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Adaptive Subscription to YANG Notification

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Abstract

This document defines a YANG data model and associated mechanism to

enable adaptive subscriptions to YANG notifications. The publisher

can dynamically adjust the periodic update interval based on the

evaluation of pre-configured conditions (e.g., thresholds or

expressions). This allows for finer-grained telemetry by increasing

update frequency when certain criteria are met, and reducing it

otherwise.

Editorial Note (To be removed by RFC Editor)

Note to the RFC Editor: This section is to be removed prior to

publication. Please also remove Section 6.

This document contains placeholder values that need to be replaced

with finalized values at the time of publication. This note

summarizes all of the substitutions that are needed. No other RFC

Editor instructions are specified elsewhere in this document.

Please apply the following replacements:

\* XXXX --> the assigned RFC number for this document

\* 2025-05-21 --> the actual date of the publication of this document

Status of This Memo

This Internet-Draft is submitted in full conformance with the

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1. Introduction

YANG-Push subscriptions [RFC8641] allow subscriber applications to

request a continuous customized stream of updates from a YANG

datastore without needing to poll. It defines a mechanism (i.e.,

update trigger) to determine when an update record needs to be

generated. Two types of subscription are introduced in [RFC8641],

distinguished by how updates are triggered: periodic and on-change.

\* Periodic subscription allows subscribed data to be streamed to the

destination at a configured fixed time interval;

\* On-change subscription allows update to be triggered whenever a

change in the subscribed information is detected.

However, in some deployments involving an increased data collection

rate or "on-change" subscription to push updates that change

frequently, it becomes more likely that both clients and servers

could be temporarily overwhelmed with a burst of streamed data, and

network and computation resources could be excessively consumed.

Therefore, it may be expensive to continuously monitor operational

data at a high collection rate, and on-change subscriptions are only

suitable for data that changes infrequently and may not be supported

by all implementations or every data object. Conversely, if a stream

of data is collected at a lower rate or some low priority data is

allowed to be dropped, insufficient data might not be able to detect

and diagnose service problems.

A client might choose to monitor the operational state and send a

request to modify the data collection rate on the server as needed.

But how often the client evaluates if the modification of the data

collection rate is required highly depends on the current collection

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rate, collecting a stream of data at a low rate prevents the

subscriber from capturing sufficient data for timely decision-making.

In addition, when tens of thousands of network devices need to be

managed, frequent follow-up modification requests are prone to

errors.

This document defines a YANG data model and associated mechanism that

enable adaptive subscription to YANG notifications. Servers can be

configured with multiple different period intervals and corresponding

period update conditions which allow servers/publishers to

automatically switch to different period intervals according to the

network condition changes without the interaction with the client for

policy update instructions. Applying adaptive subscription allows

publishers to adjust the subscription period dynamically based on

pre-defined threshold for finer-grained network telemetry data sent

to receivers.

1.1. Terminology

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] [RFC8174] when, and only when, they appear in all

capitals, as shown here.

The following terms are defined in [RFC5277], [RFC7950], [RFC8342],

[RFC8639], [RFC8641] and are not redefined here:

\* Event

\* Client

\* Configuration

\* Configured subscription

\* Configuration datastore

\* Notification message

\* Publisher

\* Receiver

\* Subscriber

\* Subscription

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\* On-change subscription

\* Periodic subscription

\* Selection filter

This document defines the following term:

Adaptive Subscription: A subscription that specifies subscription

period update policy on the servers when the subscription is

initialized and allows servers/publishers to automatically switch

to different period intervals according to network condition

changes without interacting with the client for update policy

instructions.

1.2. Experimental Considerations

The YANG data model and associated mechanism detailed in this

document are designated as experimental. The experiment aims to

explore the use of XPath condition expressions as defined in "eval-

expression" parameter to determine the period interval with which to

report updates. Some RPC failures specified in Section 2.2 may serve

as safeguards against the experiment inadvertently "leaking out" into

the unexpected operational environment. Additional implementations

would be necessary in the future to assess the scalability,

stability, and effectiveness of the proposed solution in the

document. Feedback garnered from deployments will be crucial in

determining whether this specification merits progression from

Experimental to the IETF Standards Track.

2. Solution Overview

2.1. Adaptive Subscription Parameters

Adaptive subscription can be implemented using either

dynamic or configured subscription. Regardless of the type of

adaptive subscription, triggered updates always occur at the

boundaries of specified time intervals when the corresponding trigger

condition is evaluated to be satisfied. These boundaries can be

calculated from the following parameters:

\* "name": represents the unique name of each adaptive period.

\* "eval-expression": represents a standard XPath evaluation

expression (Section 6.4 of [RFC7950]) that is applied against the

targeted data node, which is used to trigger/control the update

interval switching within the server. It follows the rules

defined in Section 3.4 of [XPATH1.0] and contains a comparison of

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a targeted node instance to the specific threshold in the XPath

format. Different from selection filter defined in [RFC8641], it

monitors a specific data node instance change and evaluates the

trigger condition associated with the specified threshold value to

be true or false using XPath rules and does not affect the event/

update record output generation from a publisher. The updates are

only pushed as the corresponding period interval when the XPath

expression is evaluated to "true".

The represented expression defined in "eval-expression" is

evaluated in the following XPath context:

- The set of namespace declarations is the set of prefix and

namespace pairs for all YANG modules implemented by the server,

where the prefix is the YANG module name and the namespace is

as defined by the "namespace" statement in the YANG module.

- If the leaf is encoded in XML, all namespace declarations in

scope on the "eval-expression" leaf element are added to the

set of namespace declarations. If a prefix found in the XML is

already present in the set of namespace declarations, the

namespace in the XML is used.

- The set of variable bindings is empty.

- The function library is the core function library defined in

[XPATH1.0] and the function defined in Section 10 of [RFC7950].

- The context node is the root node in the accessible tree which

is the operational state data in the server.

When specified, multiple XPath evaluation criteria inside

"adaptive-periodic" container MUST be mutually exclusive. For the

cases where the "eval-expression" parameter refers to multiple

list/leaf-list instances, XPath abbreviated syntax can be used to

identify a particular instance, e.g., to represent a comparison

for a leaf in a list entry:

/if:interfaces/if:interface[if:name="eth0"]/if:in-errors>1000.

The server MUST convert the XPath evaluation expression defined in

"eval-expression" to a boolean value and internally apply the

"boolean" function defined in Section 4.3 in [XPATH1.0] if the

evaluated result is not a boolean value. It MUST evaluates to

"false" if the target node instance to be compared is deleted.

Only if the XPath expression is evaluated to "true", does the

publisher switch to the corresponding period with which push

updates are reported.

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\* "eval-interval": defines how often the XPath condition expression

as defined in "eval-expression" is evaluated to decide whether to

switch to another period interval. If an "eval-interval" is not

provided, then the "eval-interval" is set with the minimum time

interval that the server is able to detect wherever changes to the

targeted data node occurs.

\* "period": defines the duration between push updates, in units of

0.01 seconds. The "period" has the same definition as the

yp:period for periodic subscription defined in [RFC8641], while it

must be present with the "eval-expression" parameter so that

update interval can be switched based on trigger conditions

indicated by the "eval-expression" parameter;

\* "anchor-time": update intervals fall on the points in time that

are a multiple of a "period" from an "anchor-time". If an

"anchor-time" is not provided, then the "anchor-time" MUST be set

with the creation time of the initial update record inside each

periodic timeframe. The "anchor-time" parameter, together with

the "eval-interval" value, specifies when the initial update is to

be pushed within each adaptive periodic timeframe.

Note that the adaptive subscription may not be supported by every

YANG datastore node. The solution presented in this document

augments the "ietf-notification-capabilities" YANG module defined in

[RFC9196] to enable a subscriber to discover adaptive subscription

capabilities. A publisher MAY decide to simply reject an adaptive

subscription with "adaptive-unsupported" (defined in Section 2.2) if

the subscription contains selected data nodes for which adaptive

subscription is not supported.

2.2. RPC Failures

RPC error responses from the publisher are used to indicate a

rejection of an RPC for any reason. In addition to the RPC failures

defined in [RFC8639] and [RFC8641], this document introduces

following RPC errors for "establish-subscription" and "modify-

subscription" RPCs.

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establish-subscription

-----------------------------

adaptive-unsupported

xpath-evaluation-unsupported

evaluation-interval-unsupported

multi-xpath-criteria-conflict

modify-subscription

-----------------------------

xpath-evaluation-unsupported

evaluation-interval-unsupported

multi-xpath-criteria-conflict

The "adaptive-unsupported" RPC error is used to indicate that the

adaptive subscription is not supported for the targeted set of data

nodes that are selected by the filter.

The "xpath-evaluation-unsupported" RPC error is used to indicate that

a server failed to parse syntax defined in "eval-expression". The

failure can be caused by either a syntax error or some XPath 1.0

syntax not supported against the specific data node.

The "evaluation-interval-unsupported" RPC error is used to indicate

that the requested XPath evaluation interval represented by "eval-

interval" is too short. Hints suggesting alternative intervals may

be returned as supplemental information.

The "multi-xpath-criteria-conflict" error is used to indicate that

the multiple XPath evaluation criteria represented by "eval-

expression" are evaluated as conflicting, i.e., more than one

condition expressions may be evaluated to "true" at the same time.

For an example of how the above RPC errors can be returned, see the

"xpath-evaluation-unsupported" error response illustrated in

Appendix C.3.

Note that existing RPC errors defined in [RFC8639] and [RFC8641] are

still supported by this document. For example, if any configured

period for adaptive subscription is not supported by the publisher, a

"period-unsupported" error response could be used.

2.3. Subscription State Change Notifications

This document reuses subscription state change notifications and

mechanisms from [RFC8639] and [RFC8641]. Notifications

"subscription-started" and "subscription-modified" have been

augmented to include the adaptive subscription specific parameters.

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2.4. Notifications for Adaptive Subscribed Content

This document also defines a new subscription state change

notification called "adaptive-period-update", to indicate that an

adaptive subscription period interval has been switched based on its

trigger condition. Like subscription state change

notifications defined in [RFC8639], the adaptive period update

notification cannot be dropped or filtered out, it cannot be stored

in replay buffers, and it is delivered only to impacted receivers of

a subscription. The identification of the adaptive update

notification is easy to separate from other notification messages

using the YANG extension "subscription-state-

notification" defined in [RFC8639]. This extension tags a

notification as a subscription state change notification.

The elements in the "adaptive-period-update" notification include:

\* A subscription ID of the subscription for which the update record

was generated.

\* A "period" that defines the duration between push updates, the

period can be changed based on trigger conditions.

\* A "period-update-time" that designates a timestamp when the server

starts to switch to another period interval because the evaluated

"eval-expression" result changed.

\* A chunk of data defined as an anydata YANG node called "satisfied-

criteria-data" to include the instance nodes and values specified

in "eval-expression" that satisfy the condition and thus trigger

the period interval switching within the server. This node could

be useful for troubleshooting.

\* A selection filter to identify YANG nodes of interest in a

datastore. Filter contents are specified via a reference to an

existing filter or via an in-line definition for only that

subscription based on XPath Section 6.4 of [RFC7950] evaluation

criteria. Referenced filters allow an implementation to avoid

evaluating filter acceptability during a dynamic subscription

request. The "case" statement differentiates the options. Note

that filter contents are not affected by the "eval-expression"

parameter defined by the update trigger.

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3. Adaptive Subscription Data Model

This document defines a YANG data model named "ietf-adaptive-

subscription" which augments the "update-trigger" choice defined in

the "ietf-yang-push" module [RFC8641] with subscription configuration

parameters that are specific to a subscriber's adaptive subscription.

In addition to subscription state notifications defined in [RFC8639]

and notifications for subscribed content defined in [RFC8641], "ietf-

adaptive-subscription" module also defines "adaptive-period-update"

notification to report the update interval change.

Additionally, it augments the "ietf-notification-capabilities" data

model defined in [RFC9196] so that the adaptive subscription

capabilities could be discovered beforehand.

3.1. YANG Tree Diagram

The following tree diagrams [RFC8340] provide an overview of the YANG data

model for "ietf-adaptive-subscription" module.

module: ietf-adaptive-subscription

augment /sn:subscriptions/sn:subscription/yp:update-trigger:

+--:(adaptive-periodic) {adaptive-subscription}?

+--rw adaptive-periodic

+--rw periodic\* [name]

+--rw name string

+--rw eval-expression yang:xpath1.0

+--rw eval-interval? yp:centiseconds

+--rw period yp:centiseconds

+--rw anchor-time? yang:date-and-time

augment /sn:establish-subscription/sn:input/yp:update-trigger:

+--:(adaptive-periodic) {adaptive-subscription}?

+-- adaptive-periodic

+-- periodic\* [name]

+-- name string

+-- eval-expression yang:xpath1.0

+-- eval-interval? yp:centiseconds

+-- period yp:centiseconds

+-- anchor-time? yang:date-and-time

augment /sn:modify-subscription/sn:input/yp:update-trigger:

+--:(adaptive-periodic) {adaptive-subscription}?

+-- adaptive-periodic

+-- periodic\* [name]

+-- name string

+-- eval-expression yang:xpath1.0

+-- eval-interval? yp:centiseconds

+-- period yp:centiseconds

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+-- anchor-time? yang:date-and-time

augment /sn:subscription-started/yp:update-trigger:

+--:(adaptive-periodic) {adaptive-subscription}?

+-- adaptive-periodic

+-- periodic\* [name]

+-- name string

+-- eval-expression yang:xpath1.0

+-- eval-interval? yp:centiseconds

+-- period yp:centiseconds

+-- anchor-time? yang:date-and-time

augment /sn:subscription-modified/yp:update-trigger:

+--:(adaptive-periodic) {adaptive-subscription}?

+-- adaptive-periodic

+-- periodic\* [name]

+-- name string

+-- eval-expression yang:xpath1.0

+-- eval-interval? yp:centiseconds

+-- period yp:centiseconds

+-- anchor-time? yang:date-and-time

augment /sysc:system-capabilities/notc:subscription-capabilities:

+--ro adaptive-notifications-supported? notification-support

augment /sysc:system-capabilities/sysc:datastore-capabilities

/sysc:per-node-capabilities

/notc:subscription-capabilities:

+--ro adaptive-notifications-supported? notification-support

notifications:

+---n adaptive-period-update {adaptive-subscription}?

+--ro id?

| sn:subscription-id

+--ro period yp:centiseconds

+--ro period-update-time?

| yang:date-and-time

+--ro satisfied-criteria-data? <anydata>

+--ro datastore identityref

+--ro (selection-filter)?

+--:(by-reference)

| +--ro selection-filter-ref

| selection-filter-ref

+--:(within-subscription)

+--ro (filter-spec)?

+--:(datastore-subtree-filter)

| +--ro datastore-subtree-filter? <anydata>

| {sn:subtree}?

+--:(datastore-xpath-filter)

+--ro datastore-xpath-filter? yang:xpath1.0

{sn:xpath}?

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3.2. The "ietf-adaptive-subscription" Module

This YANG module imports modules from [RFC6991],[RFC8639], [RFC8641],

and [RFC9196].

<CODE BEGINS> file "ietf-adaptive-subscription@2025-05-21.yang"

module ietf-adaptive-subscription {

yang-version 1.1;

namespace "urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription";

prefix as;

import ietf-subscribed-notifications {

prefix sn;

reference

"RFC 8639: Subscription to YANG Notifications";

}

import ietf-yang-push {

prefix yp;

reference

"RFC 8641: Subscription to YANG Notifications for Datastore

Updates";

}

import ietf-yang-types {

prefix yang;

reference

"RFC 6991: Common YANG Data Types";

}

import ietf-system-capabilities {

prefix sysc;

reference

"RFC 9196: YANG Modules Describing Capabilities for

Systems and Datastore Update Notifications";

}

import ietf-notification-capabilities {

prefix notc;

reference

"RFC 9196: YANG Modules Describing Capabilities for

Systems and Datastore Update Notifications";

}

organization

"IETF NETCONF (Network Configuration) Working Group";

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description

"This module extends the YANG data module defined in

YANG-push to enable the subscriber's adaptive

subscriptions to a publisher's event streams with various

different period intervals to report updates.

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This version of this YANG module is part of RFC XXXX

(https://www.rfc-editor.org/info/rfcXXXX); see the RFC

itself for full legal notices.

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 (RFC 2119)

(RFC 8174) when, and only when, they appear in all

capitals, as shown here.";

revision 2025-05-21 {

description

"Initial revision";

reference

"RFC XXXX: Adaptive Subscription to YANG Notification.";

}

feature adaptive-subscription {

description

"This feature indicates that adaptive-subscriptions are

supported.";

}

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identity adaptive-unsupported {

base sn:establish-subscription-error;

description

"Adaptive-subscription is not supported for the targeted set

of objects that are selectable by the filter.";

}

identity xpath-evaluation-unsupported {

base sn:establish-subscription-error;

base sn:modify-subscription-error;

description

"Unable to parse the XPath evaluation criteria defined in

'eval-expression' because of a syntax error or some XPath

1.0 syntax not supported against the specific data node.";

}

identity evaluation-interval-unsupported {

base sn:establish-subscription-error;

base sn:modify-subscription-error;

description

"The requested XPath evaluation interval represented by

'eval-interval' is too short. Hints suggesting alternative

intervals may be returned as supplemental information.";

}

identity multi-xpath-criteria-conflict {

base sn:establish-subscription-error;

base sn:modify-subscription-error;

description

"Multiple XPath evaluation criteria represented by

'eval-expression' are evaluated as a conflict. I.e.,

more than one condition expression is evaluated to

'true'.";

}

grouping adaptive-subscription-modifiable {

description

"This grouping describes the datastore-specific adaptive

subscription conditions that can be changed during the

lifetime of the subscription.";

container adaptive-periodic {

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The publisher supports

to switch to different period intervals adaptively based

on pre-defined condition expressions.";

list periodic {

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key "name";

description

"A list of adaptive period which defines a push update

interval and trigger conditions to switch to the update

interval for sending an event record to the subscriber.";

leaf name {

type string {

length "1..64";

}

description

"The unique name of adaptive period.";

}

leaf eval-expression {

type yang:xpath1.0;

mandatory true;

description

"A standard XPath evaluation expression that is applied

against the targeted data node, which is used to

trigger/control the update interval switching within

the server. The updates are only pushed as the

corresponding period interval when the XPath expression

is evaluated to 'true'.

The expression is evaluated in the following XPath

context:

- The set of namespace declarations is the set of

prefix and namespace pairs for all YANG modules

implemented by the server, where the prefix is the

YANG module name and the namespace is as defined by

the 'namespace' statement in the YANG module.

- If the leaf is encoded in XML, all namespace

declarations in scope on the 'eval-expression' leaf

element are added to the set of namespace

declarations. If a prefix found in the XML is

already present in the set of namespace

declarations, the namespace in the XML is used.

- The set of variable bindings is empty.

- The function library is the core function library

defined in XPath1.0 and the functions defined in

Section 10 in RFC 7950.

- The context node is the root node in the accessible

tree which is the operational state data in the

server.";

reference

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"XML Path Language (XPath) Version 1.0

(https://www.w3.org/TR/1999/REC-xpath-19991116)

RFC 7950: The YANG 1.1 Data Modeling Language,

Section 10";

}

leaf eval-interval {

type yp:centiseconds;

description

"How often the Xpath condition expression is evaluated

to decide whether to switch to another period

interval.";

}

leaf period {

type yp:centiseconds;

mandatory true;

description

"Duration of time that should occur between periodic

push updates, in units of 0.01 seconds.";

}

leaf anchor-time {

type yang:date-and-time;

description

"Designates a timestamp before or after which a series

of periodic push updates is determined. The next

update will take place at a point in time that is a

multiple of a period from the 'anchor-time'.

For example, for an 'anchor-time' that is set for the

top of a particular minute and a period interval of a

minute, updates will be sent at the top of every

minute that this subscription is active.";

}

}

}

}

augment "/sn:subscriptions/sn:subscription/yp:update-trigger" {

description

"This augmentation adds additional subscription parameters

that apply specifically to adaptive subscription.";

case adaptive-periodic {

if-feature "adaptive-subscription";

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The periodicity of

these notifications are determined by adaptive criteria.";

uses adaptive-subscription-modifiable;

}

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}

augment "/sn:establish-subscription/sn:input/yp:update-trigger" {

description

"This augmentation adds additional establish-subscription

parameters that apply specifically to datastore updates to

RPC input.";

case adaptive-periodic {

if-feature "adaptive-subscription";

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The periodicity of

these notifications are determined by adaptive criteria.";

uses adaptive-subscription-modifiable;

}

}

augment "/sn:modify-subscription/sn:input/yp:update-trigger" {

description

"This augmentation adds additional modify-subscription

parameters that apply specifically to datastore updates to

RPC input.";

case adaptive-periodic {

if-feature "adaptive-subscription";

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The periodicity of

these notifications is determined by adaptive criteria.";

uses adaptive-subscription-modifiable;

}

}

augment "/sn:subscription-started/yp:update-trigger" {

description

"This augmentation adds additional adaptive subscription

parameters to the notification that a subscription has

started.";

case adaptive-periodic {

if-feature "adaptive-subscription";

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The periodicity of

these notifications are determined by adaptive criteria.";

uses adaptive-subscription-modifiable;

}

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}

augment "/sn:subscription-modified/yp:update-trigger" {

description

"This augmentation adds additional adaptive subscription

parameters to the notification that a subscription has been

modified.";

case adaptive-periodic {

if-feature "adaptive-subscription";

description

"The publisher is requested to periodically notify the

receiver regarding the current values of the datastore

as defined by the selection filter. The periodicity of

these notifications are determined by adaptive criteria.";

uses adaptive-subscription-modifiable;

}

}

notification adaptive-period-update {

if-feature "adaptive-subscription";

sn:subscription-state-notification;

description

"This notification is sent to indicate that an adaptive

subscription period interval has been switched based its

triggered condition.";

leaf id {

type sn:subscription-id;

description

"This references the subscription that drove the

notification to be sent.";

}

leaf period {

type yp:centiseconds;

mandatory true;

description

"New duration of time that should occur between periodic

push updates, in units of 0.01 seconds.";

}

leaf period-update-time {

type yang:date-and-time;

description

"Designates a timestamp when the server starts to switch

to another period interval because the evaluated

'eval-expression' expression result changed.";

}

anydata satisfied-criteria-data {

description

"The corresponding instance nodes and values specified in

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'eval-expression' that satisfy the condition and thus

trigger the update interval switching within the server.";

}

uses yp:datastore-criteria {

refine "selection-filter/within-subscription" {

description

"Specifies the selection filter and where it originated

from. If the 'selection-filter-ref' is populated, the

filter in the subscription came from the 'filters'

container. Otherwise, it is populated in-line as part

of the subscription itself.";

}

}

}

grouping adaptive-subscription-capabilities {

description

"Capabilities related to adaptive subscription and

notification.";

typedef notification-support {

type bits {

bit config-changes {

description

"The publisher is capable of sending

notifications for 'config true' nodes for the

relevant scope and subscription type.";

}

bit state-changes {

description

"The publisher is capable of sending

notifications for 'config false' nodes for the

relevant scope and subscription type.";

}

}

description

"Type for defining whether 'on-change' or

'periodic' notifications are supported for all data nodes,

'config false' data nodes, 'config true' data nodes, or

no data nodes.

The bits config-changes or state-changes have no effect

when they are set for a datastore or for a set of nodes

that does not contain nodes with the indicated config

value. In those cases, the effect is the same as if no

support was declared. One example of this is indicating

support for state-changes for a candidate datastore that

has no effect.";

}

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leaf adaptive-notifications-supported {

type notification-support;

description

"Specifies whether the publisher is capable of sending

'adaptive' notifications for the selected data nodes,

including any subtrees that may exist below them.";

}

}

augment "/sysc:system-capabilities"

+ "/notc:subscription-capabilities" {

description

"Add system level capabilities of adaptive subscription.";

uses adaptive-subscription-capabilities;

}

augment

"/sysc:system-capabilities/sysc:datastore-capabilities/"

+ "sysc:per-node-capabilities/notc:subscription-capabilities" {

description

"Add node-level capabilities of adaptive subscription.";

uses adaptive-subscription-capabilities;

}

}

<CODE ENDS>

4. IANA Considerations

4.1. Updates to the IETF XML Registry

This document registers one URI in the IETF XML registry [RFC3688].

Following the format in [RFC3688], the following registration is

requested to be made:

---------------------------------------------------------------------

URI: urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription

Registrant Contact: The IESG.

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

---------------------------------------------------------------------

4.2. Updates to the YANG Module Names Registry

This document registers one YANG module in the YANG Module Names

registry [RFC7950]. Following the format in [RFC6020], the following

registration is requested to be made:

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---------------------------------------------------------------------

Name: ietf-adaptive-subscription

Namespace: urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription

Prefix: as

Reference: RFC XXXX

---------------------------------------------------------------------

5. Operational Considerations

5.1. XPath Complexity Evaluation

YANG-Push subscriptions [RFC8641] specify selection filters to

identify targeted YANG datastore nodes and/or datastore subtrees for

which updates are to be pushed. In addition, it specifies update

policies which contain conditions that trigger generation and pushing

of new update records. To support a subscriber's adaptive

subscription defined in this document, the trigger condition also

uses similar selection filters to express a standard XPath evaluation

criterion that is applied against the targeted data node(s).

The subscriber must take care about the following complex XPath

evaluation criteria design and usage, although they have already been

well supported by the Section 3.4 of [XPATH1.0]:

\* Apply XPath evaluation criteria on any arbitrary "config true" and

"config false" data nodes;

\* Have more than one target data node selection and operation (e.g.,

addition, subtraction, division and multiplication) in a single

XPath evaluation criterion;

\* Target any type of node value in the XPath evaluation criterion,

e.g., string, int64, uint64, and decimal64 types;

\* Both objects in the XPath evaluation criterion to be compared are

node-sets;

\* Targeted data to be compared are in different data types, e.g.,

one is an integer, the other is a string.

As described in Section 6.4 of [RFC7950], Numbers in XPath 1.0 are

IEEE 754 [IEEE754-2008] double-precision floating-point values; some

values of int64, uint64, and decimal64 types cannot be exactly

represented in XPath expressions.

If targeted data to be compared are in different data types, a

conversion function is needed to convert different data types into

numbers.

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If both objects in XPath evaluation criteria to be compared are node-

sets, more computation resources are required which add complexity.

To reduce these complexities, the following implementation and use

principles are RECOMMENDED:

\* XPath evaluation criteria are applied against a minimal set of

data nodes in the data model, the minimal set of data nodes can be

advertised using "ietf-notification-capabilities" module defined

in [RFC9196];

\* Both targets in the XPath evaluation criterion to be compared are

in the same data type;

\* One target to be compared in the XPath evaluation criterion is a

leaf/leaf-list data node with numerical data type (e.g., signed/

unsigned integer) and the other is a numerical threshold value.

If a server receives an XPath evaluation criterion with some XPath

syntax unsupported against the specific targeted data node, an RPC

error with "xpath-evaluation-unsupported" MUST be returned.

5.2. Threshold Selection for XPath Evaluation

Determining the threshold used in an XPath expression criterion can

be challenging for subscribers sometimes. Generally, the selection

of a threshold should be based on the impact of the targeted node on

monitored service/application and experience from deployments. In

extreme cases, setting a too high or low threshold may make adaptive

subscription degenerated to periodic subscription. Sometimes the

threshold needs to be adjusted during the lifecycle of an adaptive

subscription, depending on factors like historical fluctuation range,

how rapid the targeted value of the node changes, distribution

characteristics of the targeted node value and even the generated

volume of telemetry traffic.

6. Implementation Status

Note to the RFC Editor: Please remove this section before

publication, as well as the reference to [RFC7942].

This section records the status of known implementations of the

mechanism defined by this specification at the time of posting of

this Internet-Draft, and is based on a proposal described in

[RFC7942]. The description of implementations in this section is

intended to assist the IETF in its decision processes in progressing

drafts to RFCs. Please note that the listing of any individual

implementation here does not imply endorsement by the IETF.

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Furthermore, no effort has been spent to verify the information

presented here that was supplied by IETF contributors. This is not

intended as, and must not be construed to be, a catalog of available

implementations or their features. Readers are advised to note that

other implementations may exist.

According to [RFC7942], "this will allow reviewers and working groups

to assign due consideration to documents that have the benefit of

running code, which may serve as evidence of valuable experimentation

and feedback that have made the implemented protocols more mature.

It is up to the individual working groups to use this information as

they see fit".

There is at least one known implementation, the details of which are

as follows.

\* Organization: Huawei Technologies Co.,Ltd.

\* Implementation: https://github.com/IETF-Hackathon/ietf113-project-

presentations/blob/main/ietf-hackathon-adaptive-subscription.pdf

\* Description: gRPC-based adaptive telemetry to collect data from

Access Points (APs) in a campus network.

\* Level of maturity: prototype.

\* Coverage: The "ietf-adaptive-subscription" module with the

evaluation criteria supporting a comparison of a limited set of

targeted node instances to the threshold in the XPath format.

\* Contact: maqiufang1@huawei.com

\* Test Scenario: The radio signals of an AP can cover only a limited

area, Wi-Fi roaming is what happens when a wireless client

disconnects from one AP because it receives weak signals (i.e.,

the Received Signal Strength Indicator (RSSI) lower than the

threshold) and connects to another as the client moves from the

coverage area of an AP to that of another AP. One objective of

telemetry in this scenario is to collect the RSSI values of a

specific client as it moves and detect real-time Wi-Fi roaming

events. We also collect the bytes sent from the AP uplink so as

to detect the possible uplink congestion. Three data collection

ways are evaluated:

- Periodic subscriptions with periods of 2 seconds for RSSI

collection and 1 minute for upbytes collection.

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- Periodic subscriptions with periods of 30 seconds for RSSI

collection and 10 minutes for upbytes collection.

- Adaptive subscriptions:

o For the RSSI collection, if the RSSI value is greater than

or equal to -65 dB, switch to 30 seconds for publication;

otherwise, switch to 2 seconds for publication; threshold

detection occurs every 2 seconds.

o For the upbytes collection, if the upbytes value is greater

than or equal to 60000 bytes, switch to 1 minute for

publication; otherwise, switch to 10 minutes for

publication; threshold detection occurs every minute.

\* Implementation experience: The results show adaptive telemetry can

greatly reduce the data volume but still ensure network events can

be captured at the same time. When the specific value does not

reach the threshold, a lower frequency data publication can

greatly reduce the amount of collected data; when it does exceed

the threshold, the device detects the change and switches to a

higher frequency data publication so that sufficient data will not

be missed to diagnose network events. Adaptive subscription can

be served as a compromise between data management resource cost

and data fidelity for network diagnosis. However, the selection

of threshold is crucial to adaptive subscription and should be

based on operational experience and adjusted as needed.

7. Security Considerations

This section is modeled after the template described in Section 3.7

of [I-D.ietf-netmod-rfc8407bis].

The "ietf-adaptive-subscription" YANG module defines a data model

that is designed to be accessed via YANG-based management protocols,

such as NETCONF [RFC6241] and RESTCONF [RFC8040]. These YANG-based

management protocols (1) have to use a secure transport layer (e.g.,

SSH [RFC4252], TLS [RFC8446], and QUIC [RFC9000]) and (2) have to use

mutual authentication.

The Network Configuration Access Control Model (NACM) [RFC8341]

provides the means to restrict access for particular NETCONF or

RESTCONF users to a preconfigured subset of all available NETCONF or

RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are

writable/creatable/deletable (i.e., "config true", which is the

default). All writable data nodes are likely to be reasonably

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sensitive or vulnerable in some network environments. Write

operations (e.g., edit-config) and delete operations to these nodes

without proper protection or authentication can have a negative

effect on network operations. The following subtrees and data nodes

have particular sensitivities/vulnerabilities:

\* "periodic": By modifying this list, an attacker might alter the

updates that are being sent in order to confuse a receiver,

withhold certain updates to be sent to the receiver, and/or

overwhelm a receiver. For example, an attacker might modify the

period with which updates are reported and/or the XPath evaluation

expression, resulting in certain updates not being published or a

high volume of updates being published to exhaust receiver

resources.

This YANG module uses groupings from other YANG modules that define

nodes that may be considered sensitive or vulnerable in network

environments. Refer to the Security Considerations of [RFC8641] for

information as to which nodes may be considered sensitive or

vulnerable in network environments.

8. Contributors

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Appendix A. Use Cases

A.1. Wireless Network Performance Monitoring

Wireless signal strength is a critical factor in determining the

quality and reliability of a wireless network connection. In

practical scenarios, when the wireless signal strength drops below a

specific threshold, the network may experience issues such as

increased latency, packet loss, or even disconnections, which would

require more frequent monitoring of network and service performance

metrics to detect anomalies in a timely manner. Conversely, when the

wireless signal strength exceeds a specific threshold, indicating a

stable and strong connection, the data streaming rate can be reduced

to a reasonable value to help conserve network bandwidth and

computational resources.

To optimize the process, adaptive subscription can be employed. When

the wireless signal strength falls below a configured threshold, the

subscribed data can be streamed at a higher rate to capture

potentially important data and events that might indicate continuous

service degeneration or anomalies; while when the wireless signal

strength crosses a configured threshold, the subscribed data can be

streamed at a lower rate to maintain efficient resource utilization.

A.2. Reducing Impact on High CPU Utilization

Continuous monitoring of some metrics is essential for maintaining

network and service health, however, this can place a significant

burden on the device's CPU utilization, especially when the device is

running resource-intensive tasks and is overloaded. When the CPU

utilization on the device exceeds a certain high-level value, it is

crucial to manage the network monitoring process in a way that

minimizes its impact on overall system performance.

In such cases, adaptive subscription can dynamically adjust the

period interval with which to report streaming update and help

balance monitoring needs with computational demands. When the CPU

utilization on the device exceeds a certain high-level value, the

subscriber can specify a longer period interval for some less

critical statistics to make room and save more resources.

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Conversely, When the CPU utilization falls below a specified

threshold, indicating the device has sufficient idle resources, the

subscriber can revert to a shorter period interval for streaming data

without exhausting the CPU resources at the same time.

Appendix B. Example YANG Module

This section presents an example YANG module so that Appendix C can

give examples of how the YANG module defined in Section 3.2 is used

to perform adaptive subscription. The example YANG module used in

this section represents a Wi-Fi Network Diagnostics data specified in

[CHIP] which can be used by a Node to assist a user or Administrative

Node in diagnosing potential problems.

YANG tree diagram for the "example-wifi-network-diagnostic" module:

module: example-wifi-network-diagnostic

+--ro server

| +--ro bssid? yang:mac-address

| +--ro security-type? enumeration

| +--ro wifi-version? enumeration

| +--ro channel-num? int8

| +--ro rssi? int8

| +--ro beacon-lost-count? int8

| +--ro beacon-rx-count? int8

| +--ro packet-multicast-rx-count? int8

| +--ro packet-multicast-tx-count? int8

| +--ro packet-unicast-rx-count? int8

| +--ro packet-unicast-tx-count? int8

| +--ro current-max-rate? int8

| +--ro overrun-count? int8

+--ro events

+--ro event\* [name]

+--ro name string

+--ro disconnection? enumeration

+--ro association-failure? enumeration

+--ro connection-status? enumeration

B.1. "example-wifi-network-diagnostic" YANG Module

module example-wifi-network-diagnostic {

yang-version 1;

namespace "http://example.com/yang/wifi-network-diagnostic";

prefix wnd;

import ietf-yang-types {

prefix yang;

}

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container server {

config false;

description

"Configuration of the Wi-Fi Server logical entity.";

leaf bssid {

type yang:mac-address;

description

"The MAC address of a wireless access point.";

}

leaf security-type {

type enumeration {

enum unspecified {

value 0;

}

enum none {

value 1;

}

enum wep {

value 2;

}

enum wpa {

value 3;

}

enum wpa2 {

value 4;

}

enum wpa3 {

value 5;

}

}

description

"The type of Wi-Fi security used. A value of 0

indicate that the interface is not currently

configured or operational.";

}

leaf wifi-version {

type enumeration {

enum 80211a {

value 0;

}

enum 80211b {

value 1;

}

enum 80211g {

value 2;

}

enum 80211n {

value 3;

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}

enum 80211ac {

value 4;

}

enum 80211ax {

value 5;

}

}

description

"The highest 802.11 standard version usable

by the Node.";

}

leaf channel-num {

type int8;

description

"The channel that Wi-Fi communication is currently

operating on. A value of 0 indicates that the interface

is not currently configured or operational.";

}

leaf rssi {

type int8;

description

"The RSSI of the Node's Wi-Fi radio in dBm.";

}

leaf beacon-lost-count {

type int8;

description

"The count of the number of missed beacons the

Node has detected.";

}

leaf beacon-rx-count {

type int8;

description

"The count of the number of received beacons. The

total number of expected beacons that could have been

received during the interval since association matches

the sum of BeaconRxCount and BeaconLostCount. ";

}

leaf packet-multicast-rx-count {

type int8;

description

"The number of multicast packets received by

the Node.";

}

leaf packet-multicast-tx-count {

type int8;

description

"The number of multicast packets transmitted by

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the Node.";

}

leaf packet-unicast-rx-count {

type int8;

description

"The number of multicast packets received by

the Node.";

}

leaf packet-unicast-tx-count {

type int8;

description

"The number of multicast packets transmitted by

the Node.";

}

leaf current-max-rate {

type int8;

description

"The current maximum PHY rate of transfer of

data in bytes-per-second.";

}

leaf overrun-count {

type int8;

description

"The number of packets dropped either at ingress or

egress, due to lack of buffer memory to retain all

packets on the ethernet network interface. The

OverrunCount attribute is reset to 0 upon a

reboot of the Node.";

}

}

container events {

config false;

description

"Configuration of WI-FI Network Diagnostic events.";

list event {

key "name";

description

"The list of event sources configured on the

server.";

leaf name {

type string;

description

"The unique name of an event source.";

}

leaf disconnection {

type enumeration {

enum de-authenticated {

value 1;

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}

enum dis-association {

value 2;

}

}

description

"A Node's Wi-Fi connection has been disconnected as a

result of de-authenticated or dis-association and

indicates the reason.";

}

leaf association-failure {

type enumeration {

enum unknown {

value 0;

}

enum association-failed {

value 1;

}

enum authentication-failed {

value 2;

}

enum ssid-not-found {

value 3;

}

}

description

"A Node has attempted to connect, or reconnect, to

a Wi-Fi access point, but is unable to successfully

associate or authenticate, after exhausting all

internal retries of its supplicant.";

}

leaf connection-status {

type enumeration {

enum connected {

value 1;

}

enum notconnected {

value 2;

}

}

description

"A Node's connection status to a Wi-Fi network has

changed. Connected, in this context, means that

a Node acting as a Wi-Fi station is successfully

associated to a Wi-Fi Access Point.";

}

}

}

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}

Appendix C. Adaptive Subscription and Notification Example

The examples within this document use the normative YANG module

"ietf-adaptive-subscription" defined in Section 3.2 and the non-

normative example YANG module "example-wifi-network-diagnostic"

defined in Appendix B.1.

This section shows some typical adaptive subscription and

notification message exchanges.

C.1. Configured Subscription Example

The client configures adaptive subscription policy parameters on the

server. The adaptive subscription configuration parameters require

the server to support two update intervals (i.e., 5 seconds, 20

seconds) and report updates every 20 seconds if the RSSI value is

greater than or equal to -65 dB; If the RSSI value is less than -65

dB, switch to 5 seconds period value to report updates. The server

compares the rssi value with -65 dB every 2 seconds. Figure 1

specifies an example of configured subscription with the <edit-

config> operation.

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

<edit-config>

<target>

<running/>

</target>

<config>

<subscriptions

xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications"

xmlns:yp="urn:ietf:params:xml:ns:yang:ietf-yang-push">

<subscription>

<id>1011</id>

<yp:datastore

xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">

ds:operational

</yp:datastore>

<yp:datastore-xpath-filter

xmlns:wnd="http://example.com/yang/wifi-network-diagnostic">

/wnd:server

</yp:datastore-xpath-filter>

<as:adaptive-periodic

xmlns:as="urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription">

<as:periodic>

<as:name>adaptive-period-1</as:name>

<as:eval-expression>

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/wnd:server/wnd:rssi&lt;-65

</as:eval-expression>

<as:eval-interval>200</as:eval-interval>

<as:period>500</as:period>

<as:anchor-time>2025-04-11T08:00:00Z</as:anchor-time>

</as:periodic>

<as:periodic>

<as:name>adaptive-period-2</as:name>

<as:eval-expression>

/wnd:server/wnd:rssi&gt;=-65

</as:eval-expression>

<as:eval-interval>200</as:eval-interval>

<as:period>2000</as:period>

<as:anchor-time>2025-04-11T08:00:00Z</as:anchor-time>

</as:periodic>

</as:adaptive-periodic>

<receivers>

<receiver>

<name>host.example.com</name>

</receiver>

</receivers>

</subscription>

</subscriptions>

</config>

</edit-config>

</rpc>

Figure 1: An Example of Configured Subscription

C.2. Dynamic Subscription Example

Alternatively, the subscriber may send an "establish-subscription"

RPC with the parameters listed in Section 2.1 to request the creation

of an adaptive subscription. The adaptive subscription configuration

parameters require the server to report updates every 5 seconds if

the RSSI value is less than -65 dB; If the RSSI value is greater than

or equal to -65 dB, switch to 20 seconds period value. The server

compares the RSSI value with -65 dB every 2 seconds. Figure 2

specifies an example of the "establish-subscription" RPC request.

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<netconf:rpc message-id="101"

xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0">

<establish-subscription

xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications"

xmlns:yp="urn:ietf:params:xml:ns:yang:ietf-yang-push">

<yp:datastore

xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">

ds:operational

</yp:datastore>

<yp:datastore-xpath-filter

xmlns:wnd="http://example.com/yang/wifi-network-diagnostic">

/wnd:server

</yp:datastore-xpath-filter>

<as:adaptive-periodic

xmlns:as="urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription">

<as:periodic>

<as:name>adaptive-period-1</as:name>

<as:eval-expression>

/wnd:server/wnd:rssi&lt;-65

</as:eval-expression>

<as:eval-interval>200</as:eval-interval>

<as:period>500</as:period>

<as:anchor-time>2025-04-11T08:00:00Z</as:anchor-time>

</as:periodic>

<as:periodic>

<as:name>adaptive-period-2</as:name>

<as:eval-expression>

/wnd:server/wnd:rssi&gt;=-65

</as:eval-expression>

<as:eval-interval>200</as:eval-interval>

<as:period>2000</as:period>

<as:anchor-time>2025-04-11T08:00:00Z</as:anchor-time>

</as:periodic>

</as:adaptive-periodic>

</establish-subscription>

</netconf:rpc>

Figure 2: An Example of Dynamic Subscription

C.3. "xpath-evaluation-unsupported" error response example

If the subscriber has authorization to establish the subscription

with a server, but the server had not been able to fully satisfy the

request from the subscriber, the server should send an RPC error

response.

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For instance, if the XPATH 1.0 syntax against the targeted data node

defined in "eval-expression" is not supported by the server' s

implementation, the server returns a reply indicating a failure.

Figure 3 illustrates an example of RPC error response with this.

<?xml version="1.0" encoding="utf-8"?>

<rpc-reply message-id="101"

xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">

<rpc-error>

<error-type>application</error-type>

<error-tag>invalid-value</error-tag>

<error-severity>error</error-severity>

<error-app-tag>

ietf-adaptive-subscription:xpath-evaluation-unsupported

</error-app-tag>

<error-path

xmlns:wnd="http://example.com/yang/wifi-network-diagnostic">

/wnd:server/wnd:rssi

</error-path>

</rpc-error>

</rpc-reply>

Figure 3: An Example of RPC Error Response

Since adaptive subscription allows a server to be configured with

multiple different period intervals and corresponding XPath

evaluation criteria to trigger update interval switch in the server,

it may be possible for the server to return multiple <rpc-error>

elements with "xpath-evaluation-unsupported" failure specified by

different error paths. The subscriber can use this information in

future attempts to establish a subscription.

C.4. "adaptive-period-update" notification example

Suppose initially the RSSI value is below -65dB, the server pushes

updates every 5 seconds starting at 2025-04-11T08:00:00Z and

continuing through 2025-04-11T08:02:05Z. The server evaluates the

RSSI value against -65 dB every 2 seconds and from

2025-04-11T08:02:06Z it detects that the RSSI value exceeds -65 dB

continuously. As the "anchor-time" is set to 2025-04-11T08:00:00Z

for adaptive-period-2, which means updates can only be sent at the

top of every 00, 20, 40 second, the server sends the next update

record at 2025-04-11T08:02:20Z and adjust the update interval to 20

seconds. Before this, the server generates and sends an "adaptive-

period-update" notification to inform receivers of the new period

interval value. An example of "adaptive-period-update" notification

is indicated in Figure 4.

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<notification

xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0"

xmlns:yp="urn:ietf:params:xml:ns:yang:ietf-yang-push">

<eventTime>2025-04-11T08:02:19.33Z</eventTime>

<adaptive-period-update

xmlns="urn:ietf:params:xml:ns:yang:ietf-adaptive-subscription">

<id>1011</id>

<period>2000</period>

<period-update-time>2025-04-11T08:02:20Z</period-update-time>

<satisfied-criteria-data>

<path>/wnd:server/wnd:rssi</path>

<value>-40</value>

</satisfied-criteria-data>

<yp:datastore

xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">

ds:operational

</yp:datastore>

<yp:datastore-xpath-filter

xmlns:wnd="http://example.com/yang/wifi-network-diagnostic">

/wnd:server

</yp:datastore-xpath-filter>

</adaptive-period-update>

</notification>

Figure 4: An Example of "adaptive-period-update" Notification

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