Performance Improvements

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Schema Memory Usage

- Data models are growing
- Size of data models for Junos/IOS/IOSXR is about 1.9 GB
- Models are rarely used, but must be present on device
- Using CDM will result in multiple version of data models being loaded

FXS files

- An FXS file is primarily a sequence of #cs{} records (ConfSpec), stored in chunks.
- Loading FXSs consists of
  - Reading #cs{} records from files and storing them in ETS tables, which are generic in-memory hash tables.
  - Resolving augmentations between name spaces.
  - An ETS table consists of records for a namespace, and all augmentation into that namespace.
  - In addition to #cs{} records there are #docs{}, #exs_type{}, and header information.

#cs{} record layout

```
-record(cs, {
          tagpath,
          htagpath,
          namespace,
          hnamespace,
          exs,
          keys = [],
          flags = ?F_CS_READ bor ?F_CS_WRITE,
          dbm,
          dba = [],
          validatemfas = [],
          actions = [],
          cmp = 0,
          hooks = [],
          hidden = none,
          notifs = [],
          symlink = undefined,
          extra = [],
          default_ref,
          secondary_indices = [],
          cli_flags = 0
        }).
```

```
-record(exs, {
          tagpath,
          type,
          primitive_type,
          default,
          attrs = [],
          min_occurs = 1,
          max_occurs = 1,
          children = [],
          flags = 0
        }).
```

A typical distribution

- With Juniper, IOS, and IOSXR

```
cs: 1600 MiB
doc: 160.12 MiB
action: 64.56 KiB
exs_type: 44.57 KiB
fxs_header: 5.09 KiB
info: 1.25 KiB
augments_header: 40 bytes
```

```
#cs{
 tagpath =
  [address,'ipv6-addrees','eid-cont','database-mapping',ipv6,
   service,'instance-list','instance-container',
   ['http://cisco.com/ns/yang/Cisco-IOS-XE-lisp'|lisp],
   router,native],
 htagpath =
  [1266954393,1103441164,1502191743,1365224135,1228132394,
   855380710,2088542428,608613614,
   [247644804|1303297170],
   532320551,472211213],
 namespace = 'http://cisco.com/ns/yang/Cisco-IOS-XE-native',
 hnamespace = 1270643900,
 exs =
  {exs,
   [address,'ipv6-addrees','eid-cont','database-mapping',ipv6,
    service,'instance-list','instance-container',
    ['http://cisco.com/ns/yang/Cisco-IOS-XE-lisp'|lisp],
    router,native],
   {'urn:ietf:params:xml:ns:yang:ietf-inet-types',
    'ipv6-address'},
   inetAddressIPv6,undefined,[],1,1,[],0},
 keys = [],flags = 61897001964269013744958007O,dbm = cdb,
 dba = [],validatemfas = [],actions = [],cmp = 1,hooks = [],
 hidden = none,notifs = [],symlink = undefined,extra = [],
 default_ref = undefined,secondary_indices = [],
 cli_flags = 524288}]
```

Compaction

- Remove redundant information
  - Multiple copies of tagpath
  - htagpath and hnamespace are computed
  - Default values in record

```
-record(cs_trim, {
          key,
          dmap,
          record
        }).
```

- Performance penalty on sync & show ~1-2% slowdown.

Compaction (cont.)

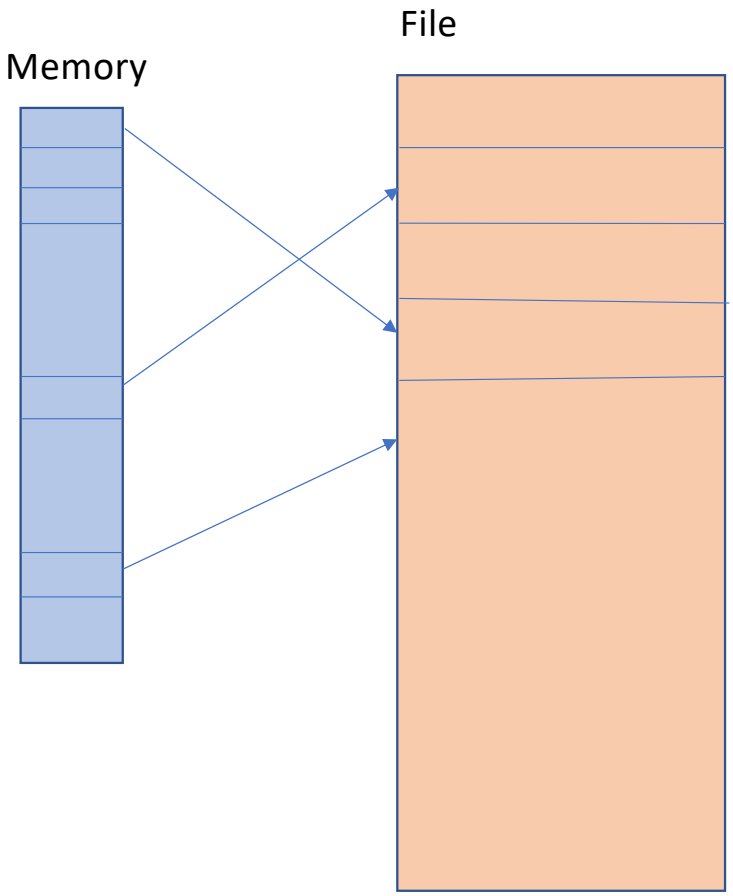
```
#cs_trim{
    key =
        ['Cellular','update-source',neighbor,
         ['http://cisco.com/ns/yang/Cisco-IOS-XE-bgp'|bgp],
         router,native],
    dmap = 229264,
    record =
        {'http://cisco.com/ns/yang/Cisco-IOS-XE-native',
            {exs_trim,1970,
                {'http://www.w3.org/2001/XMLSchema',string},
                string,0},
            6189700196426903457554938 94,cdb,
            [{cli_allow_join_with_value_r,154742504910672534362390528,
                 []}],
            207691874341393105141219853168803 84}}
```

Version	FXS table size	Ratio
NSO 5.1	1.93 GiB	1
#cs_trim{}	0.80 GiB	2.4

Lazy loading

- Flush all #cs_trim{} records to disk, and only store
  - Path
  - Position in file
- Read records on demand and store in ETS table.

```
-record(cs_file, {
          tagpath,
          pos
         }).
```



Lazy loading (cont.)

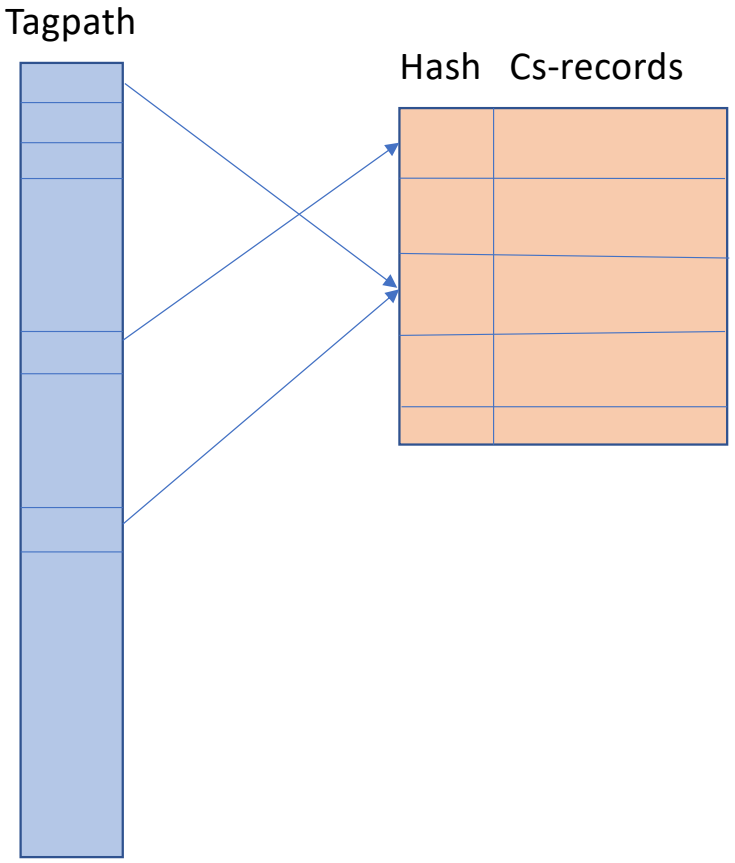
Version	FXS table size	Ratio
NSO 5.1	1.93 GiB	1
#cs_trim{}	0.80 GiB	2.4
#cs_file{}	0.55 GiB	3.5

- Pros
  - Use less memory
- Cons
  - Require a baking phase
  - Slower access
  - Somewhat unpredictable memory usage
  - Requite disk space

De-duplicate

Only 3% of #cs{} records are unique when factoring out tagpath

Version	FXS table size	Ratio
NSO 5.1	1.93 GiB	1
#cs_trim{}	0.80 GiB	2.4
#cs_file{}	0.55 GiB	3.5
#cs_ref{}	0.60 GiB	3.2



Path Sharing

- Large parts of data is now tagpaths
- Tag paths are paths from root, in reverse

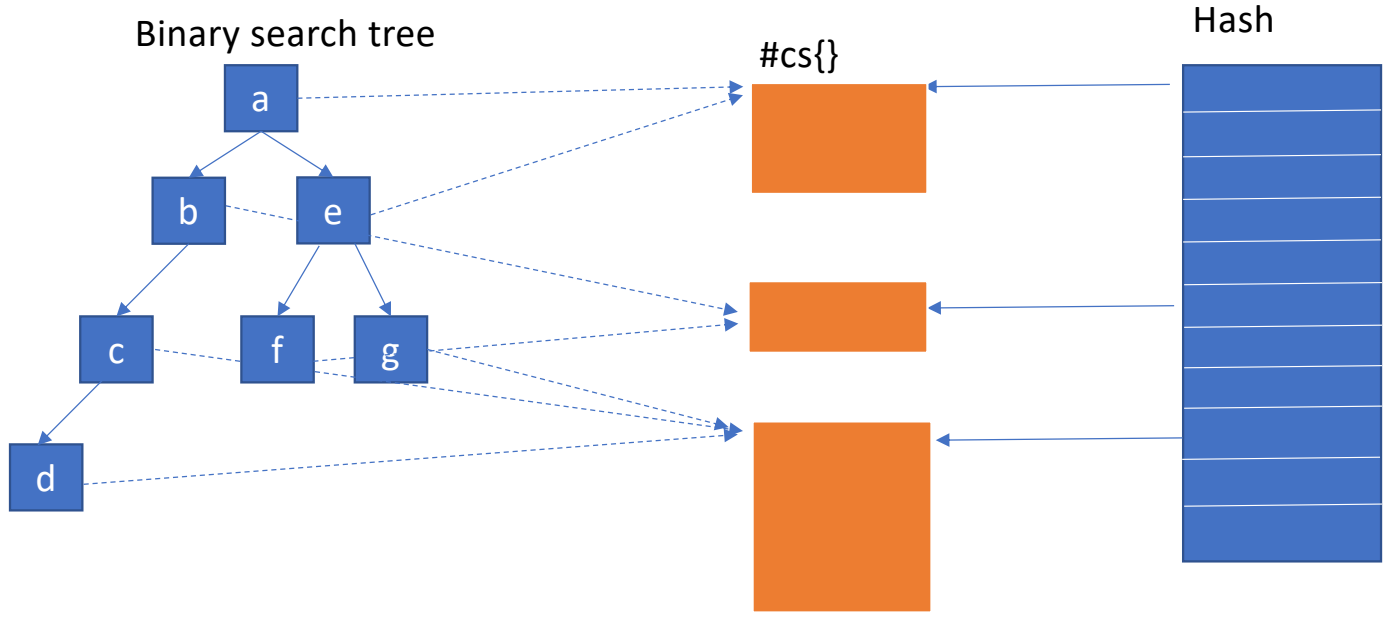
```
[]
[devices]
[devices,device]
[devices,device,config]
[devices,device,config,native]
[devices,device,config,native,router]
[devices,device,config,native,router,['http://cisco.com/ns/yang/Cisco-IOS-XE-bgp'|bgp]]
[devices,device,config,native,router,['http://cisco.com/ns/yang/Cisco-IOS-XE-bgp'|bgp],neighbor]
[devices,device,config,native,router,['http://cisco.com/ns/yang/Cisco-IOS-XE-bgp'|bgp],neighbor,'update-so
```

- Only tail of path is unique, rest is shared with parent

Implementation for Path Sharing

- Custom data structure, mix of trees and hash tables

```
[d,c,b,a]
[c,b,a]
[b,a]
[a]
[f,e,a]
[e,a]
[b,e,a]
```



New FXS Implementation

Version	FXS table size	Ratio
NSO 5.1	1.93 GiB	1
#cs_trim{}	0.80 GiB	2.4
#cs_file{}	0.55 GiB	3.5
#cs_ref{}	0.60 GiB	3.2
Path sharing	0.08 GiB	24
Path sharing trim	0.07 GiB	26

Approximately twice as fast as the original implementation, and 1/20:th the size. Present in NSO 5.1.

Cisco-style CLI Parsing

- Large configurations takes a long time to process
- Reading from CLI NEDs
- Loading configurations in NSO
- Native implementation
  - Reduced memory usage compared to Java implementation

NSO CLI: Top-down, breadth-first (on drop-node-name)

Goal: User friendly CLI, provide help and alternatives, precise error reporting

```
interface Loopback0
  ip address 127.0.0.1 255.255.255.255
exit
```

Algorithm:

Step1: /: **collect** interface, policy, mpls, ... **select** interface

Step2: /interface: **collect** Ethernet, ..., Loopback, … **select** Loopback

Step3: /interface/Loopback/: **collect** ip, ntp, peer, vrf, … **select** ip

Step4: /interface/Loopback/ip: **collect** access-group, address, arp, rip,… **select** address

YANG tree:

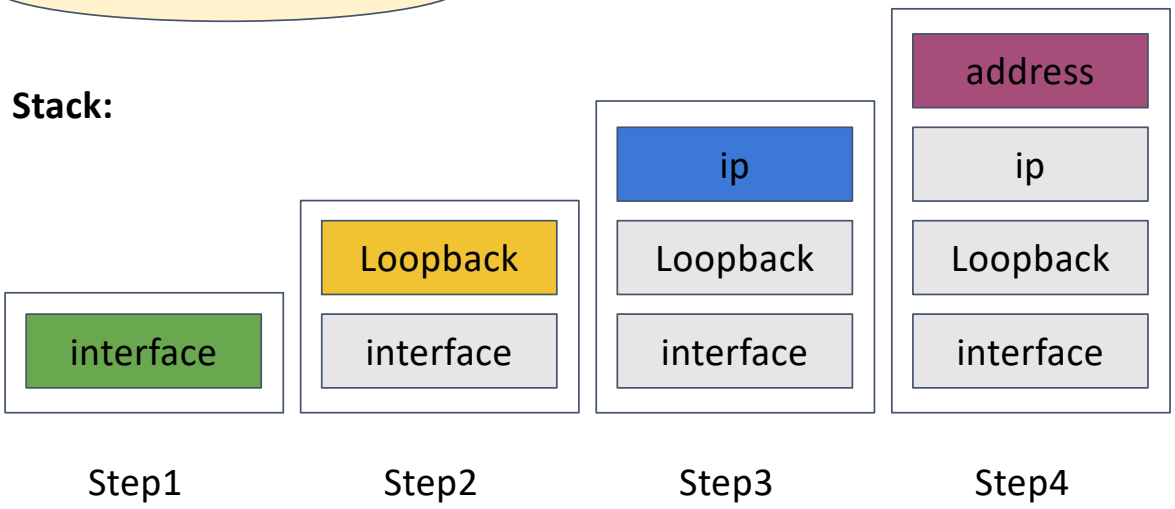
```
interface
   Ethernet
   FastEthernet
   GigabitEthernet
   ...
   Loopback
      ...
      ip
         address
         ....
      ....
   ...
policy
mpls
...
```

Turbo CLI: Top-down, depth-first, stack based parser

Goal: Fast parsing for programmatic users, pick first best match

```
interface Loopback0
   ip address 127.0.0.1 255.255.255.255
exit
```

Stack:



YANG tree:

```
interface
   Ethernet
   FastEthernet
   GigabitEthernet
   ...
   Loopback
      ...
      ip
         address
         ....
      ....
   ...
policy
mpls
...
```

Turbo Parser vs Regular Parser

File	Regular CLI	Turbo Parser	Ratio
1000-lb-config	30 s	5.8 s	5.2
10,000-ace-config-cli-sequence	320 s	26 s	12.3
30,000-ace-config-cli-sequence	940 s	76 s	12.3
huge/nonwireless_CLI.txt	50 s	4.2 s	11.9
huge/ncs4216-all_config.txt	2.7 s	0.67 s	4.0

Filtering on List Instances in Data Provider

Would be nice to pass “filters” to the DP instead of filtering in NSO – subtree filter, XPath, CLI.

- Avoid round trips between NSO and data provider
- Simple XPath evaluation in DP

Important when

- Reading large sets of operational data and configuration
- Configuration validation
- Evaluating XPath expressions (e.g. must & when expressions)

Filter Example

```
list foo {
  key name;
  leaf name { type string; }
  leaf value { type int32; }
}

list bar {
  key name;
  leaf name { type string; }
  leaf fooref {
    type leafref {
      path "/foo/value";
    }
  }
```

XPath example:

```
/foo[value > 42 or starts-with(name, “eth-”)]
```

NETCONF subtree example:

```
<foo>
  <value>42</value>
</foo>
```

CLI

```
show foo eth-*
show foo * value 42
```

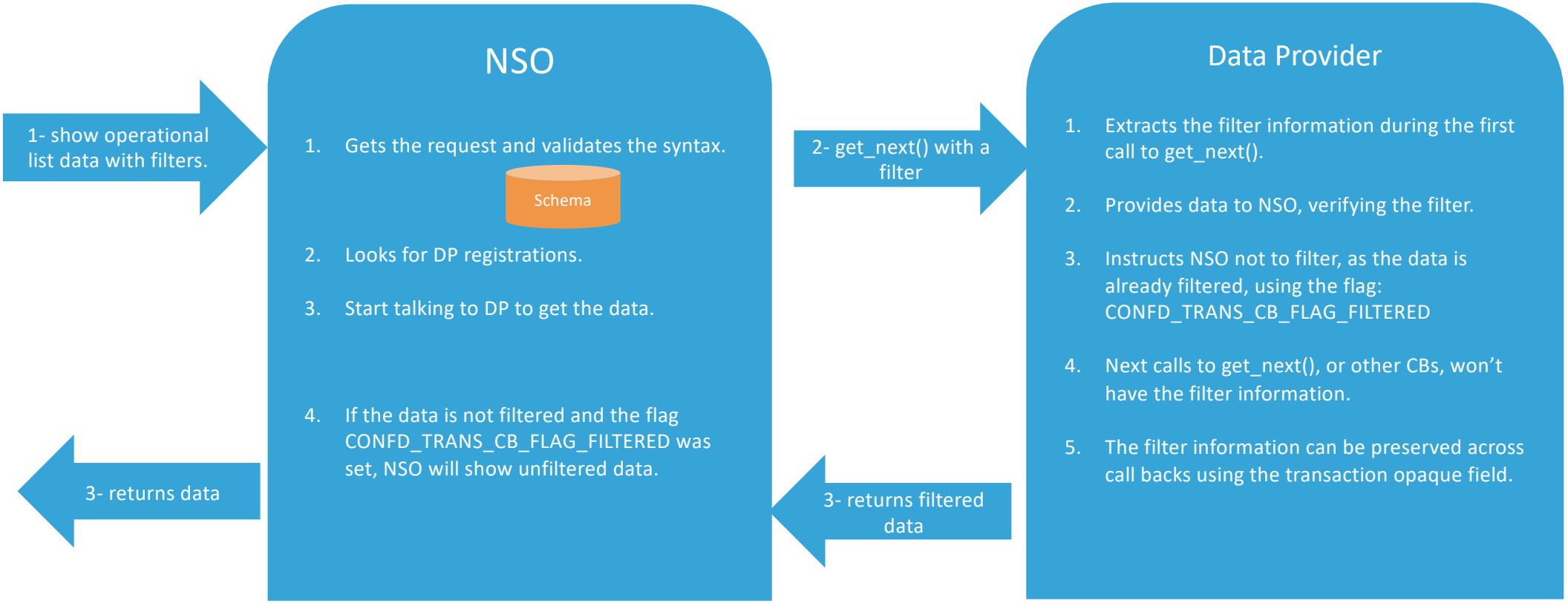
Validation

```
list foo {
  key name;
  leaf name { type string; }
  leaf value { type int32; }
}

list bar {
  key name;
  leaf name { type string; }
  leaf fooref {
    type leafref {
      path "/foo/value";
    }
  }
```

Delete of “/foo” with “value” 42 will get_next through the entire list bar to see if any list entry has a leaf “fooref” with value 42.

Flow


1- show operational list data with filters.
NSO
1. Gets the request and validates the syntax.
Schema
2. Looks for DP registrations.
3. Start talking to DP to get the data.
4. If the data is not filtered and the flag CONFD_TRANS_CB_FLAG_FILTERED was set, NSO will show unfiltered data.
3- returns data
2- get_next() with a filter
3- returns filtered data
Data Provider
1. Extracts the filter information during the first call to get_next().
2. Provides data to NSO, verifying the filter.
3. Instructs NSO not to filter, as the data is already filtered, using the flag: CONFD_TRANS_CB_FLAG_FILTERED
4. Next calls to get_next(), or other CBs, won't have the filter information.
5. The filter information can be preserved across call backs using the transaction opaque field.

Filter syntax

```
<expr> = <expr> 'or' <expr>
       / <expr> 'and' <expr>
       / 'not' <expr>
       / 'cmp' <op> <node> <value>
       / 'exec' <func> <node> <value>
       / 'exists' <node>

<op> = 'eq' / 'gt' / 'lt' / 'gte' / 'lte' / 'neq'

<func> = 're-match' / 'starts-with'
       / 'derived-from' / 'derived-from-or-self'

<node> = "array of tags (points to a leaf or leaf-list)"
```

Performance

Operation	Regular	With filters	Ratio
Validate leaf-ref list of 10,000	22 s	1.5 s	14.7

Supported in 5.2

- Implemented in data providers
- Used between LSA nodes in cluster
- NETCONF NED live-status

Not yet implemented

- CLI and Generic NED live-status