List Pagination Mechanisms
for NETCONF and RESTCONF

draft-wwlh-netconf-list-pagination-00
draft-wwlh-netconf-list-pagination-nc-02
draft-wwlh-netconf-list-pagination-rc-02

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Recap

- Motivation and Goal:
  - To better support user-facing client interfaces to retrieve large number of entries from lists or leaf-lists.
    - Applicable to both config data and state data.
    - Examples: traffic logs, interfaces, ACLs, etc.

  - Server-side processing reduces latency, bandwidth, and client-resources.

  - Enables servers to leverage "indexes" maintained by their backend storage system

- Originally presented in IETF 109
  - 50+ number of msgs on RESTCONF Collection problem
  - List Pagination design team was set up.

List Pagination Acronyms

- **List Pagination (LP):**

  - A standard mechanisms to control the filtering, sorting, and retrieval of entries of list or leaf-list.

- **NETCONF List Pagination (LP-NC):**

  - NETCONF Extensions to Support List Pagination

- **RESTCONF List Pagination (LP-RC):**
  - RESTCONF Extensions to Support List Pagination

Since IETF 109

- **List Pagination (v00)**

  - Factored out from the "list-pagination-nc" and the "list-pagination-rc" drafts.

  - Renamed "count" and "skip" parameters into "limit" and "offset".

  - General definitions

    - Five query parameters for list pagination.
    - One query parameter for descendant list pagination.
    - Per schema-node tags on server 'list pagination' capability constraints.

  - Appendix contains example YANG module, data set, and queries.

Since IETF 109

- **List Pagination for NETCONF**

  - Change from new RPC "get-pageable-list" **to** augmenting three NETCONF "rpc" statements: get, get-config, and get-data.

  - Use grouping factored out from ietf-list-pagination in ietf-list-pagination-nc.

  - Provide example of list pagination with all query parameters in LP NC draft.

- **List Pagination for RESTCONF**

  - Align query parameters for RC with 6 query parameters for list pagination draft.

  - Declaring "list" and "leaf-list" as valid resource targets for the GET operation and optionally for the DELETE operation if needed.

  - Remove YANG module for LP RC.

draft-wwlh-netconf-list-pagination-00

List or Leaf-list Pagination

- **Query Parameters:**

Query Parameters	Target Data object	Description
where	List or leaf-list	Filter expression for result set entries to match
Sort-by	List or leaf-list	Node to sort result set entries
Direction	List or leaf-list	The direction of result set entries to be returned
Offset	List or leaf-list	The number of entries to be skiped in the result set
Limit	List or leaf-list	The number of entries returned
Sublist-limit	Descendant List or leaf-list	The number of entries returned For descendant list or leaf-list, the target can be any node or a datastore

- **Server Processing order :**

Where > Sort-by > Direction > Offset> Limit.

- **MetaData attribute - remaining:**

  - Used together with limit or sublimit.
  - Return the number of entries not included due to the limit operation.

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List or Leaf-list Pagination Example

Combination of 6 query parameters used in the Request/Response message pair to guide how list or leaf-list should be returned

```
REQUEST

    Datastore: <operational>
    Target: /example-social:members/member
    Sublist-limit: 1
    Pagination Parameters:
      Where:    //stats//joined[starts-with(@timestamp,'2020')]
      Sort-by:  member-id
      Direction: backwards
      Offset:   2
      Limit:    2
```

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```
RESPONSE

{
  "example-social:member": [
    {
      "@": {
        "ietf-list-pagination:remaining": "1"
      },
      "member-id": "eric",
      "email-address": "eric@example.com",
      "password": "$0$1543",
      "avatar": "BASE64VALUE=",
      "tagline": "Go to bed with dreams; wake up with a purpose.",
      "following": ["alice"],
      "posts": {
        "post": [
          {
            "timestamp": "2020-09-17T18:02:04Z",
            "title": "Son, brother, husband, father",
            "body": "What's your story?"
          }
        ]
      },
      "favorites": {
        "bits": ["two"],
        "@bits": [
          {
            "ietf-list-pagination:remaining": "2"
          }
        ]
      },
      "stats": {
        "joined": "2020-09-17T19:38:32Z",
        "membership-level": "pro",
        "last-activity": "2020-09-17T18:02:04Z"
      }
    },
    {
      "member-id": "bob",
      "email-address": "bob@example.com",
      "password": "$0$1543",
      "avatar": "BASE64VALUE=",
      "tagline": "Here and now, like never before.",
      "posts": {
        "post": [
          {
            "@": {
              "ietf-list-pagination:remaining": "2"
            },
            "timestamp": "2020-08-14T03:32:25Z",
            "body": "Just got in."
          }
        ]
      },
      "favorites": {
        "decimal64-numbers": ["3.14159"],
        "@decimal64-numbers": [
          {
            "ietf-list-pagination:remaining": "1"
          }
        ]
      },
      "stats": {
        "joined": "2020-08-14T03:30:00Z",
        "membership-level": "standard",
        "last-activity": "2020-08-14T03:34:30Z"
      }
    }
  ]
}
```

Descendant List or Leaf-list pagination
'Remaining' Usage Examples

Example1: Target node: '/example-social:members/
member=alice' in the <intended> datastore.

Example2: Target node: <intended> datastore

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A.3.6.2 of draft-wwlh-netconf-list-pagination

Server List Pagination Capability Discovery

- Constraints parameters Defintion:
  - o Constrained: indicate which "config false" list and/or "leaf-list" nodes are constrained.

  - o Indexed: and, if so, which nodes may be used in "where" and "sort-by" expressions.

- Constraints parameters Extensibility:
  - o There may be other constraints that need to be added in this module, e.g., not supporting 100% of the XPath 1.0 syntax or derived-from()and derived-from-or-self() not supported.

```
module: ietf-list-pagination

  augment /sysc:system-capabilities/sysc:datastore-capabilities
             /sysc:per-node-capabilities:
    +--ro constrained?    empty
    +--ro indexed?        empty
```

```
<system-capabilities
  xmlns="urn:ietf:params:xml:ns:yang:ietf-system-capabilities"
  xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores"
  xmlns:es="http://example.com/ns/example-social"
  xmlns:lpg="urn:ietf:params:xml:ns:yang:ietf-list-pagination">
  <datastore-capabilities>
    <datastore>ds:operational</datastore>
    <per-node-capabilities>
      <node-selector>/es:audit-logs/es:audit-log</node-selector>
      <lpg:constrained/>
    </per-node-capabilities>
    <per-node-capabilities>
      <node-selector>/es:audit-logs/es:audit-log/es:timestamp</node-\
selector>
      <lpg:indexed/>
    </per-node-capabilities>
    <per-node-capabilities>
      <node-selector>/es:audit-logs/es:audit-log/es:member-id</node-\
selector>
      <lpg:indexed/>
    </per-node-capabilities>
    <per-node-capabilities>
      <node-selector>/es:audit-logs/es:audit-log/es:outcome</node-se\
lector>
      <lpg:indexed/>
    </per-node-capabilities>
  </datastore-capabilities>
</system-capabilities>
```

Section 4.2.1 of draft-wwlh-netconf-list-pagination

draft-wwlh-netconf-list-pagination-nc-02

LP NC Protocol Extension

Augment 3 NETCONF RPC statement <get>,<getconfig>,<get-data>.
Aligned with LP draft for query parameters.

```
module: ietf-list-pagination-nc

  augment /nc:get/nc:input:
    +---w list-pagination
        +---w where?              union
        +---w sort-by?            union
        +---w direction?          enumeration
        +---w offset?             uint32
        +---w limit?              union
        +---w sublist-limit?      union
  augment /nc:get-config/nc:input:
    +---w list-pagination
        +---w where?              union
        +---w sort-by?            union
        +---w direction?          enumeration
        +---w offset?             uint32
        +---w limit?              union
        +---w sublist-limit?      union
  augment /ncds:get-data/ncds:input:
    +---w list-pagination
        +---w where?              union
        +---w sort-by?            union
        +---w direction?          enumeration
        +---w offset?             uint32
        +---w limit?              union
        +---w sublist-limit?      union
```

LP NC Protocol Extension

List Pagination NC with all parameters
in the Request/Response message pair.

```
<rpc xmlns="urn:ietf:params:xml:ns:netconf:base:1.0" message-id="42">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="xpath" select="/es:members/es:member"
      xmlns:es="http://example.com/ns/example-social"/>
      <list-pagination
        xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-list-paginat\
ion">true</list-pagination>
      <where>//stats//joined[starts-with(@timestamp,'2020')]</where>
      <sort-by>timestamp</sort-by>
      <direction>backwards</direction>
      <offset>2</offset>
      <limit>2</limit>
      <sublist-limit>1</sublist-limit>
    </filter>
  </get-config>
</rpc>
```

Response from the NETCONF server:

```
=============== NOTE: '\' line wrapping per RFC 8792 ================

<lp:xml-list xmlns:lp="urn:ietf:params:xml:ns:yang:ietf-restconf-lis\
t-pagination"
  xmlns="http://example.com/ns/example-social">
  <member lp:remaining="1">
    <member-id>eric</member-id>
    <email-address>eric@example.com</email-address>
    <password>$0$1543</password>
    <avatar>BASE64VALUE=</avatar>
    <tagline>Go to bed with dreams; wake up with a purpose.</tagline>
    <following>alice</following>
    <posts>
      <post>
        <timestamp>2020-09-17T18:02:04Z</timestamp>
        <title>Son, brother, husband, father</title>
        <body>What's your story?</body>
      </post>
    </posts>
    <favorites>
      <bits lp:remaining="2">two</bits>
    </favorites>
    <stats>
      <joined>2020-09-17T19:38:32Z</joined>
      <membership-level>pro</membership-level>
      <last-activity>2020-09-17T18:02:04Z</last-activity>
    </stats>
  </member>
  <member lp:remaining="1">
    <member-id>bob</member-id>
    <email-address>bob@example.com</email-address>
    <password>$0$1543</password>
    <avatar>BASE64VALUE=</avatar>
    <tagline>Here and now, like never before.</tagline>
    <posts>
      <post lp:remaining="2">
        <timestamp>2020-08-14T03:32:25Z</timestamp>
        <body>Just got in.</body>
      </post>
    </posts>
    <favorites>
      <decimal64-numbers lp:remaining="1">3.14159</bits>
    </favorites>
    <stats>
      <joined>2020-08-14T03:30:00Z</joined>
      <membership-level>standard</membership-level>
      <last-activity>2020-08-14T03:34:30Z</last-activity>
    </stats>
  </member>
</lp:xml-list>
```

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Update RESTCONF to Support List Pagination

3 Protocol Extensions:
1. Add list and leaf-list as valid resource target for the GET and DELETE operations.
2. Add new media type "application/yang-data+xml-list".
3. Add 6 new query parameters "limit", "offset", "direction", "sort", "where", and "sublist-limit".

```
+-----------+----------+----------------------------------------+
| Name      | Methods  | Description                            |
+-----------+----------+----------------------------------------+
| limit     | GET,     | Limits the number of entries returned. |
|           | HEAD     | If not specified, the number of entries|
|           |          | that may be returned is unbounded.     |
|           |          |                                        |
| offset    | GET,     | Indicates the number of entries in the |
|           | HEAD     | result set that should the skipped over|
|           |          | when preparing the response.  If not   |
|           |          | specified, then no entries in the      |
|           |          | result set are skipped.                |
|           |          |                                        |
| direction | GET,     | Indicates the direction that the result|
|           | HEAD     | set is to be traversed.  If not        |
|           |          | specified, then the result set is      |
|           |          | traversed in the "forwards" direction. |
|           |          |                                        |
| sort-by   | GET,     | Indicates the node name that the result|
|           | HEAD     | set should be sorted by.  If not       |
|           |          | specified, then the result set's       |
|           |          | default order is used, per YANG's      |
|           |          | "ordered-by" statement.                |
|           |          |                                        |
| where     | GET,     | Specifies a filter expression that     |
|           | HEAD     | result set entries must match.  If     |
|           |          | not specified, then no entries are     |
|           |          | filtered from the result set.          |
|           |          |                                        |
| sublist-  | GET,     | Limits the number of entries returned  |
|   limit   | HEAD     | returned for descendent lists and      |
|           |          | leaf-lists. If not specified, the      |
|           |          | number of entries that may be returned |
|           |          | is unbounded.                          |
+-----------+----------+----------------------------------------+
```

Deletion of a list

```
DELETE /restconf/ds/ietf-datastores:running/example-social:members/m\
ember=bob/favorites/decimal64-numbers HTTP/1.1
Host: example.com
Accept: application/yang-data+xml

Response from the RESTCONF server:

HTTP/1.1 204 No Content
Date: Thu, 26 Jan 2017 20:56:30 GMT
Server: example-server
```

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Open Issue 1: Cursors support

- For server w/ cursor support:

    - Enable the paging to continue over the snapshot, despite the dataset changing.
    - The client assumes the list doesn't change??

- For server w/o cursor or snapshot support:

    - Might return larger remaining value than previous fetch during refetching page in a time series log (where logs are appended).

- For config, many systems have an internal reader/writer mutex, so a cursor would never be needed

    - Etags/Timestamps can be used to detect dynamic list change.

    - The error message is used to indicate the end of the list.

- Question: Do we have a compelling use case for this?

Open Issue 2: Zero vs Unknown

- The 'remaining 'annotation is used to return the number of elements not included in a result set after a 'limit' or 'sublist-limit' operation.

- The current draft states that:

  "If no elements were removed, this
  annotation MUST NOT appear.
  The minimum value (0), which
  never occurs in normal operation, is
  reserved to represent 'unknown'. "

- But one best practice proposed by one of design team members is:

  - No more entries ---> Return zero
  - Unknown   ---> Not return the "remaining" annotation at all

- Comments and suggestions?

```
md:annotation remaining {
  type union {
    type uint32;
    type enumeration {
      enum "unknown" {
        description
          "Indicates that number of remaining entries is unknown
           to the server in case, e.g., the server has determined
           that counting would be prohibitively expensive.";
      }
    }
  }
  description
    "This annotation contains the number of elements not included
     in the result set (a positive value) due to a 'limit' or
     'sublist-limit' operation.  If no elements were removed,
     this annotation MUST NOT appear.  The minimum value (0),
     which never occurs in normal operation, is reserved to
     represent 'unknown'.  The maximum value (2^32-1) is
     reserved to represent any value greater than or equal
     to 2^32-1 elements.";
}
```

Next Step

- Two-partial implementations are underway
    - One from Kent;
    - The other from Olof.

- Questions, comments?

Thank You