Scaling Indexer Clustering

5 Million Unique Buckets and Beyond

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Agenda

1. Introduction to Indexer Clustering
2. Scalability Improvements
3. Performance
Introduction to Indexer Clustering
Indexer Clustering Topology

- Search Head
- Cluster Master
- Indexers
- Forwarders

Replication: Master-Peer
Data input
Searches
Cluster Nodes

► Cluster Master (CM)
  • Stateless
  • Maintains in-memory state of all the peers and buckets
  • Coordinates the replicating activities of the peer nodes
  • Tells the search head where to find data

► Cluster Peer (Indexer)
  • Indexes, replicates data
  • Responds to the incoming search requests
  • Report its state and all its buckets to CM

► Search head

► Forwarder
Buckets

- Unit of data the cluster is aware of
- Created on the indexer
  - Indexer notifies CM upon every state transition of its bucket
- Configurable size
- Bucket manipulation is centric of CM’s responsibility
- More data, more buckets

Flow of bucket creation

1. Rawdata
2. Events
3. Slice
4. Bucket

Rawdata broken into Events are grouped into Slice are written into Bucket
One of the mechanisms CM uses to communicate with peers

Status synchronization

Once peer registers to master, it starts to heartbeat to master every `heartbeat_period` seconds (defaults to 1)

CM utilizes `heartbeat_timeout` to consider if peer is offline and perform fixup if necessary
Scalability
Improvements
Quick Glance of Improvements since 6.6

- 3x more cluster-wide buckets (vs 6.5)
  - 15M cluster-wide buckets, or 150 PB data (10GB/bucket)
- Faster cluster management with scale
  - rolling restart: ~2x faster
  - peer failure recovery: ~2x faster
  - Improved responsiveness
    - Better average turn-around time: 2x faster and more
    - and more…
- Less memory (vs Splunk 6.6)
  - ~15% reduction in CM
Challenges to scale up

- More data, more buckets
  - more complexity
  - more fixes to reach healthy state
  - more memory consumed, less cache hit-rate, higher cache miss penalty

- Extreme conditions are difficult to fulfill in time
  - Long-running transactions
  - When CM’s CPU is burned out, requests could be possibly timeout and result in failure recovery
    - Add into cluster, huge amount of fix jobs
    - More fix ups, higher demand of CPU
  - False positive scenarios due to above reasons
    - unnecessary fixes

- Network latency
Improvements

- Peer adding with configurable amount of buckets
- Limit job processing time
- Lockless heartbeat
- Enhanced bucket management
Peer adding - configurable amount of buckets

- Splunk 6.5 and prior
  - Peer sends all buckets within a single operation
  - High requirement for CM processing power
  - Might result in unresponsive CM
  - Long-running transaction is fragile

- Splunk 6.6+
  - Configurable amount of buckets to replace long-running add-peer
  - Reduce the requirement of CM computing power
  - Reduce the variation caused by network latency
  - Better turn-around time
  - More responsive CM
Peer adding - configurable amount of buckets

<table>
<thead>
<tr>
<th>i</th>
<th>Peer Name</th>
<th>Site</th>
<th>Fully Searchable</th>
<th>Status</th>
<th>Buckets</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;</td>
<td>perf086</td>
<td>site3</td>
<td><img src="false" alt="No" /></td>
<td>BatchAdding</td>
<td>1564000</td>
</tr>
<tr>
<td>&gt;</td>
<td>idx_08_204.107.141.240</td>
<td>site2</td>
<td><img src="true" alt="Yes" /></td>
<td>Up</td>
<td>1625673</td>
</tr>
<tr>
<td>&gt;</td>
<td>perf089</td>
<td>site3</td>
<td><img src="false" alt="No" /></td>
<td>BatchAdding</td>
<td>1483000</td>
</tr>
<tr>
<td>&gt;</td>
<td>perf084</td>
<td>site1</td>
<td><img src="true" alt="Yes" /></td>
<td>Up</td>
<td>1342597</td>
</tr>
</tbody>
</table>
Peer adding - configurable amount of buckets

- buckets_per_addpeer = <non-negative integer> in server.conf
- Defaults to 1000
- The more buckets in add-peer, the quicker it adds to cluster
  - Needs larger REST receive timeout `rcv_timeout` and heartbeat timeout `heartbeat_timeout`
  - Less responsive CM
  - Less up-to-date cluster
- Needs tweaking along with
  - Computing power of CM
  - Related timeout settings
  - Number of buckets
  - Number of indexers
Limit job processing time

▶ Splunk 6.5 and prior
  • CM used to process all jobs within a single service duration, which could be many seconds or even minutes
    • Replication (to meet RF)
    • Search (to meet SF)
    • Primality (all buckets need to have a primary copy per site)
    • Others (freezing, checksum, rolling, etc)

▶ Splunk 6.6+
  • An option to limit how long CM spends per fixup
  • CM is forced to context switch to serve other requests
  • More responsive CM, however fixups take longer
Limit job processing time

- `max_fixup_time_ms = <zero or positive integer>`
- Defaults to 0 (unused)
- Limits how long each fixup level runs
- Useful on larger clusters having massive amount of buckets
- Enable it when there are massive amount of buckets, and cluster failures result in extra busy cluster master fixup activity (where service duration takes more than 10 seconds)
Lockless heartbeat

- Splunk 6.5 and prior
  - The heartbeat processing in CM was blocking
  - Frequent heartbeat and massive indexers will result in less responsive CM
  - False positive errors

- Splunk 6.6+
  - Re-designed heartbeat mechanism
  - Not blocking anymore
  - Incoming heartbeats are stored, cached, and processed later
  - Scaling up with increasing number of indexers won’t significantly affect CM responsiveness
Enhanced bucket management

- Bucket is centric of CM’s responsibility
  - Bucket manipulation is required by mostly all processing in CM
  - Improving it will generally improve all critical paths
- Available since Splunk 7.0
- Bonus: ~15% memory saving in master node

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Splunk 6.6</th>
<th>Splunk 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1M bucket Insertions</td>
<td>60ms</td>
<td>2.42ms</td>
</tr>
<tr>
<td>1M bucket Lookups</td>
<td>60ms</td>
<td>2.26ms</td>
</tr>
</tbody>
</table>
Indexer Clustering Performance

Scale tests with 5 Million Unique Buckets
Deployment

- Search Head
- Cluster Master
- Site 1
- Site 2
- Site 3
- Forwarders
- Indexers
Test Configuration

- **Machine Specs**
  - 2x12 Xeon 2.30 GHz
  - 24 cores (48 w/HT)
  - 128 GB RAM
  - 8 x 300GB 15k RPM disks in RAID-0
  - 1 Gb Ethernet NIC
  - CentOS 7.6

- **Multi-site Cluster Configuration**
  - 3 sites
  - Replication factor – origin:2, total:3
  - Search factor – origin:1, total:2

- **No other load on the box**
1.9 Million Bucket Test
Splunk 6.5 vs Splunk 7.0

- 640,000 unique buckets
- 200,000 buckets/peer
- Default cluster timeout configurations
- No Search or Indexing load
## Test Results

<table>
<thead>
<tr>
<th>Test Case</th>
<th>Success Condition</th>
<th>Time for Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM Restart</td>
<td>Cluster Complete</td>
<td>43.08 secs</td>
</tr>
<tr>
<td>Peer Failure</td>
<td>Cluster Searchable</td>
<td>60 + 73.8 secs</td>
</tr>
<tr>
<td>Rolling Restart</td>
<td>Cluster Complete</td>
<td>19.1 mins</td>
</tr>
<tr>
<td>Bundle Push</td>
<td>100 MB Pushed</td>
<td>49.2 secs</td>
</tr>
</tbody>
</table>
## Improved CM responsiveness

<table>
<thead>
<tr>
<th>Endpoints</th>
<th>Average Time (milliseconds)</th>
<th>Splunk 6.5</th>
<th>Splunk 7.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>/services/cluster/master/generation</td>
<td></td>
<td>778 ms</td>
<td>262 ms</td>
</tr>
<tr>
<td>/services/cluster/master/peers</td>
<td></td>
<td>1972 ms</td>
<td>119 ms</td>
</tr>
<tr>
<td>/services/cluster/master/buckets</td>
<td></td>
<td>818 ms</td>
<td>440 ms</td>
</tr>
<tr>
<td>/services/cluster/master/info</td>
<td></td>
<td>4293 ms</td>
<td>1796 ms</td>
</tr>
<tr>
<td>/services/cluster/master/indexes</td>
<td></td>
<td>1874 ms</td>
<td>598 ms</td>
</tr>
</tbody>
</table>
CM Memory Footprint

CM Resident Memory Usage

- **splunk_version 6.5**
  - avg(mem_mb): 6,889.784
  - max(mem_mb): 8,990.453
- **splunk_version 7.0**
  - avg(mem_mb): 5,996.361
  - max(mem_mb): 7,738.262
15 million Bucket Test

- 5 million unique buckets
- 3x more buckets cluster-wide compared to Splunk 6.5
- No Search or Indexing Load
### Buckets per Peer

#### Indexer Clustering: Master Node

- **All Data is Searchable**: 10 searchable, 0 not searchable
- **Search Factor is Met**: 96 searchable, 0 not searchable
- **Replication Factor is Met**: 96 searchable, 0 not searchable

#### Peers (10) | Indexes (96) | Search Heads (1)

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<tr>
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<th>Site</th>
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<td>Yes</td>
<td>Up</td>
<td>1767520</td>
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<td>site2</td>
<td>Yes</td>
<td>Up</td>
<td>1625686</td>
</tr>
<tr>
<td>perf089</td>
<td>site3</td>
<td>Yes</td>
<td>Up</td>
<td>1749115</td>
</tr>
<tr>
<td>perf084</td>
<td>site1</td>
<td>Yes</td>
<td>Up</td>
<td>1348108</td>
</tr>
<tr>
<td>perf090</td>
<td>site1</td>
<td>Yes</td>
<td>Up</td>
<td>1432264</td>
</tr>
<tr>
<td>perf082</td>
<td>site2</td>
<td>Yes</td>
<td>Up</td>
<td>1621469</td>
</tr>
<tr>
<td>perf085</td>
<td>site2</td>
<td>Yes</td>
<td>Up</td>
<td>1560173</td>
</tr>
<tr>
<td>perf081</td>
<td>site1</td>
<td>Yes</td>
<td>Up</td>
<td>1344318</td>
</tr>
<tr>
<td>perf087</td>
<td>site1</td>
<td>Yes</td>
<td>Up</td>
<td>1449131</td>
</tr>
<tr>
<td>perf083</td>
<td>site3</td>
<td>Yes</td>
<td>Up</td>
<td>1167682</td>
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</tr>
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CM Memory Footprint

- 18.5% reduction in avg. Resident Memory & 23% reduction in max Resident Memory
Splunk CPU Usage

- cm: avg(cpu_perc) = 101.13, max(cpu_perc) = 326.5
- peer: avg(cpu_perc) = 99.27, max(cpu_perc) = 199.4
Cluster Configuration

Cluster Master - server.conf
[clustering]
  • heartbeat_timeout = 600
  • rcv_timeout = 600
  • send_timeout = 600
  • cxn_timeout = 600
  • max_fixup_time_ms = 5000

Indexers - server.conf
[clustering]
  • heartbeat_period = 40
  • cxn_timeout = 600
  • send_timeout = 600
  • rcv_timeout = 600
  • buckets_per_addpeer = 1000
Key Takeaways

1. Enhancements - Peer adding with configurable amount of buckets, Lockless heartbeat, Limit job processing time etc.

2. CM scales up to 5+ million unique buckets (3x more compared to Splunk 6.5)

3. Faster Cluster recovery and Improved CM responsiveness.

4. ~15% CM memory reduction.
Thank You

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