource Deprivation Due to Infinite Event Queue

The infinite event queue length for event processing, results in processor and memory resources wasted on faulty event processing like:

1) Wrong configuration – same IP/MAC for two hosts results in continuous host movement, host probing for discovery and related Route/Flow processing
2) Flapping links – continuous link entry addition/removal and corresponding topology convergence processing each time
3) Packet-in Storm – Rogue hosts sending NDP/ARP/DHCP can hog the controller resources due to continuous packet-in processing

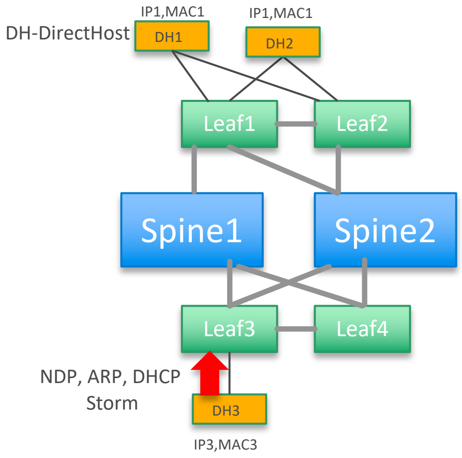


- Continuous host moves and related host probing with duplicate IP/Mac have filled the queue so deep that even host entry is removed processing continued for hours.

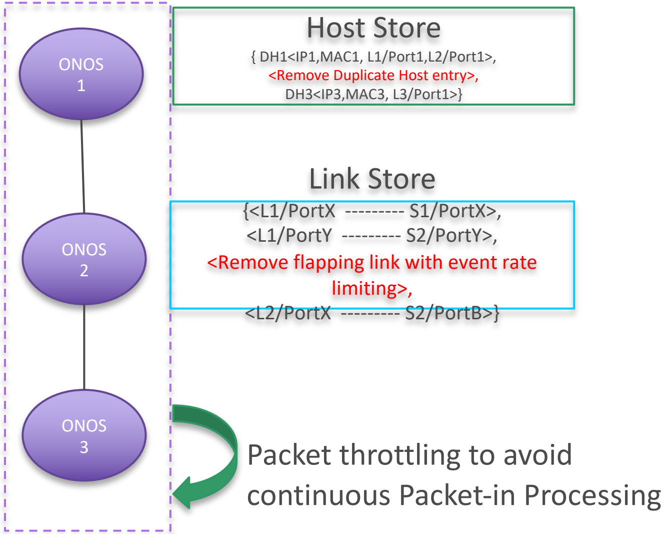
Resource Deprivation Due to Infinite Event Queue

1) Packet Throttling – To avoid continuous packet-in processing during a storm
2) Symmetric Probing – To avoid too many host probe discovers by assuming symmetric host connectivity
3) Event Rate limiting – To avoid continuous event processing by monitoring for same event type occurrence
4) Duplicate Host Detection – To avoid processing duplicate hosts due to configuration mistakes.

Leaf-Spine-Leaf Data Plane



3 Node ONOS Cluster Control Plane

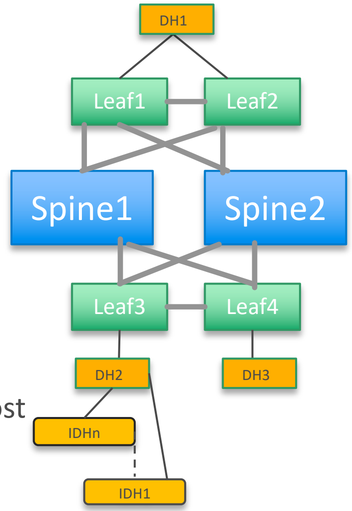


* Symmetric Host probing and Duplicate host detection stops hours of unnecessary processing.

Route/Flow Calculation Suppression

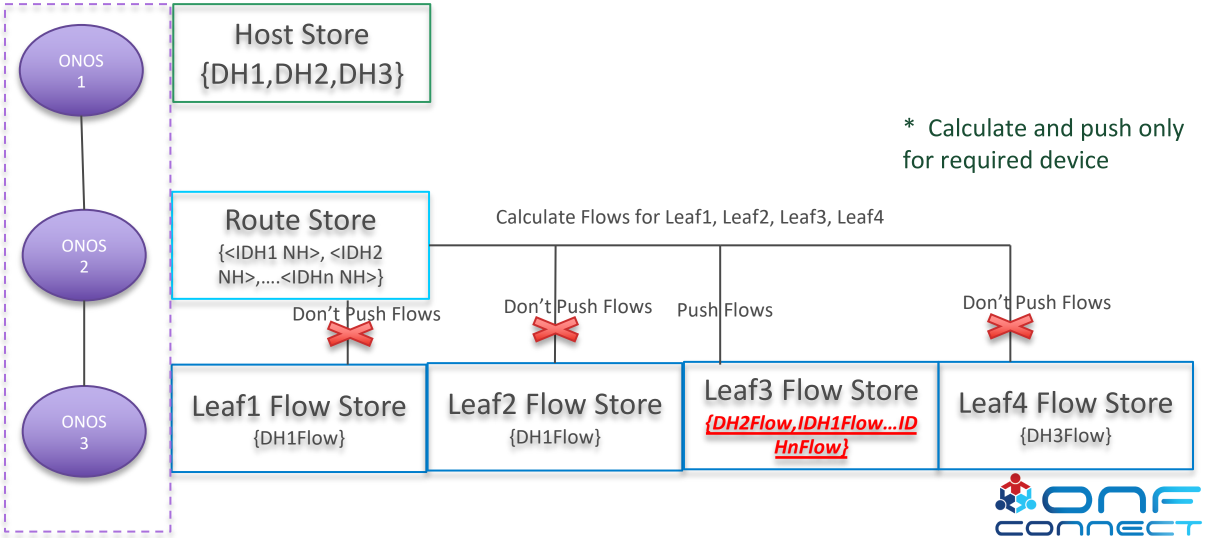
- Current Route Simplification suppresses pushing flows, but at higher scale even calculation is costly.
- Suppress calculation for devices which don't need the flows!

Leaf-Spine-Leaf Data Plane



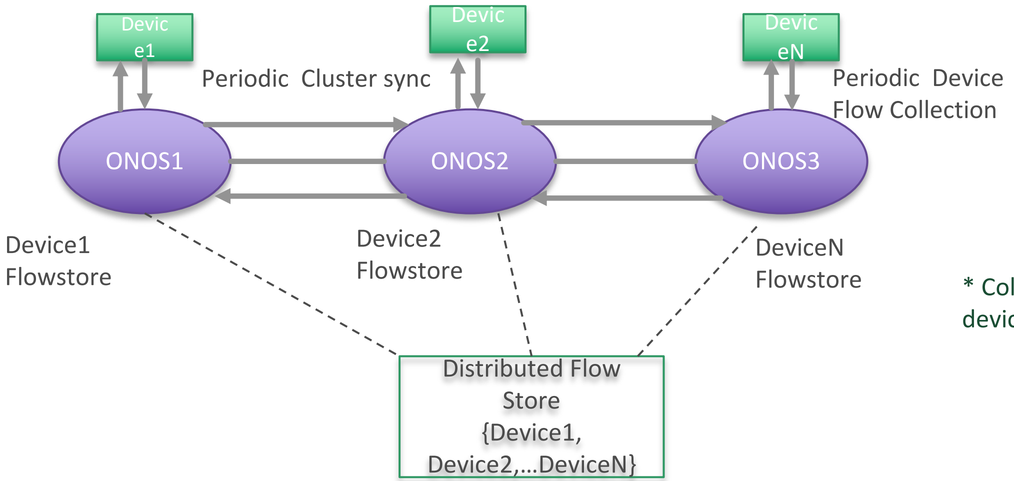
DH-DirectHost
IDH-InDirectHost

3 Node ONOS Cluster Control Plane



Optimize Flow Stat Collection

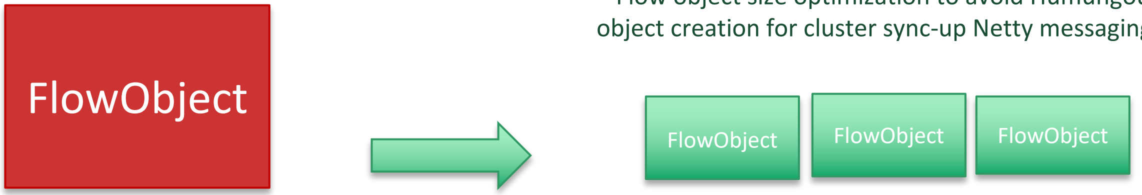
- Periodic Flow stat collection from devices and syncing across distributed cluster is a costly process at very high scale.
- Only collect when there is a flow change or device mastership change!



* Collect Device flow only when there is flow change or device mastership change

Avoid Network Meltdown

- Humungous flow object synchronization failures during device mastership change handling causing network meltdown.

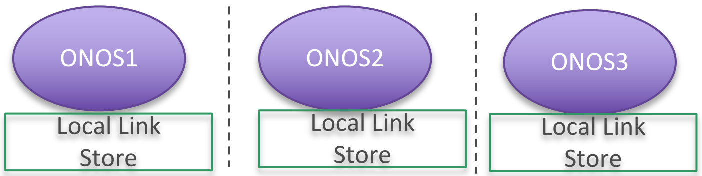


* Flow object size optimization to avoid Humungous object creation for cluster sync-up Netty messaging

- When all instances in the distributed cluster has a partition, it results in link store clean-up forcing a complete topology convergence. At very high scale this topology convergence can cause network meltdown.

* Local Link store of one of the instance can be taken as source of truth and avoid the clean-up

All 3 instances partitioned



Thank You