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Partial Lock Remote Procedure Call (RPC) for NETCONF

Abstract

The Network Configuration protocol (NETCONF) defines the lock and unlock Remote Procedure Calls (RPCs), used to lock entire configuration datastores. In some situations, a way to lock only parts of a configuration datastore is required. This document defines a capability-based extension to the NETCONF protocol for locking portions of a configuration datastore.

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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1. Introduction

The [NETCONF] protocol describes the lock and unlock operations that operate on entire configuration datastores. Often, multiple management sessions need to be able to modify the configuration of a managed device in parallel. In these cases, locking only parts of a configuration datastore is needed. This document defines a capability-based extension to the NETCONF protocol to support partial locking of the NETCONF running datastore using a mechanism based on the existing XPath filtering mechanisms.

1.1. Definition of Terms

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, [RFC2119].

Additionally, the following terms are defined:

- o Instance Identifier: an XPath expression identifying a specific node in the conceptual XML datastore. It contains an absolute path expression in abbreviated syntax, where predicates are used only to specify values for nodes defined as keys to distinguish multiple instances.
- o Scope of the lock: initially, the set of nodes returned by the XPath expressions in a successful partial-lock operation. The set might be modified if some of the nodes are deleted by the session owning the lock.
- o Protected area: the set of nodes that are protected from modification by the lock. This set consists of nodes in the scope of the lock and nodes in subtrees under them.

2. Partial Locking Capability

2.1. Overview

The :partial-lock capability indicates that the device supports the locking of its configuration with a more limited scope than a complete configuration datastore. The scope to be locked is specified by using restricted or full XPath expressions. Partial locking only affects configuration data and only the running datastore. The candidate or the start-up datastore are not affected.

The system MUST ensure that configuration resources covered by the lock are not modified by other NETCONF or non-NETCONF management operations such as Simple Network Management Protocol (SNMP) and the Command Line Interface (CLI).

The duration of the partial lock begins when the partial lock is granted and lasts until (1) either the corresponding <partial-unlock> operation succeeds or (2) the NETCONF session terminates.

A NETCONF session MAY have multiple parts of the running datastore locked using partial lock operations.

The <partial-lock> operation returns a lock-id to identify each successfully acquired lock. The lock-id is unique at any given time for a NETCONF server for all partial-locks granted to any NETCONF or non-NETCONF sessions.

2.1.1. Usage Scenarios

In the following, we describe a few scenarios for partial locking. Besides the two described here, there are many other usage scenarios possible.

2.1.1.1. Multiple Managers Handling the Writable Running Datastore with Overlapping Sections

Multiple managers are handling the same NETCONF agent simultaneously. The agent is handled via the writable running datastore. Each manager has his or her own task, which might involve the modification of overlapping sections of the datastore.

After collecting and analyzing input and preparing the NETCONF operations off-line, the manager locks the areas that are important for his task using one single <partial-lock> operation. The manager executes a number of <edit-config> operations to modify the configuration, then releases the partial-lock. The lock should be held for the shortest possible time (e.g., seconds rather than minutes). The manager should collect all human input before locking anything. As each manager locks only a part of the data model, usually multiple operators can execute the <edit-config> operations simultaneously.

2.1.1.2. Multiple Managers Handling the Writable Running Datastore, Distinct Management Areas

Multiple managers are handling the same NETCONF agent simultaneously. The agent is handled via the writable running datastore. The agent's data model contains a number of well-defined separate areas that can be configured without impacting other areas. An example can be a server with multiple applications running on it, or a number of network elements with a common NETCONF agent for management.

Each manager has his or her own task, which does not involve the modification of overlapping sections of the datastore.

The manager locks his area with a <partial-lock> operation, uses a number of <edit-config> commands to modify it, and later releases the lock. As each manager has his functional area assigned to him, and he locks only that area, multiple managers can edit the configuration simultaneously. Locks can be held for extended periods (e.g., minutes, hours), as this will not hinder other managers.

This scenario assumes that the global lock operation from [NETCONF] is not used.

2.2. Dependencies

The device MUST support restricted XPath expressions in the select element, as described in Section 2.4.1. Optionally, if the :xpath capability is also supported (as defined in [NETCONF], Section 8.9. "XPath Capability"), the device MUST also support using any XPath 1.0 expression in the select element.

2.3. Capability Identifier

urn:ietf:params:netconf:capability:partial-lock:1.0

2.4. New Operations

2.4.1. <partial-lock>

The <partial-lock> operation allows the client to lock a portion of the running datastore. The portion to lock is specified with XPath expressions in the "select" elements in the <partial-lock> operation. Each XPath expression MUST return a node set.

When a NETCONF session holds a lock on a node, no other session or non-NETCONF mechanism of the system can change that node or any node in the hierarchy of nodes beneath it.

Locking a node protects the node itself and the complete subtree under the node from modification by others. The set of locked nodes is called the scope of the lock, while all the locked nodes and the nodes in the subtrees under them make up the protected area.

The XPath expressions are evaluated only once: at lock time. Thereafter, the scope of the lock is maintained as a set of nodes, i.e., the returned nodeset, and not by the XPath expression. If the configuration data is later altered in a way that would make the original XPath expressions evaluate to a different set of nodes, this does not affect the scope of the partial lock.

Let's say the agent's data model includes a list of interface nodes. If the XPath expression in the partial-lock operation covers all interface nodes at locking, the scope of the lock will be maintained as the list of interface nodes at the time when the lock was granted. If someone later creates a new interface, this new interface will not be included in the locked-nodes list created previously so the new interface will not be locked.

A <partial-lock> operation MUST be handled atomically by the NETCONF server. The server either locks all requested parts of the datastore or none. If during the <partial-lock> operation one of the requested parts cannot be locked, the server MUST unlock all parts that have already been locked during that operation.

If a node in the scope of the lock is deleted by the session owning the lock, it is removed from the scope of the lock, so any other session or non-NETCONF mechanism can recreate it. If all nodes in the scope of the lock are deleted, the lock will still be present. However, its scope will become empty (since the lock will not cover any nodes).

A NETCONF server that supports partial locking MUST be able to grant multiple simultaneous partial locks to a single NETCONF session. If the protected area of the individual locks overlap, nodes in the common area MUST be protected until all of the overlapping locks are released.

A <partial-lock> operation MUST fail if:

- o Any NETCONF session (including the current session) owns the global lock on the running datastore.
- o Any part of the area to be protected is already locked (or protected by partial locking) by another management session, including other NETCONF sessions using <partial-lock> or any other non-NETCONF management method.

- o The requesting user is not successfully authenticated.
- o The NETCONF server implements access control and the locking user does not have sufficient access rights. The exact handling of access rights is outside the scope of this document, but it is assumed that there is an access control system that MAY deny or allow the <partial-lock> operation.

The <partial-lock> operation is designed for simplicity, so when a partial lock is executed, you get what you asked for: a set of nodes that are locked for writing.

As a consequence, users must observe the following:

- o Locking does not affect read operations.
- o If part of the running datastore is locked, this has no effect on any unlocked parts of the datastore. If this is a problem (e.g., changes depend on data values or nodes outside the protected part of the datastore), these nodes SHOULD be included in the protected area of the lock.
- o Configuration data can be edited both inside and outside the protected area of a lock. It is the responsibility of the NETCONF client application to lock all relevant parts of the datastore that are crucial for a specific management action.

Note: The <partial-lock> operation does not modify the global <lock> operation defined in the base NETCONF protocol [NETCONF]. If part of the running datastore is already locked by <partial-lock>, then a global lock for the running datastore MUST fail even if the global lock is requested by the NETCONF session that owns the partial lock.

2.4.1.1. Parameters, Results, Examples

Parameters:

select: One or more 'select' elements, each containing an XPath expression. The XPath expression is evaluated in a context where the context node is the root of the server's conceptual data model, and the set of namespace declarations are those in scope on the select element.

The nodes returned from the select expressions are reported in the rpc-reply message.

Each select expression MUST return a node set, and at least one of the node sets MUST be non-empty.

If the device supports the `:xpath` capability, any valid XPath 1.0 expression can be used. If the device does not support the `:xpath` capability, the XPath expression MUST be limited to an Instance Identifier expression. An Instance Identifier is an absolute path expression in abbreviated syntax, where predicates are used only to specify values for nodes defined as keys to distinguish multiple instances.

Example: Lock virtual router 1 and interface eth1

```
<nc:rpc
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  message-id="135">
  <partial-lock>
    <select xmlns:rte="http://example.com/ns/route">
      /rte:routing/rte:virtualRouter[rte:routerName='router1']
    </select>
    <select xmlns:if="http://example.com/ns/interface">
      /if:interfaces/if:interface[if:id='eth1']
    </select>
  </partial-lock>
</nc:rpc>
```

```
<nc:rpc-reply
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  message-id="135">
  <lock-id>127</lock-id>
  <locked-node xmlns:rte="http://example.com/ns/route">
    /rte:routing/rte:virtualRouter[rte:routerName='router1']
  </locked-node>
  <locked-node xmlns:if="http://example.com/ns/interface">
    /if:interfaces/if:interface[if:id='eth1']
  </locked-node>
</nc:rpc-reply>
```

Note: The XML Schema in [NETCONF] has a known bug that requires the `<data>` XML element in a `<rpc-reply>`. This means that the above examples will not validate using the XML Schema found in [NETCONF].

Positive Response:

If the device was able to satisfy the request, an `<rpc-reply>` is sent with a `<lock-id>` element (lock identifier) in the `<rpc-reply>` element. A list of locked nodes is also returned in Instance Identifier format.

Negative Response:

If any select expression is an invalid XPath expression, the <error-tag> is 'invalid-value'.

If any select expression returns something other than a node set, the <error-tag> is 'invalid-value', and the <error-app-tag> is 'not-a-node-set'.

If all the select expressions return an empty node set, the <error-tag> is 'operation-failed', and the <error-app-tag> is 'no-matches'.

If the :xpath capability is not supported and the XPath expression is not an Instance Identifier, the <error-tag> is 'invalid-value', the <error-app-tag> is 'invalid-lock-specification'.

If access control denies the partial lock, the <error-tag> is 'access-denied'. Access control SHOULD be checked before checking for conflicting locks to avoid giving out information about other sessions to an unauthorized client.

If a lock is already held by another session on any node within the subtrees to be locked, the <error-tag> element is 'lock-denied' and the <error-info> element includes the <session-id> of the lock owner. If the lock is held by a non-NETCONF session, a <session-id> of 0 (zero) SHOULD be included. The same error response is returned if the requesting session already holds the (global) lock for the running datastore.

If needed, the returned session-id may be used to <kill-session> the NETCONF session holding the lock.

2.4.1.2. Deadlock Avoidance

As with most locking systems, it is possible that two management sessions trying to lock different parts of the configuration could become deadlocked. To avoid this situation, clients SHOULD lock everything they need in one operation. If locking fails, the client MUST back-off, release any previously acquired locks, and SHOULD retry the procedure after waiting some randomized time interval.

2.4.2. <partial-unlock>

The operation unlocks the parts of the running datastore that were previously locked using <partial-lock> during the same session. The operation unlocks the parts that are covered by the lock identified by the lock-id parameter. In case of multiple potentially overlapping locks, only the lock identified by the lock-id is removed.

Parameters:

lock-id: Identity of the lock to be unlocked. This lock-id MUST have been received as a response to a lock request by the manager during the current session, and MUST NOT have been sent in a previous unlock request.

Example: Unlock a previously created lock

```
<nc:rpc xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  message-id="136">
  <partial-unlock>
    <lock-id>127</lock-id>
  </partial-unlock>
</nc:rpc>
```

Positive Response:

If the device was able to satisfy the request, an <rpc-reply> is sent that contains an <ok> element. A positive response MUST be sent even if all of the locked parts of the datastore have already been deleted.

Negative Response:

If the <lock-id> parameter does not identify a lock that is owned by the session, an 'invalid-value' error is returned.

2.5. Modifications to Existing Operations

A successful partial lock will cause a subsequent operation to fail if that operation attempts to modify nodes in the protected area of the lock and is executed in a NETCONF session other than the session that has been granted the lock. The <error-tag> 'in-use' and the <error-app-tag> 'locked' is returned. All operations that modify the

running datastore are affected, including: `<edit-config>`, `<copy-config>`, `<delete-config>`, `<commit>`, and `<discard-changes>`. If partial lock prevents `<edit-config>` from modifying some data, but the operation includes the `continue-on-error` option, modification of other parts of the datastore, which are not protected by partial locking, might still succeed.

If the datastore contains nodes locked by partial lock, this will cause the (global) `<lock>` operation to fail. The `<error-tag>` element `'lock-denied'` and an `<error-info>` element including the `<session-id>` of the lock owner will be returned. If the lock is held by a non-NETCONF session, a `<session-id>` of 0 (zero) is returned.

All of these operations are affected only if they are targeting the running datastore.

2.6. Interactions with Other Capabilities

2.6.1. Candidate Configuration Capability

The candidate datastore cannot be locked using the `<partial-lock>` operation.

2.6.2. Confirmed Commit Capability

If:

- o a partial lock is requested for the running datastore, and
- o the NETCONF server implements the `:confirmed-commit` capability, and
- o there was a recent confirmed `<commit>` operation where the confirming `<commit>` operation has not been received

then the lock MUST be denied, because if the confirmation does not arrive, the running datastore MUST be rolled back to its state before the commit. The NETCONF server might therefore need to modify the configuration.

In this case, the `<error-tag>` `'in-use'` and the `<error-app-tag>` `'outstanding-confirmed-commit'` is returned.

2.6.3. Distinct Startup Capability

The startup datastore cannot be locked using the `<partial-lock>` operation.

3. Security Considerations

The same considerations are relevant as for the base NETCONF protocol [NETCONF]. <partial-lock> and <partial-unlock> RPCs MUST only be allowed for an authenticated user. <partial-lock> and <partial-unlock> RPCs SHOULD only be allowed for an authorized user. However, as NETCONF access control is not standardized and not a mandatory part of a NETCONF implementation, it is strongly recommended, but OPTIONAL (although nearly all implementations include some kind of access control).

A lock (either a partial lock or a global lock) might prevent other users from configuring the system. The following mechanisms are in place to prevent the misuse of this possibility:

A user, that is not successfully authenticated, MUST NOT be granted a partial lock.

Only an authorized user SHOULD be able to request a partial lock.

The partial lock is automatically released when a session is terminated regardless of how the session ends.

The <kill-session> operation makes it possible to terminate other users' sessions.

The NETCONF server MAY log partial lock requests in an audit trail.

A lock that is hung for some reason (e.g., a broken TCP connection that the server has not yet recognized) can be released using another NETCONF session by explicitly killing the session owning that lock using the <kill-session> operation.

Partial locking is not an authorization mechanism; it SHOULD NOT be used to provide security or access control. Partial locking SHOULD only be used as a mechanism for providing consistency when multiple managers are trying to configure the node. It is vital that users easily understand the exact scope of a lock. This is why the scope is determined when granting a lock and is not modified thereafter.

4. IANA Considerations

This document registers one capability identifier URN from the "Network Configuration Protocol (NETCONF) Capability URNs" registry, and one URI for the NETCONF XML namespace in the "IETF XML registry" [RFC3688]. Note that the capability URN is compliant to [NETCONF], Section 10.3.

Index	Capability Identifier
:partial-lock	urn:ietf:params:netconf:capability:partial-lock:1.0

URI: urn:ietf:params:xml:ns:netconf:partial-lock:1.0

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

5. Acknowledgements

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6. References

6.1. Normative References

- [NETCONF] Enns, R., "NETCONF Configuration Protocol", RFC 4741, December 2006.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, January 2004.

6.2. Informative References

- [YANG] Bjorklund, M., "YANG - A data modeling language for NETCONF", Work in Progress, December 2009.

Appendix A. XML Schema for Partial Locking (Normative)

The following XML Schema defines the <partial-lock> and <partial-unlock> operations:

<CODE BEGINS>

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  targetNamespace="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  elementFormDefault="qualified" attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:documentation>
      Schema defining the partial-lock and unlock operations.
      organization "IETF NETCONF Working Group"

      contact
      Netconf Working Group
      Mailing list: netconf@ietf.org
      Web: http://www.ietf.org/html.charters/netconf-charter.html

      Balazs Lengyel
      balazs.lengyel@ericsson.com

      revision 2009-10-19
      description Initial version, published as RFC 5717.
    </xs:documentation>
  </xs:annotation>

  <xs:import namespace="urn:ietf:params:xml:ns:netconf:base:1.0"
    schemaLocation="urn:ietf:params:xml:ns:netconf:base:1.0"/>

  <xs:simpleType name="lock-id-type">
    <xs:annotation>
      <xs:documentation>
        A number identifying a specific
        partial-lock granted to a session.
        It is allocated by the system, and SHOULD
        be used in the unlock operation.
      </xs:documentation>
    </xs:annotation>
    <xs:restriction base="xs:unsignedInt"/>
  </xs:simpleType>
```

```
<xs:complexType name="partialLockType">
  <xs:annotation>
    <xs:documentation>
      A NETCONF operation that locks parts of
      the running datastore.
    </xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="nc:rpcOperationType">
      <xs:sequence>
        <xs:element name="select" type="xs:string"
          maxOccurs="unbounded">
          <xs:annotation>
            <xs:documentation>
              XPath expression that specifies the scope
              of the lock. An Instance Identifier
              expression must be used unless the :xpath
              capability is supported in which case any
              XPath 1.0 expression is allowed.
            </xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>

<xs:complexType name="partialUnLockType">
  <xs:annotation>
    <xs:documentation>
      A NETCONF operation that releases a previously acquired
      partial-lock.
    </xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="nc:rpcOperationType">
      <xs:sequence>
        <xs:element name="lock-id" type="lock-id-type">
          <xs:annotation>
            <xs:documentation>
              Identifies the lock to be released. MUST
              be the value received in the response to
              the partial-lock operation.
            </xs:documentation>
          </xs:annotation>
        </xs:element>
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```

```
    </xs:complexContent>
  </xs:complexType>

  <!-- <partial-lock> operation -->
  <xs:element name="partial-lock" type="partialLockType"
    substitutionGroup="nc:rpcOperation"/>

  <!-- <partial-unlock> operation -->
  <xs:element name="partial-unlock" type="partialUnLockType"
    substitutionGroup="nc:rpcOperation"/>

  <!-- reply to <partial-lock> -->

  <xs:complexType name="contentPartInPartialLockReplyType">
    <xs:annotation>
      <xs:documentation>
        The content of the reply to a successful
        partial-lock request MUST conform to this complex type.
      </xs:documentation>
    </xs:annotation>
    <xs:sequence>
      <xs:element name="lock-id" type="lock-id-type">
        <xs:annotation>
          <xs:documentation>
            Identifies the lock to be released. Must be the value
            received in the response to a partial-lock operation.
          </xs:documentation>
        </xs:annotation>
      </xs:element>
      <xs:element name="locked-node" type="xs:string"
        maxOccurs="unbounded">
        <xs:annotation>
          <xs:documentation>
            List of locked nodes in the running datastore.
          </xs:documentation>
        </xs:annotation>
      </xs:element>
    </xs:sequence>
  </xs:complexType>
</xs:schema>

<CODE ENDS>
```


Appendix B. YANG Module for Partial Locking (Non-Normative)

The following YANG module defines the <partial-lock> and <partial-unlock> operations. The YANG language is defined in [YANG].

<CODE BEGINS>

```
module ietf-netconf-partial-lock {

  namespace urn:ietf:params:xml:ns:netconf:partial-lock:1.0;
  prefix pl;

  organization "IETF Network Configuration (netconf) Working Group";

  contact
    "Netconf Working Group
    Mailing list: netconf@ietf.org
    Web: http://www.ietf.org/html.charters/netconf-charter.html

    Balazs Lengyel
    Ericsson
    balazs.lengyel@ericsson.com";

  description
    "This YANG module defines the <partial-lock> and
    <partial-unlock> operations.";

  revision 2009-10-19 {
    description
      "Initial version, published as RFC 5717.";
  }

  typedef lock-id-type {
    type uint32;
    description
      "A number identifying a specific partial-lock granted to a session.
      It is allocated by the system, and SHOULD be used in the
      partial-unlock operation.";
  }

  rpc partial-lock {
    description
      "A NETCONF operation that locks parts of the running datastore.";
    input {
      leaf-list select {
        type string;
        min-elements 1;
        description

```

```
    "XPath expression that specifies the scope of the lock.
    An Instance Identifier expression MUST be used unless the
    :xpath capability is supported, in which case any XPath 1.0
    expression is allowed.";
  }
}
output {
  leaf lock-id {
    type lock-id-type;
    description
      "Identifies the lock, if granted. The lock-id SHOULD be
      used in the partial-unlock rpc.";
  }
  leaf-list locked-node {
    type instance-identifier;
    min-elements 1;
    description
      "List of locked nodes in the running datastore";
  }
}
}
}
rpc partial-unlock {
  description
    "A NETCONF operation that releases a previously acquired
    partial-lock.";
  input {
    leaf lock-id {
      type lock-id-type;
      description
        "Identifies the lock to be released. MUST be the value
        received in the response to a partial-lock operation.";
    }
  }
}
}
```

<CODE ENDS>

Appendix C. Usage Example - Reserving Nodes for Future Editing (Non-Normative)

Partial lock cannot be used to lock non-existent nodes, which would effectively attempt to reserve them for future use. To guarantee that a node cannot be created by some other session, the parent node should be locked, the top-level node of the new subtree created, and then locked with another <partial-lock> operation. After this, the lock on the parent node should be removed.

In this section, an example illustrating the above is given.

We want to create <user> Joe under <users>, and start editing it. Editing might take a number of minutes. We want to immediately lock Joe so no one will touch it before we are finished with the editing.

We also want to minimize locking other parts of the running datastore as multiple managers might be adding users near simultaneously.

First, we check what users are already defined.

Step 1 - Read existing users

```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <source>
      <running/>
    </source>
    <filter type="subtree">
      <top xmlns="http://example.com/users">
        <users/>
      </top>
    </filter>
  </get-config>
</rpc>
```

The NETCONF server sends the following reply.

Step 2 - Receiving existing data

```
<rpc-reply message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <top xmlns="http://example.com/users">
      <users>
        <user>
          <name>fred</name>
          <phone>8327</phone>
        </user>
      </users>
    </top>
  </data>
</rpc-reply>
```

We want to add the new user Joe and immediately lock him using partial locking. The way to do this, is to first lock all <user> nodes by locking the <users> node.

Note that if we would lock all the <user> nodes using the select expression '/usr:top/usr:users/usr:user'; this would not lock the new user Joe, which we will create after locking. So we rather have to lock the <users> node.

Step 3 - Lock users

```
<nc:rpc
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  message-id="102">
  <partial-lock>
    <select xmlns:usr="http://example.com/users">
      /usr:top/usr:users
    </select>
  </partial-lock>
</nc:rpc>
```

The NETCONF server grants the partial lock. The scope of the lock includes only the <users> node. The lock protects the <users> node and all <user> nodes below it from modification (by other sessions).

Step 4 - Receive lock

```
<nc:rpc-reply
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  message-id="102">
  <lock-id>1</lock-id>
  <locked-node xmlns:usr="http://example.com/users">
    /usr:top/usr:users
  </locked-node>
</nc:rpc-reply>
```

Next we create user Joe. Joe is protected by the lock received above, as it is under the subtree rooted at the <users> node.

Step 5 - Create user Joe

```
<rpc message-id="103"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <top xmlns:usr="http://example.com/users">
        <users>
          <user>
            <name>Joe</name>
          </user>
        </users>
      </top>
    </config>
  </edit-config>
</rpc>
```

We receive a positive reply to the <edit-config> (not shown). Next we request a lock, that locks only <user> Joe, and release the lock on the <users> node. This will allow other managers to create additional new users.

Step 6 - Lock user Joe

```
<nc:rpc
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  message-id="104">
  <partial-lock>
    <select xmlns:usr="http://example.com/users">
      /usr:top/usr:users/user[usr:name="Joe"]"
    </select>
  </partial-lock>
</nc:rpc>
```

The NETCONF server grants the partial lock. The scope of this second lock includes only the <user> node with name Joe. The lock protects all data below this particular <user> node.

Step 7 - Receive lock

```
<nc:rpc-reply
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  message-id="104">
  <lock-id>2</lock-id>
  <locked-node xmlns:usr="http://example.com/users">
    /usr:top/usr:users/user[usr:name="Joe"]"
  </locked-node>
</nc:rpc-reply>
```

The scope of the second lock is the <user> node Joe. It protects this <user> node and any data below it (e.g., phone number). At this point of time, these nodes are protected both by the first and second lock. Next, we unlock the other <user>s and the <users> node, to allow other managers to work on them. We still keep the second lock, so the <user> node Joe and the subtree below is still protected.

Step 8 - Release lock on <users>

```
<nc:rpc xmlns="urn:ietf:params:xml:ns:netconf:partial-lock:1.0"
  xmlns:nc="urn:ietf:params:xml:ns:netconf:base:1.0"
  message-id="105">
  <partial-unlock>
    <lock-id>1</lock-id>
  </partial-unlock>
</nc:rpc>
```

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