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Time Capability in NETCONF
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Abstract

This document defines a capability-based extension to the Network Configuration Protocol (NETCONF) that allows time-triggered configuration and management operations. This extension allows NETCONF clients to invoke configuration updates according to scheduled times, and allows NETCONF servers to attach timestamps to the data they send to NETCONF clients.

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1. Introduction

The Network Configuration Protocol (NETCONF) defined in [RFC6241] provides mechanisms to install, manipulate, and delete the

configuration of network devices. NETCONF allows clients to configure and monitor NETCONF servers using remote procedure calls (RPC).

NETCONF, as defined in [RFC6241], is asynchronous; when a client invokes an RPC, it has no control over the time at which the RPC is executed, nor does it have any feedback from the server about the execution time.

Time-based configuration ([HotSDN], [TimeTR]) can be a useful tool that enables an entire class of coordinated and scheduled configuration procedures. Time-triggered configuration allows coordinated network updates in multiple devices; a client can invoke a coordinated configuration change by sending RPCs to multiple servers with the same scheduled execution time. A client can also invoke a time-based sequence of updates by sending n RPCs with n different update times, T1, T2, ..., Tn, determining the order in which the RPCs are executed.

This memo defines the time capability in NETCONF. This extension allows clients to determine the scheduled execution time of RPCs they send. It also allows a server that receives an RPC to report its actual execution time to the client.

2. Conventions used in this document

2.1. Keywords

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2199].

2.2. Abbreviations

NETCONF Network Configuration Protocol

RPC Remote Procedure Call

TAI International Atomic Time

2.3. Terminology

- Capability [RFC6142]: A functionality that supplements the base NETCONF specification.

- Client [RFC6142]: Invokes protocol operations on a server. In addition, a client can subscribe to receive notifications from a server.

- Execution time: The execution time of an RPC is defined as the time at which a server completes the execution of an RPC.

- Scheduled time: The scheduled time of an RPC is the time at which the RPC should be completed. The scheduled time is determined by the client, and enforced by the server.

- Server [RFC6142]: Executes protocol operations invoked by a client. In addition, a server can send notifications to a client.

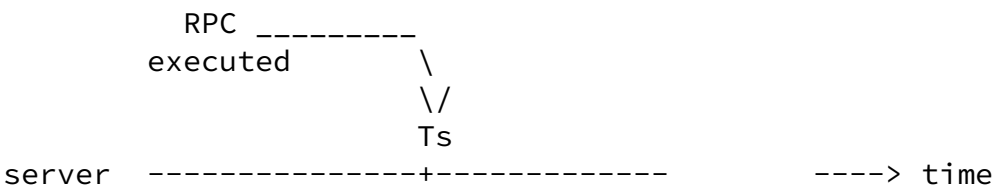
3. Using Time in NETCONF

3.1. The Time Capability in a Nutshell

The :time capability provides two main functions:

- Scheduling:
  When a client sends an RPC to a server, the RPC message MAY include a scheduled time, Ts (see Figure 1). The server then executes the RPC at the scheduled time Ts, and once completed the server can respond with an RPC reply message.

- Reporting:
  When a client sends an RPC to a server, the RPC message MAY include a get-time element (see Figure 2), requesting the server to return the execution time of the RPC. In this case, after the server performs the RPC it responds with an RPC reply that includes the execution time, Te.



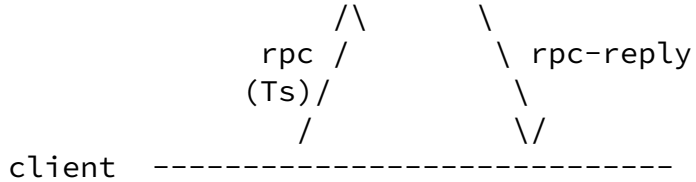


Figure 1 Scheduled RPC

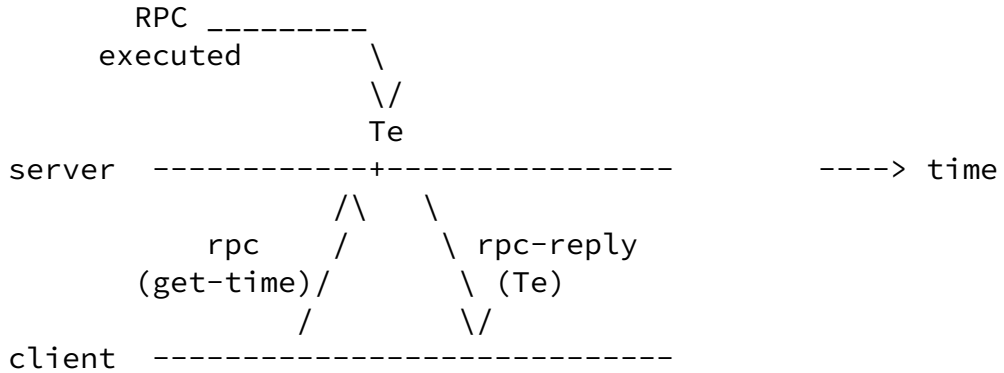
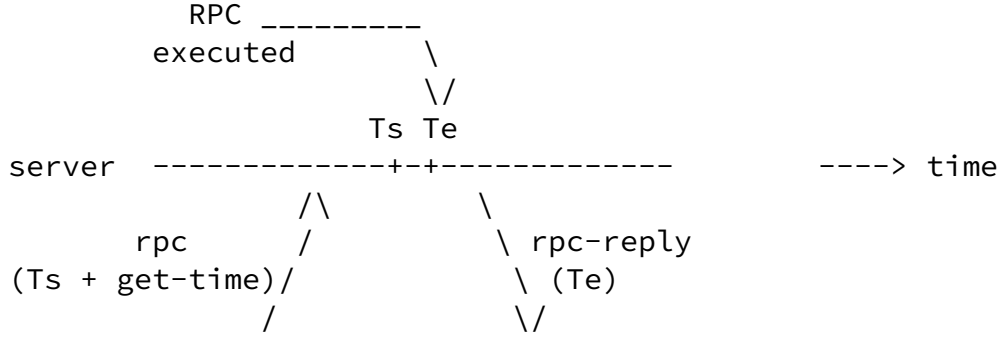


Figure 2 Reporting the Execution Time of an RPC

The two scenarios discussed above imply that a third scenario can also be supported (Figure 3), where the client invokes an RPC that includes a scheduled time, Ts, as well as the get-time element. This allows the client to receive feedback about the actual execution time, Te. Ideally, Ts=Te. However, the server may execute the RPC at a slightly different time than Ts, for example if the server is tied up with other tasks at Ts.



```
client  ----------------------------
```

Figure 3 Scheduling and Reporting

3.2. Synchronization Aspects

The time capability defined in this document requires clients and servers to maintain clocks. It is assumed that clocks are synchronized by a method that is outside the scope of this document, e.g., [NTP] or [IEEE1588].

This document does not define any requirements pertaining to the degree of accuracy of performing scheduled RPCs. Note that two factors affect how accurately the server can perform a scheduled RPC;

one factor is the accuracy of the clock synchronization method used to synchronize the clients and servers, and the second factor is the server's ability to execute real-time configuration changes, which greatly depends on how it is implemented. Typical networking devices are implemented by a combination of hardware and software. While the execution time of a hardware module can typically be predicted with a high level of accuracy, the execution time of a software module may be variable and hard to predict. A configuration update would typically require the server's software to be involved, thus affecting how accurately the RPC can be scheduled.

Since servers do not perform configuration changes instantaneously, the processing time of an RPC should not be overlooked. The scheduled time and execution time always refer to the start time of the RPC.

3.3. Scheduled Time Format

The scheduled time and execution time fields in RPC messages use a common time format field.

The time format used in this document is the date-and-time format, that is defined in Section 5.6 of [RFC3339] and in Section 3 of [RFC6021].

```
leaf scheduled-time {
  description
  "The time at which the RPC is scheduled to be performed.";
```

```
      type yang:date-and-time;
    }


    leaf execution-time {
      description
      "The time at which the RPC is was executed.";
      type yang:date-and-time;
    }
```

3.4. Time Interval Format

The time-interval format is used for representing the length of a time interval, and is based on the date-and-time format. While the date-and-time type uniquely represents a specific point in time, the

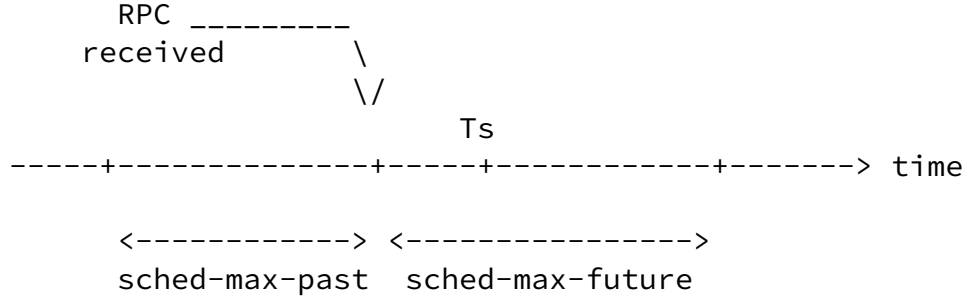
time-interval type defined below can be used to represent the length of a time interval without specifying a specific date.

The time-interval type is defined as follows:

```
   typedef time-interval {
     type string {
       pattern '\d{2}:\d{2}:\d{2}(\.\d+)?';
     }
```

3.5. Scheduling Tolerance

When a client sends an RPC that is scheduled to Ts, the server MUST verify that the value Ts is not too far in the past or in the future. As illustrated in Figure 4, the server verifies that Ts is within the scheduling tolerance range.



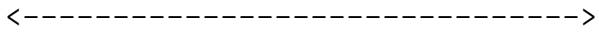


Figure 4 Scheduling Tolerance

The scheduling tolerance is determined by two parameters, sched-max-future and sched-max-past. The default value of these two parameters is 1 second. A client can override these defaults with different values by including the <sched-max-past> and <sched-max-future> parameters in the scheduled RPC.

If the scheduled time, Ts is within the scheduling tolerance range, the scheduled RPC is performed; if Ts occurs in the past and within the scheduling tolerance, the server performs the RPC as soon as possible, whereas if Ts is a future time, the server performs the RPC at Ts.

If Ts is not within the scheduling tolerance range, the server responds with an error message.

4. Time Capability

The structure of this section is as defined in Appendix D of [RFC6241].

4.1. Overview

A server that supports the time capability can perform time-triggered operations as defined in this document.

A server implementing the :time capability:

- MUST support the ability to receive <rpc> messages that include a time element, and perform a time-triggered operation accordingly.
- MUST support the ability to include a time element in the <rpc-reply> messages that it transmits.

4.2. Dependencies

None.

4.3. Capability Identifier

The :time capability is identified by the following capability string (to be assigned by IANA - see Section 7.):

urn:ietf:params:netconf:capability:time:1.0

4.4. New Operations

None.

4.5. Modifications to Existing Operations

Three new elements are added to all existing operations:

- <schedule>
  This element is added to the input of each operation, indicating the time at which the server is scheduled to complete the operation. Every <rpc> message MAY include the <scheduled> element. A server that supports the :time capability and receives an <rpc> message with a <scheduled> element MUST perform the operation at the scheduled time.

- <get-time>
  This element is added to the input of each operation. An <rpc> message MAY include a <get-time> element, indicating that the server MUST include an <execution-time> in its corresponding <rpc-reply>.

- <execution-time>
  This element is added to the output of each operation, indicating the time at which the server completed the operation. An <rpc-reply> MAY include the <execution-time> element. A server that supports the :time capability and receives an operation with the <get-time> element MUST include the execution time in its response.

4.5.1. <schedule> element

The <schedule> element is a container that uses the scheduled-time-parameters grouping. This grouping is defined as follows:

```
    grouping scheduled-time-parameters {

      description
      "Contains the parameters of the scheduled time.";

      leaf scheduled-time {
        description
        "The time at which the RPC is scheduled to be performed.";
        type yang:date-and-time;
      }

      leaf sched-max-past {
        description
        "When the scheduled time is in the future, i.e., greater
         than the present time, this leaf defines the maximal
         difference between the scheduled time
         and the present time that the server is willing to
         accept. If the difference exceeds this number, the
         server responds with an error.";

        type time-interval;
      }

      leaf sched-max-past {
```



```
        description
        "When the scheduled time is in the past, i.e., less
         than the present time, this leaf defines the maximal
         difference between the present time
         and the scheduled time that the server is willing to
         accept. If the difference exceeds this number, the
         server responds with an error.";

        type time-interval;
      }
    }
```

4.6. Interactions with Other Capabilities

Confirmed Commit Capability

The confirmed commit capability is defined in Section 8.4 of [RFC6241]. According to [RFC6241], a confirmed <commit> operation MUST be reverted if a confirming commit is not issued within the timeout period (which by default is 600 seconds).

When the time capability is supported, and a confirmed <commit> operation is used with the <scheduled-time> element, the confirmation timeout MUST be counted from the scheduled time, i.e., the client begins the timeout measurement starting at the scheduled time.

5. Examples

5.1. <scheduled-time> Example

The following example extends the example presented in Section 7.2 of [RFC6241] by adding the time capability. In this example, the <scheduled-time> element is used to specify the scheduled execution time of the configuration update (as shown in Figure 1).

```
<rpc message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <schedule>
      <scheduled-time
       xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-time">
```



```
        2015-10-21T04:29:00.235
      </scheduled-time>
    </schedule>
    <config>
      <top xmlns="http://example.com/schema/1.2/config">
        <interface>
          <name>Ethernet0/0</name>
          <mtu>1500</mtu>
        </interface>
      </top>
    </config>
  </edit-config>
</rpc>
```

```
<rpc-reply message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ok/>
</rpc-reply>
```

5.2. <get-time> Example

The following example is similar to the one presented in Section 5.1. , except that in this example the client includes a <get-time> element in its RPC, and the server consequently responds with an <execution-time> element (as shown in Figure 2).

```
<rpc message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <get-time
     xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-time">
    </get-time>
    <config>
      <top xmlns="http://example.com/schema/1.2/config">
        <interface>
          <name>Ethernet0/0</name>
          <mtu>1500</mtu>
        </interface>
```



```
      </top>
    </config>
  </edit-config>
</rpc>

<rpc-reply message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <ok/>
  <execution-time>
     2015-10-21T04:29:00.235
  </execution-time>
</rpc-reply>
```

6. Security Considerations

The security considerations of the NETCONF protocol in general are discussed in [RFC6241].

The usage of the time capability defined in this document can assist an attacker in gathering information about the system, such as the exact time of future configuration changes. Moreover, the time elements can potentially allow an attacker to learn information about the system's performance. Furthermore, an attacker that sends malicious RPC messages can use the time capability to amplify her attack; for example, by sending multiple RPC messages with the same scheduled time. It is important to note that the security measures described in [RFC6241] can prevent these vulnerabilities.

The time capability relies on an underlying time synchronization protocol. Thus, an attack against the time protocol can potentially compromise NETCONF when using the time capability. A detailed discussion about the threats against time protocols and how to mitigate them is presented in [TimeSec].

7. IANA Considerations

This document proposes to register the following capability identifier URN in the 'Network Configuration Protocol (NETCONF) Capability URNs' registry:

urn:ietf:params:netconf:capability:time:1.0

This document proposes to register the following XML namespace URN in the 'IETF XML registry', following the format defined in [RFC3688]:

URI: urn:ietf:params:xml:ns:yang:ietf-netconf-time

8. Acknowledgments

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This document was prepared using 2-Word-v2.0.template.dot.

9. References

9.1. Normative References

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[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., Bierman, A., Ed., "Network Configuration Protocol (NETCONF)", RFC 6241, June 2011.

9.2. Informative References

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[TimeSec] Mizrahi, T., "Security Requirements of Time Protocols in Packet Switched Networks", draft-ietf-tictoc-security-requirements (work in progress), October 2013.

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