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An Application Layer Interface for Non-IP device control (NIPC)
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Abstract

This memo describes an API that allows applications to perform operations against a gateway serving one or more devices described by an SDF model. The document describes a RESTful application layer interface to perform operations on those devices, as well as a CBOR-based publish-subscribe interface for streaming data.

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1. Introduction

1.1. Motivation

Low-power sensors, actuators and other connected devices introduced in environments and use cases such as building management, healthcare, workplaces, manufacturing, logistics and hospitality are often battery-powered. With limited power budget, they may not be able to support the IP protocol on their wired or wireless interfaces, hence they support protocols that require a lower power budget. Prominent examples of such protocols are [BLE53] and [Zigbee22]. These devices typically need to communicate with devices or applications that are connected to IP-based networking infrastructure. Therefore, applications on the IP network that need to communicate or receive telemetry from these non-IP low-power devices must do so through a gateway function on the IP network. This gateway function then translates the communication to the non-IP protocol that the low-power device supports.

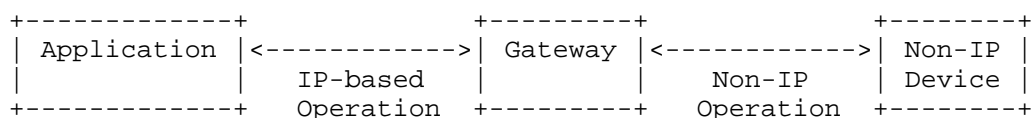


Figure 1: Gateway for non-IP Devices

There have been efforts to define Gateway functions for devices that support a particular protocol, such as a BLE GATT REST API for BLE Gateways ([Gatt-REST-API]), however they have been limited to a single protocol or a particular use case. In absence of an open standard describing how applications on an IP network communicate with non-IP devices, bespoke and vendor-specific implementations have proliferated. The implication of this is that every use case deployment requires implementation of a new API, and possibly requires its own gateway, which results in proliferation of network infrastructure. This specification aims to define a Gateway API for these Non-IP protocols that can be leveraged by a Network Gateway connected to a wireless network. The API aims to enable a Gateway to support any non-IP protocol. The gateway can simultaneously support

multiple applications and multiple non-IP protocols as well as different versions of the same protocol. The specification is extensible, in order to support existing and future non-IP protocols.

A standardized Non-IP Gateway interface has following benefits:

- * Avoid the need for applications to perform new and bespoke integrations for different environments.
- * Avoid having to deploy multiple Gateway functions to support multiple non-IP use cases.
- * Faster and more cost-effective adoption of Non-IP devices in IP network environments.

1.2. Non-IP Gateway

A non-IP gateway is an application layer gateway that allows Applications on IP networks to communicate with Non-IP devices leveraging NIPC APIs. NIPC APIs consist of reading or writing properties of devices, performing actions on devices, as well as enabling or disabling events on devices.

In order to perform NIPC operations on a device, 2 prerequisites must be fulfilled: - The device must be onboarded on the gateway. Onboarding declares a device instance to the gateway. This allows the NIPC Gateway to retrieve the device object, identified by an id referenced in the path of the NIPC API. The definition of the onboarding function is out of scope of this document, but can be provided by a provisioning interface such as [RFC7644] leveraging [I-D.ietf-scim-device-model]. - An interaction model for the class of devices must be registered with the gateway. This allows the gateway to understand how to interact with the device in a protocol-neutral way. The interaction model is provided to the gateway by means of an SDF model, described in [I-D.ietf-asdf-sdf].

A non-IP gateway provides following functions:

- * Authentication and authorization of application clients that will leverage the gateway API to communicate with Non-IP devices.
- * Access to a database of onboarded devices.
- * The ability to consume an interaction model for a class of devices.

- * An API that allows for reading or writing properties of devices, performing actions on devices, as well as enabling or disabling events on devices.
- * The ability to manage connections to Non-IP devices, either implicitly when performing a NIPC operation, or explicitly by means of a connection management API.
- * The ability to stream events from Non-IP devices to applications on the IP network by means of a publish/subscribe interface.
- * One or more channels to process requests, responses, and asymmetric communications with the non-IP radio resources (Access Points) at its disposal.

The Application gateway is a network function, so its goal is to proxy payloads between Non-IP and IP networks. It is not intended to be a middleware function that interprets, decodes or modifies these payloads.

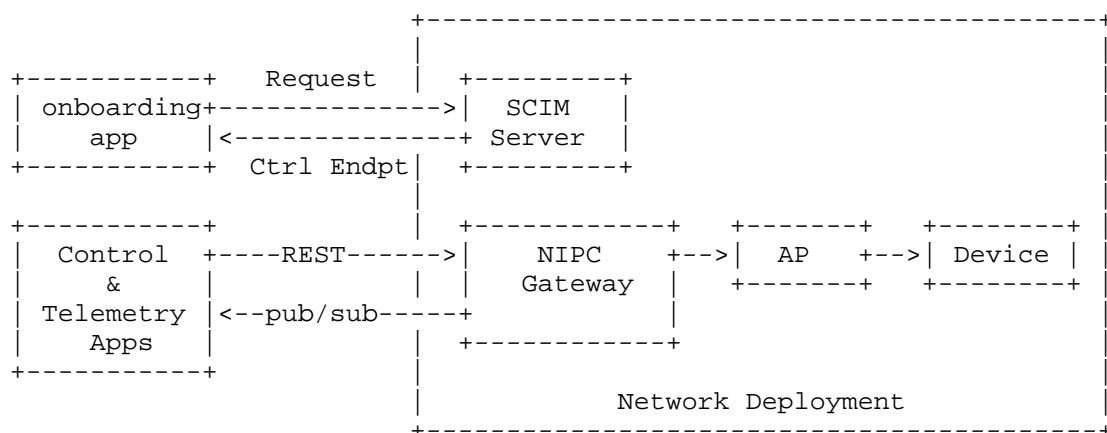


Figure 2: Basic Architecture

Figure 2 shows us applications, the NIPC application layer gateway (ALG), an access point (AP), and a device (D). The applications, application layer gateway and access point are deployed on an IP-Network. The AP supports a Non-IP interface, which it uses to communicate with the device. The Application is deployed in a different administrative domain than the network elements (ALG & AP). The role of the application layer gateway is to provide a gateway function to applications wishing to communicate with non-IP devices in the network domain served by the gateway. Applications implementing Non-IP Control can leverage RESTful interfaces to communicate with Non-IP devices in the network domain and subscribe to events leveraging a CBOR-based pub/sub interface.

1.3. 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.

1.4. Glossary

- * NIPC: Non-IP Control, the application layer interface defined in this document.
- * NIPC Gateway: An application layer gateway that implements the NIPC interface.
- * SDF: Semantic Device Format, a standardized format to describe devices and their interaction models, as defined in [I-D.ietf-asdf-sdf].
- * SDF Affordance: An interaction point on a device as defined in an SDF model. Examples of affordances are properties, actions & events.
- * SDF Global Name: Absolute URI (with fragment) identifying an SDF affordance.
- * SCIM: System for Cross-domain Identity Management, a standardized protocol to manage identity information, as defined in [RFC7644].
- * ALG: Application Layer Gateway.
- * Non-IP Device: Device using a non-IP protocol (e.g. BLE, Zigbee) requiring a gateway for IP interaction.

- * Protocol Mapping / sdfProtocolMap: Mapping from protocol-neutral SDF affordances to protocol-specific operations.
- * BLE: Bluetooth Low Energy protocol.
- * Zigbee: Low-power mesh networking protocol.
- * GATT: Generic Attribute Profile used in BLE for services/characteristics/descriptors.
- * Service (BLE): Top-level GATT grouping of characteristics.
- * Characteristic (BLE): GATT data element supporting read/write/notify.
- * Descriptor (BLE): Metadata element attached to a characteristic.
- * Bonding (BLE): Procedure to establish trusted, reusable security keys.
- * Service Discovery (BLE): Procedure to enumerate GATT services/characteristics/descriptors.
- * Device Onboarding: Registration of a device identity and metadata before NIPC operations.
- * Device ID / Group ID: UUID identifying a device or a group of devices.
- * UUID: Universally unique identifier (128-bit).
- * Data Application / Data App: Registered application receiving streamed event data.
- * MQTT: Publish/subscribe messaging protocol used for streaming.
- * Webhook: HTTP callback endpoint for push delivery.
- * WebSocket: Bidirectional TCP-based message channel over HTTP.
- * Publish/Subscribe Interface: Streaming channel for events (CBOR-encoded payloads).
- * CBOR: Concise Binary Object Representation; compact binary data format.
- * CDDL: Concise Data Definition Language; schema language for CBOR data.

- * JSON: JavaScript Object Notation; text encoding used for API payloads.
- * Access Point (AP): Network element with non-IP radio interface communicating with devices.

2. Architecture

2.1. Overview

Non-IP protocols, such as BLE or Zigbee, typically define a number of basic operations that are similar across protocols. Examples of this are read and write data. NIPC provides a unified API to support those operations.

To perform NIPC operations on a device, the gateway has 2 prerequisites:

1. Information about the instance of the device or thing: The device must be onboarded on the gateway (e.g. by means of SCIM with [I-D.ietf-scim-device-model]). This allows the NIPC Gateway to retrieve the device object, identified by an ID referenced in the path of the NIPC API.
2. Information about the interaction model: The Gateway must be able to perform protocol-neutral operations, and hence requires a mapping of protocol-neutral operations to protocol specific operations. These are supplied to the gateway by means of an SDF model, described in [I-D.ietf-asdf-sdf].

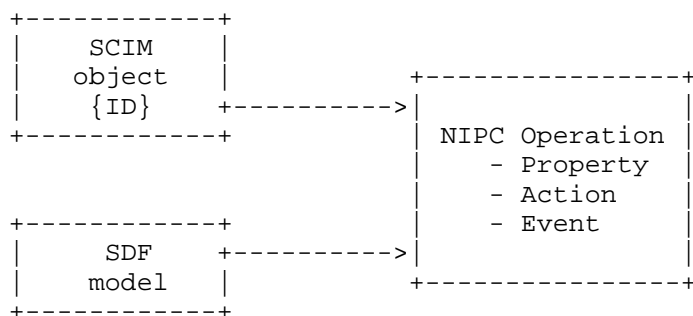


Figure 3: NIPC prerequisites

Once these 2 prerequisites have been fulfilled, applications that are authorized can perform NIPC operations on device IDs. Please review Section 9 for more information on authorization. NIPC operations are operations on properties, or constitute actions or events on devices, as per the affordances defined in an SDF model.

2.2. Onboarding

In order to perform a NIPC operation on a device, the device has to have its identity declared to the NIPC gateway. We refer to this as 'onboarding'. Apart from the device identity, it is also necessary that the device object contains all required information to bootstrap trust with the device, as well as establish connectivity, as NIPC operations assume that connectivity can be set up without explicitly calling an API. Although onboarding could theoretically be performed in different ways, it is strongly recommended to leverage [RFC7644] with [I-D.ietf-scim-device-model], as the SCIM device schema has been developed to contain all necessary attributes and extensions to support NIPC.

2.3. Registrations

NIPC registration APIs allow applications to declare information about a device class, or an application authorization. These APIs do not perform any operations on a specific device. NIPC supports 2 types of registrations: - Registering an SDF model for a class of devices. - Registering an authorization for a data application. This authorizes an application to receive streaming event data from devices. Optionally a pointer to the model and the data-app registration can be included in the SCIM object for the device. See [I-D.ietf-scim-device-model] and [I-D.ietf-asdf-sdf-protocol-mapping] for more information.

2.3.1. SDF model registrations

The SDF model for a class of devices determines how a gateway may interact with these devices in a protocol-neutral way. In order to do that, the SDF model must contain protocol mappings, mapping protocol-neutral SDF affordances to protocol-specific ones as defined in [I-D.ietf-asdf-sdf-protocol-mapping]. The SDF affordances supported by the device, as well as its protocol-mappings, are provided to the gateway by means of an SDF model registration. SDF models are described in [I-D.ietf-asdf-sdf].

2.3.2. Data application registrations

An application authorized to perform NIPC operations on devices needs to be able to define which applications can receive streaming event data from the gateway. The data-app registrations API allows mapping of an event to a data app as well as a protocol.

2.4. NIPC Operations

NIPC operations are protocol-neutral operations on SDF affordances, more specifically properties, actions & events. NIPC operations can happen against affordances that were registered in an SDF model. If connection management is required to execute a NIPC operation, it is assumed that the gateway implicitly establishes and tears down required connections.

The NIPC APIs that perform NIPC operations are organized in 3 main categories:

- * Properties APIs: These APIs allow applications to perform operations on properties, such as to read or write values to them.
- * Actions APIs: These APIs perform actions on devices, such as enabling or disabling a feature on a device.
- * Events APIs: These APIs allow apps to enable or disable event reporting on devices. Events are reported over the events publish/subscribe interface.

2.4.1. Connection management for NIPC Operations

For protocols that require connection management before executing an operation, a NIPC gateway will perform implicit connection management. When executing a NIPC operation, a NIPC Gateway can set up a connection with a device as well as tear down the connection after the operation has completed. A NIPC Gateway may support explicit connection management as well. Explicit connection management can be used by an app that wants to perform multiple NIPC operations in a single connection. Explicit connection management can be performed by calling the APIs in Section 4.4. After establishing an explicit connection to a device, an application calls a NIPC Operation, the Gateway will leverage the existing connection and will also not tear the connection down after the operation completes. The app will have to explicitly close the connection.

2.4.2. Extensions

NIPC is extendable as a NIPC gateway may want to provide a way to execute a complex set of NIPC operations in a single API call, or may want to perform an operation that can deliver an outcome more efficiently than a NIPC API. An example of an extension that uses compound operation is the bulk API.

Extensions must leverage the /extensions path element. In order to assure inter-operability, extensions must be IANA registered in the registry in Section 10.2.

2.5. Events publish subscribe interface

Events are published on a publish/subscribe interface. Events can be of different types:

- * Streaming data from devices: Streaming data is activated/deactivated with the NIPC events API
- * Broadcasts from devices
- * Connection events: Devices connecting & disconnecting

2.6. Protocols

2.6.1. NIPC APIs

NIPC is a protocol that is based on RESTful HTTP [RFC9114]. Along with HTTP headers and URIs, NIPC uses JSON [RFC7159] payloads to convey NIPC operations, such as registrations, actions, event and property operations. This is the case for both request and response parameters, as well as errors. NIPC uses the JSON media type "application/nipc+json" that is registered in Section 10.1, except for the SDF model registrations APIs, where the media type reflects the content as an SDF model, and hence is media type "application/sdf+json". The NIPC property APIs also support the use of other media types to describe the content of the property.

2.6.2. NIPC publish/subscribe events

NIPC publish/subscribe events are encoded in CBOR ([RFC8949]) and can be delivered over either:

- * MQTT
- * Webhook

- * WebSocket

CBOR was selected for the publish/subscribe interface as Non-IP payloads are typically binary. CBOR encodes binary payloads efficiently, and is more compact than JSON, therefore reducing the amount of data that needs to be transmitted to the application.

2.7. Paths

2.7.1. General

The NIPC HTTP protocol is described in terms of a path relative to a Base URI. The Base URI MUST NOT contain a query string, as clients MAY append additional path information and query parameters as part of forming the request. The base URI is a URL that most often consists of the "https" protocol scheme, a domain name, and an initial path [RFC3986]. That initial path for NIPC is recommended to be /nipc. For example:

```
"https://example.com/nipc/"
```

Additionally a version number may be added, for example:

```
"https://example.com/nipc/v1/"
```

After the base or version number, the path must contain a collection identifier. The collection identifier can be one of the following:

- * /registrations: for NIPC registration APIs
- * /devices: for NIPC operations on devices
- * /groups: for NIPC operations on groups of devices
- * /extensions: for NIPC extension APIs

The well-known URI /.well-known/nipc defined in Section 10.3 can be used to discover the base path of the NIPC APIs and the supported versions and extensions. The response to a GET request on this URI MUST be a JSON document that contains the base path, and optionally the supported versions and extension APIs. The paths MUST be a URI template as defined in [RFC6570]. The following is an example of a template defining the NIPC base path as well as supported extensions on a server.

```
{
  "base_path": "/nipc",
  "versions": [
    "/v1"
  ],
  "extensions": [
    "/extensions/{id}/bulk",
    "/extensions/{id}/properties/blob",
    "/extensions/{id}/properties/file",
    "/extensions/{id}/properties/read/conditional",
    "/extensions/{id}/events/conditional",
    "/extensions/{id}/properties/write"
  ]
}
```

Figure 4: Example response for /.well-known/nipc

A formal CBOR definition of the well-known response is as follows:

```
NipcWellKnown = {
  base_path: text,
  ? versions: [* uri / text],
  ? extensions: [* uri / text]
}
```

2.7.2. NIPC Registrations

Registrations leverage the base path + /registrations. NIPC supports SDF model registrations and data-app registrations.

paths:

- * /registrations/models
- * /registrations/data-apps

2.7.3. NIPC Operations

Every NIPC Operations API pertains to either a device or group of devices, identified by an ID, hence the ID will be reflected as the first parameter in the path. For example:

```
"https://example.com/nipc/v1/{id}"
```

The second parameter in the path refers to the NIPC operation that the API will perform on the device. This can be:

- * properties

- * events
- * actions
- * extensions

These are described in Section 2.4.

2.8. Schema

The NIPC schema leans heavily on the SDF schema, as defined in [I-D.ietf-asdf-sdf]. NIPC operations map directly to SDF affordances.

2.8.1. SDF model registrations

In order to perform a NIPC operation on a device, an SDF interaction model needs to be declared that provides protocol mappings for the SDF affordances the operations will be performed on.

The SDF model can be registered by means of a registrations API POST with the SDF model in the body of the request. A registered SDF model can be fetched by a registrations API GET with an sdfReference.

2.8.2. NIPC Operations

NIPC operations require 2 key parameters: 1) A device ID identifying the device the operation should be executed on 2) an SDF name for the SDF affordance the operation pertains to

2.8.2.1. Device ID

All NIPC operations are executed against a device or a group of devices. Devices or groups of devices are identified by a unique UUID, adhering to the [RFC9562].

Attribute	Type	Example
id	uuid	12345678-1234-5678-1234-56789abcdef4

Table 1: Definition of a device or group of devices

ID is the unique UUID of the device. This ID is generated when onboarding the device, for example by a SCIM server. This identifier is returned to the application. As such, this ID is a common identifier, known both to the application as well as the NIPC Server.

If the server is not collocated with the SCIM server, the NIPC server will have to retrieve the device object from the SCIM server by means of the ID.

2.8.3. SDF Name

NIPC operations happen against SDF affordances and are referenced with an global sdfName, which is the full path including the namespace.

The operations are either Properties, Events or Actions and their references are of type string

For example:

NIPC Operation Example SDF Name used in the API	
Property	https://example.com/heartrate#/sdfObject/thermostat/sdfProperty/temperature
Event	https://example.com/heartrate#/sdfObject/healthsensor/sdfEvent/fallDetected
Action	https://example.com/heartrate#/sdfObject/thermostat/sdfAction/resetThermostat

Table 2: Example SDF names for NIPC operations

2.8.4. Responses

A NIPC Gateway will respond to a NIPC operation request synchronously, and provide the result of the completed operation in the HTTP response.

The exception to the above are NIPC extensions, Section 5.2. These contain compound statements, and thus require the gateway to execute multiple NIPC operations. In this case the NIPC gateway will return HTTP status code 202 after receiving the request and verifying it is able to execute it. The client can then perform an HTTP GET of the extensions API to get the execution status for the request. If a callback URL address was defined in the request, the NIPC Gateway can optionally perform a callback with a response to the compound request after the compound statement completes.

Actions also follow an asynchronous pattern, returning HTTP status code 202 when the action is accepted, along with a Location header pointing to the action instance for status tracking.

A failure response will consist of a HTTP status code of 4xx or 5xx, and will follow the [RFC9457] Problem Details format with application/problem+json media type. The response will contain a type field with a URI identifying the error type, and a human-readable detail field. The type field is a URI and is described in Section 6.

Failure response:

Example of a failure response:

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

```
{
  "type": "https://www.iana.org/assignments/nipc-problem-types#invalid-id",
  "status": 400,
  "title": "Invalid Device ID",
  "detail": "Device ID 12345678-1234-5678-1234-56789abcdef4 does not\
\ exist or is not a device"
}
```

Figure 5: Example failure response

where-

- * "type" is a URI identifying the specific error type
- * "status" is the HTTP status code
- * "title" is a brief, human-readable summary of the error type
- * "detail" is a human-readable explanation specific to this occurrence

3. NIPC Registrations

NIPC allows an application to register an SDF model for a class of devices, as well as a data application that will receive streaming data from the gateway.

3.1. SDF model registrations APIs

These APIs allow applications to register an SDF model for a class of devices. These APIs use the application/sdf+json media type, as described in Section 7.1 of [I-D.ietf-asdf-sdf].

3.1.1. Register an SDF model

Method: POST /registrations/models

Description: Registers one or more SDF models for a class of devices

Request Body:

- * an SDF document in JSON format containing one or more sdfThings or sdfObjects, similar to the example in Appendix D.

Response:

Example of a response:

```
[
  {
    "sdfName": "https://example.com/heartrate#/sdfObject/healthsensor"
  }
]
```

Figure 6: Example of a response to an SDF model registration

where-

- * "sdfName" is the name of the top-level sdfThing or sdfObject in the SDF model

The sdfName in the response is wrapped in an object to allow for future extensions to the response.

3.1.2. Get all SDF models

Method: GET /registrations/models

Description: Gets all SDF models registered with the gateway

Response:

Example of a response:

```
[
  {
    "sdfName": "https://example.com/hearttrate#/sdfObject/healthsensor"
  },
  {
    "sdfName": "https://example.com/thermometer#/sdfObject/thermometer"
  }
]
```

Figure 7: Example get all SDF models response

where-

- * "sdfName" is the name of the top-level sdfThing or sdfObject in the SDF model

3.1.3. Get an SDF model

Method: GET /registrations/models{?sdfName}

Description: Gets an SDF model registered with the gateway

Query Parameters:

- * sdfName: the name of the top-level sdfThing or sdfObject in the SDF model.

Response:

The SDF model is returned in JSON format, similar to the example in Appendix D.

3.1.4. Delete an SDF model

Method: DELETE /registrations/models{?sdfName}

Description: Deletes an SDF model registered with the gateway

Query Parameters:

- * sdfName: the name of the top-level sdfThing or sdfObject in the SDF model.

Response:

Example of a response:

```
{
  "sdfName": "https://example.com/heartrate#/sdfObject/healthsensor"
}
```

Figure 8: Example delete SDF model response

where-

- * "sdfName" is the name of the top-level sdfThing or sdfObject in the SDF model

3.1.5. Update an SDF model

Method: PUT /registrations/models{?sdfName}

Description: Updates an SDF model registered with the gateway

Query Parameters:

- * sdfName: the name of the top-level sdfThing or sdfObject in the SDF model.

Request Body:

- * an SDF model in JSON format, similar to the example in Appendix D.

Response:

Example of a response:

```
{
  "sdfName": "https://example.com/heartrate#/sdfObject/healthsensor"
}
```

Figure 9: Example update SDF model response

where-

- * "sdfName" is the name of the top-level sdfThing or sdfObject in the SDF model

3.2. Data application registrations APIs

These APIs allow applications to register a data application that will receive streaming data from the gateway. These APIs operate on a data app ID. This ID corresponds to the endpoint app ID of the telemetry endpoint app that is registered with the SCIM server. The endpoint app is defined in Section 6 of [I-D.ietf-scim-device-model].

Apart from the endpoint app ID, the API also registers the protocol the data-app supports. These can be one of the following:

- * mqttClient: The data-app is an MQTT client, which means that the gateway is an MQTT broker.
- * mqttBroker: The data-app is an MQTT broker. The registration API has to include the MQTT broker configuration data, such as the URI, credentials and MQTT topic to publish to.
- * webhook: The data-app supports a webhook the gateway can publish to. The registration API has to include the webhook URI & credentials.
- * websocket: The data-app supports a websocket interface. The registration API has to include the websocket URI & credentials.

3.2.1. Register a data application

Method: POST /registrations/data-apps{?dataAppId}

Description: Registers a data application with the gateway

Query Parameters:

- * dataAppId: the ID of the data application

Request Body:

- * events: a list of events that the data application wants to receive streaming data for.

The request body also contains one of the following:

- * mqttClient: a boolean that denotes that the data application is an MQTT client that will receive streaming data over MQTT
- * mqttBroker: an object that contains the MQTT broker information where the broker will publish the streaming data.
 - URI: the URI of the MQTT broker.
 - username: the username to authenticate with the MQTT broker
 - password: the password to authenticate with the MQTT broker
 - brokerCACert: the base64-encoded CA certificate of the MQTT broker (optional)

- customTopic: By default, the topic will be composed of data-app/<dataAppId>/<namespace>/<json_pointer_to_sdf_event>, as described in Section 4.2. You can configure a custom topic to publish the streaming data to (optional)
- * webhook: an object that contains a webhook URL along with any credentials that are required to authenticate the webhook. The webhook URL is the endpoint where the streaming data will be sent.
 - URI: the webhook URL. The URL MUST include the scheme used by the webhook server (e.g., "https://"). It is up to the implementation to support different schemes. If a scheme is not supported, the NIPC gateway MUST return an error response with type "https://www.iana.org/assignments/nipc-problem-types#unsupported-uri-scheme".
 - headers: An object that contains the headers to be sent with the webhook request. The headers can contain any authentication information required by the webhook server. Each header is represented as a key-value pair in the object.
 - serverCACert: the CA certificate of the webhook server, encoded as per [RFC7468] and newlines encoded as '\n' (optional)
- * websocket: an object that contains a websocket URL along with any credentials that are required to authenticate the websocket. The websocket URL is the endpoint where the streaming data will be sent.
 - URI: the websocket URL. The URL MUST include the scheme used by the websocket server (e.g., "wss://"). It is up to the implementation to support different schemes. If a scheme is not supported, the NIPC gateway MUST return an error response with type "https://www.iana.org/assignments/nipc-problem-types#unsupported-uri-scheme".
 - headers: An object that contains the headers to be sent with the websocket request. The headers can contain any authentication information required by the websocket server. Each header is represented as a key-value pair in the object.
 - serverCACert: the CA certificate of the websocket server, encoded as per [RFC7468] and newlines encoded as '\n' (optional)

Example of a request body:

```
===== NOTE: '\ ' line wrapping per RFC 8792 =====  
  
{  
  "events": [  
    {  
      "event": "https://example.com/heartrate#/sdfObject/healthsenso\  
r/sdfEvent/fallDetected"  
    },  
  ],  
  "mqttClient": true  
}
```

Figure 10: Example with mqttClient

Example of a request body for a data application that is an MQTT broker:

```
===== NOTE: '\ ' line wrapping per RFC 8792 =====  
  
{  
  "events": [  
    {  
      "event": "https://example.com/heartrate#/sdfObject/healthsenso\  
r/sdfEvent/fallDetected"  
    },  
  ],  
  "mqttBroker": {  
    "URI": "mqtt.example.com:1883",  
    "username": "user",  
    "password": "password",  
    "customTopic": "custom/topic"  
  }  
}
```

Figure 11: Example with mqttBroker

Response:

If successful, the response will be identical to the request body.

3.2.2. Update a data application

Method: PUT /registrations/data-apps{?dataAppId}

Description: Updates a data application with the gateway

Query Parameters:

- * dataAppId: the ID of the data application

Request Body: Same as the request body for the register data application API.

Response:

If successful, the response will be identical to the request body.

3.2.3. Get a data application

Method: GET /registrations/data-apps{?dataAppId}

Description: Gets a data application registered with the gateway

Query Parameters:

- * dataAppId: the ID of the data application

Response:

The response will be identical to the request body for the register data application API.

3.2.4. Delete a data application

Method: DELETE /registrations/data-apps{?dataAppId}

Description: Deletes a data application registered with the gateway

Query Parameters:

- * dataAppId: the ID of the data application

Response:

The response will be identical to the request body for the register data application API.

4. NIPC APIs

The primary goal of the NIPC APIs is to perform operations on SDF Affordances, such as properties, events & actions. This allows a user of the NIPC API to get or update properties of devices, perform actions on devices, and consume events from devices.

The NIPC APIs consist of three main collections which reflect SDF Affordances as defined in Section 1.2 of [I-D.ietf-asdf-sdf]:

- * NIPC Property APIs: These APIs allow applications to get and update device properties.
- * NIPC Event APIs: These APIs allow applications to enable or disable event reporting on devices.
- * NIPC Action APIs: These APIs allow applications to perform actions on devices.

One or more SDF models must be registered in order to use these NIPC Property, Event and Action APIs. The SDF models can be a top-level sdfThing with multiple sdfObjects or a top-level sdfObject. These APIs depend on the SDF affordances (i.e. sdfProperty, sdfEvent and sdfAction) defined in the SDF model and a device ID that is defined in [I-D.ietf-scim-device-model]. An SDF affordance can be referenced using the global name of the SDF affordance as described in Section 4 of [I-D.ietf-asdf-sdf].

The SDF global name will be used against the registered SDF model to determine the protocol-specific protocolmap that the NIPC API will operate on. The SDF global name is also percent-encoded as per Section 2.1 of [RFC3986].

4.1. NIPC Property APIs

These APIs allow applications to get and update device properties. These operations may require a connection to the device to be established. This connection can be established as part of the same API call implicitly. If a connection is already active for this device, the existing connection will be leveraged without modifying it.

These APIs support multiple media types based on Content-Type and Accept headers to accommodate different data formats.

When using application/nipc+json, the request and response bodies follow the format shown in the examples above, with binary data encoded as base64 in the "value" field. For other content types, the data is transmitted according to the specific format requirements of that media type.

4.1.1. Write multiple values

Method: PUT /devices/{id}/properties{?propertyName}

Description: Write values to one or more properties on a device

Parameters:

- * id: the ID of the device

Query Parameters:

- * propertyName: a single property to update. If this parameter is provided, the request body can contain any content type payload with the value to write to the property. If this parameter is not provided, the request body MUST contain an application/nipc+json payload with an array of properties to update, each containing a property and a value.

Request Body:

- * If the query parameter propertyName is provided, the request body can contain any content type payload with the value to write to the property. The value is encoded as per the content type of the payload.

or

- * an array of properties to update, each containing a property and a value. The value is the raw binary data, encoded in base64 with padding as per Section 5 of [RFC4648].

Example body updating multiple properties:

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

```
[
  {
    "property": "https://example.com/heartrate#/sdfObject/thermostat\
/sdfProperty/temperature",
    "value": "dGVzdA=="
  },
  {
    "property": "https://example.com/heartrate#/sdfObject/thermostat\
/sdfProperty/humidity",
    "value": "eGVzdB=="
  }
]
```

Figure 12: Example updating multiple properties

Response:

If the Accept header is set to application/nipc+json, the response will be an array with a status field set to 200 for each property that was updated, or a problem type object for each property that failed to update.

If the Accept header is set to any other media type and the propertyName query parameter is provided, the response will be 204 No Content with no body.

Example of a response:

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

[
  {
    "status": 200
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types#invalid-property",
    "status": 400,
    "title": "Invalid Property",
    "detail": "Property https://example.com/heartrate#/sdfObject/the\
rmostat/sdfProperty/temperature does not exist or is not writable"
  }
]
```

Figure 13: Example update multiple properties response

where-

- * "properties" is an array of properties that were updated, each containing a property and a value

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.1.2. Read multiple values

Method: GET /devices/{id}/properties{?propertyName*}

Description: Read values from one or more properties on a device

Parameters:

- * id: the ID of the device

Query Parameters:

- * `propertyName`: The property to read. This can be a single property or multiple properties. If multiple properties are provided, the request body MUST contain an `application/nipc+json` payload with an array of properties to read.

Response:

If the `Accept` header is set to `application/nipc+json`, the response will be an array of properties, each containing a property and a value. The value is the raw binary data read from the property, encoded in base64 with padding as per Section 5 of [RFC4648].

Example of a response:

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

```
[
  {
    "property": "https://example.com/heartrate#/sdfObject/thermostat\
/sdfProperty/temperature",
    "value": "dGVzdA=="
  },
  {
    "property": "https://example.com/heartrate#/sdfObject/thermostat\
/sdfProperty/humidity",
    "value": "eGVzdB=="
  }
]
```

Figure 14: Example read multiple properties response

where-

- * `"property"` is the property that was read from
- * `"value"` is the bytes that were read in base64 encoding

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2. NIPC Event APIs

These APIs allow applications to enable or disable event reporting on devices. These operations may require a connection to the device to be established. This connection can be established as part of the same API call implicitly. If a connection is already active for this device, the existing connection will be leveraged without modifying it.

The event is the global name of an sdfEvent.

The ID in the path is the ID of the device or group of devices. An event can be enabled on a group of devices if it is supported by the underlying protocol. For example, if the underlying protocol is BLE, the event can be enabled on a group of devices if the event is an advertisement event or connection status event.

If the data application registered for this event is an MQTT broker or client, the event is used to construct the MQTT topic for the event. The topic is constructed using the data application ID, the default namespace for the event, and the event itself. For example, if the data application ID is "12345678-1234-5678-1234-56789abcdef4" and the event is "https://example.com/thermometer#/sdfThing/thermometer/sdfEvent/isPresent", the topic will be:

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

data-app/<dataAppId>/<namespace>/<json_pointer_to_sdf_event>

data-app/12345678-1234-5678-1234-56789abcdef4/thermometer/sdfThing/\
thermometer/sdfEvent/isPresent

A data application can subscribe to this topic using the topic or it can use MQTT wildcards to subscribe to data-app/+ /temperature/# to receive all events for the temperature namespace.

If a custom topic is provided for an MQTT broker, the custom topic is used as the MQTT topic instead.

4.2.1. Enable event reporting

Method: POST /devices/{id}/events{?eventName}

Description: Enables an event on a specific device

Parameters:

* id: the ID of the device

Query Parameters:

* eventName: the event to enable

The eventName is a URL encoded string that is the absolute URI that is the global name of an sdfEvent.

Response:

Returns HTTP status code 201 Created with a Location header pointing to the created event instance.

Example of a successful response:

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

HTTP/1.1 201 Created
Location: /devices/12345678-1234-5678-1234-56789abcdef4/events?instanceId=87654321-4321-8765-4321-fedcba9876543

The Location header contains the URI for the created event instance, which can be used to check status or disable the event.

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2.2. Disable event reporting

Method: DELETE /devices/{id}/events{?instanceId}

Description: Disables an event on a specific device

Parameters:

* id: the ID of the device or group of devices

Query Parameters:

* instanceId: the instance ID of the event to disable (obtained from the Location header when the event was enabled)

Response:

Returns HTTP status code 204 No Content on successful disable.

HTTP/1.1 204 No Content

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2.3. Get status of one or more events

Method: GET /devices/{id}/events{?instanceId*}

Description: Get the status of one or more events on a specific device

Parameters:

- * id: the ID of the device or group of devices

Query Parameters:

- * instanceId: a comma separated list of event instance IDs to filter by (optional)

Response:

Example of a response:

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

```
[
  {
    "instanceId": "87654321-4321-8765-4321-fedcba9876543",
    "event": "https://example.com/hearttrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected"
  }
]
```

Figure 15: Example get multiple events status response

where-

- * "instanceId" is the unique instance ID for each enabled event
- * "event" is the event URI for each enabled event

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2.4. Enable event reporting on a group of devices

Method: POST /groups/{id}/events

Description: Enables an event on a group of devices

Parameters:

- * id: the ID of the group of devices

Query Parameters:

* eventName: the event to enable

The eventName is a URL encoded string that is the absolute URI that is the global name of an sdfEvent.

Response:

Returns HTTP status code 201 Created with a Location header pointing to the created event instance.

Example of a successful response:

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

HTTP/1.1 201 Created
Location: /groups/12345678-1234-5678-1234-56789abcdef4/events?instanceId=87654321-4321-8765-4321-fedcba9876543

The Location header contains the URI for the created event instance, which can be used to check status or disable the event.

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2.5. Disable event reporting on a group of devices

Method: DELETE /groups/{id}/events{?instanceId}

Description: Disables an event on a group of devices

Parameters:

* id: the ID of the group of devices

Query Parameters:

* instanceId: the instance ID of the event to disable (obtained from the Location header when the event was enabled)

Response:

Returns HTTP status code 200 with a list of the event status for the group of devices. If the event was successfully disabled on a device, the response will contain the device ID and SDF event name for that device. If the event could not be disabled on a device, the response will contain a problem type error response for that device.

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

```
[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef4"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef5"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef6"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types#eve\
nt-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "12345678-1234-5678-1234-56789abcdef7",
    "detail": "Failed to disable the event for device 12345678-1234-\
5678-1234-56789abcdef7"
  }
]
```

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.2.6. Get event status on a group of devices

Method: GET /groups/{id}/events{?instanceId}

Description: Get the status of one or more events on a group of devices

Parameters:

* id: the ID of the group of devices

Query Parameters:

* instanceId: The instance ID of the event to get the status for

Response:

Returns HTTP status code 200 with a list of the event status for the group of devices. If the event was successfully enabled on a device, the response will contain the device ID and SDF event name for that device. If the event could not be enabled on a device, the response will contain a problem type error response for that device.

Example of a response:

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

```
[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef4"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef5"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef6"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types#eve\
nt-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "12345678-1234-5678-1234-56789abcdef7",
    "detail": "Failed to disable the event for device 12345678-1234-\
5678-1234-56789abcdef7"
  }
]
```

Figure 16: Example get multiple group events status response

where-

- * "instanceId" is the unique instance ID for each enabled event
- * "event" is the event URI for each enabled event

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.3. NIPC Action APIs

These APIs allow applications to perform actions on devices. These operations may require a connection to the device to be established. This connection can be established as part of the same API call implicitly. If a connection is already active for this device, the existing connection will be leveraged without modifying it.

4.3.1. Perform an action

Method: POST /devices/{id}/actions{?actionName}

Description: Perform an action on a specific device

Parameters:

- * id: the ID of the device

Query Parameters:

- * actionName: the action to perform

Request Body:

The request body is optional and may contain a value. The media type of the value can be defined by the underlying protocol, for example it could be octet-stream for binary data.

Response:

Actions are performed asynchronously. A successful request returns HTTP status code 202 Accepted with a Location header pointing to the action instance for status checking.

Example of a successful response:

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

HTTP/1.1 202 Accepted

Location: /devices/12345678-1234-5678-1234-56789abcdef4/actions?instanceId=87654321-4321-8765-4321-fedcba9876543

The Location header contains the URI for the action instance, which can be used to check the action status.

4.3.2. Check action status

Method: GET /devices/{id}/actions{?instanceId}

Description: Check the status of an action on a specific device

Parameters:

- * id: the ID of the device

Query Parameters:

- * instanceId: the instance ID of the action (obtained from the Location header)

Response:

Example of a response:

```
{
  "status": "COMPLETED"
}
```

Figure 17: Example action status response

where "status" indicates the current state of the action (e.g., "IN_PROGRESS" or "COMPLETED").

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.4. NIPC explicit connections management APIs

Many protocols do not require connection management, so for these protocols, these APIs will not apply. NIPC Gateways perform implicit connection management for protocols that require connection management (such as BLE), so in principle the user of the NIPC API does not have to perform connection management. In some cases however, a user might want to keep a connection open, perform an action, evaluate the result and perform a second action based on that result. In this case it is useful to perform explicit connection management so the connection remains established to execute subsequent actions. These APIs allow applications to explicitly manage device connections. The examples in this section will be based on BLE, which requires connection management.

4.4.1. Connect to a device

Method: POST /devices/{id}/connections

Description: Connect to a device

Parameters:

- * id: the ID of the device

Request Body:

- * Connection retry parameters
- * A protocol map object. In the case of BLE, if no protocol map is included, service discovery is performed to discover all supported properties when connecting to a device. Optionally, service discovery may be limited to properties defined in the "ble" protocol extension. The services to be discovered can be added in an array. Property discovery can be buffered across connections, so the API also supports caching parameters.

Example body of a connection without specific discovery of properties:

```
{
  "retries": 3,
  "retryMultipleAPs": true
}
```

Figure 18: Example connection

where-

- * "retries" defines the number of retries in case the operation does not succeed
- * "retryMultipleAPs" can be used in case there is an infrastructure with multiple access points or radios that can reach the device. If set to "true" a different access point may be used for retries.

In case the application would like to discover specific properties of a device, a protocol mapping can be added that defines what properties should be discovered.

Example body of a BLE connection with specific discovery of properties:

```
{
  "retries": 3,
  "retryMultipleAPs": true,
  "sdfProtocolMap": {
    "ble": {
      "services": [
        {
          "serviceID": "12345678-1234-5678-1234-56789abcdef4"
        }
      ],
      "cached": false,
      "cacheIdlePurge": 3600,
      "autoUpdate": true,
      "bonding": "default"
    }
  }
}
```

Figure 19: Example connection with explicit discovery of connections

where in the BLE protocol object:

- * "services" is an array of services defined by their serviceIDs.
- * "cached" refers to whether the services need to be cached for subsequent connects, in order not to perform service discovery on each request.
- * "cacheIdlePurge" defines how long (in seconds) the cache should be maintained before purging.
- * some devices support notifications on changes in services, "autoUpdate" allows the network to update services based on notification (on by default)
- * "bonding" allows you to override the bonding method configured when onboarding the device

Response:

Success responses include a protocol mapping with an array of discovered properties, as defined in the specific protocol. For example, for BLE, this is an array of supported services, which in turn contains an array of characteristics, which in turn contains an array of descriptors, as shown in Figure 20.

```

services
- serviceID
  |
  |> characteristics
    - characteristicID
    - flags
      |
      |> Descriptors
        - descriptorID

```

Figure 20: BLE Services

Example of a response:

```

{
  "id": "12345678-1234-5678-1234-56789abcdef4",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "12345678-1234-5678-1234-56789abcdef4",
        "characteristics": [
          {
            "characteristicID":
              "12345678-1234-5678-1234-56789abcdef4",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "12345678-1234-5678-1234-56789abcdef4"
              }
            ]
          }
        ]
      }
    ]
  }
}

```

Figure 21: Example connection response

where-

* "id" is the ID of the device

- * "sdfProtocolMap" contains an Array of BLE services as shown in Figure 20

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.4.2. Update a connection

Method: PUT /devices/{id}/connections

Description: Update cached ServiceMap for a device. Full service discovery will be performed, unless specific services are described in the API body.

Parameters:

- * id: the ID of the device

Request Body:

- * A protocol map object. In the case of BLE, if no protocol map is included, service discovery is performed to discover all supported properties when connecting to a device. Optionally, service discovery may be limited to properties defined in the "ble" protocol extension. The services to be discovered can be added in an array. Property discovery can be buffered across connections, so the API also supports caching parameters.

Example body of an update connection:

```
{
  "sdfProtocolMap": {
    "ble": {
      "services": [
        {
          "serviceID": "12345678-1234-5678-1234-56789abcdef4"
        }
      ],
      "cached": false,
      "cacheIdlePurge": 3600,
      "autoUpdate": true
    }
  }
}
```

Figure 22: Example service discovery response

where in the BLE protocol object:

- * "services" is an array of services defined by their serviceIDs
- * "cached" refers to whether the services need to be cached for subsequent connects, in order not to perform service discovery on each request
- * "cacheIdlePurge" defines how long the cache should be maintained before purging
- * some devices support notifications on changes in services, "autoUpdate" allows the network to update services based on notification (on by default)

Response:

Success responses include a protocol mapping with an array of discovered properties, as defined in the specific protocol. For example, for BLE, this is an array of supported services, which in turn contains an array of characteristics, which in turn contains an array of descriptors, as shown in Figure 20.

Example of a response:

```

{
  "id": "12345678-1234-5678-1234-56789abcdef4",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "12345678-1234-5678-1234-56789abcdef4",
        "characteristics": [
          {
            "characteristicID":
              "12345678-1234-5678-1234-56789abcdef4",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "12345678-1234-5678-1234-56789abcdef4"
              }
            ]
          }
        ]
      }
    ]
  }
}

```

Figure 23: Example connection response

where-

- * "id" is the ID of the device
- * "sdfProtocolMap" contains an Array of BLE services as shown in Figure 20

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.4.3. Disconnect from a device

Method: DELETE /devices/{id}/connections

Description: Disconnect from a device

Parameters:

- * id: the ID of the device

Response:

Returns HTTP status code 200 OK with device ID on successful disconnect.

Example of a response:

```
{
  "id": "12345678-1234-5678-1234-56789abcdef4"
}
```

Figure 24: Example disconnect response

where "id" is the ID of the device.

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

4.4.4. Get connection status

Method: GET /devices/{id}/connections

Description: Get connection status for a device. Success when device(s) is/are connected, includes service map for the device if available. Failure when a device is not connected.

Parameters:

* id: the ID of the device

Response:

Example of a response:

```

{
  "id": "12345678-1234-5678-1234-56789abcdef4",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "12345678-1234-5678-1234-56789abcdef4",
        "characteristics": [
          {
            "characteristicID":
              "12345678-1234-5678-1234-56789abcdef4",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "12345678-1234-5678-1234-56789abcdef4"
              }
            ]
          }
        ]
      }
    ]
  }
}

```

Figure 25: Example connection status response

where-

- * "id" is the ID of the device
- * "sdfProtocolMap" contains an Array of BLE services as shown in Figure 20

A failure will generate a standard failed response. Please refer to Figure 5 definition of failed response.

5. NIPC Extensibility

NIPC is extensible in two ways:

- * Protocol mapping: New protocol mapping can extend NIPC with support for new non-IP protocols

- * API extensions: API extensions leverage compound statements of basic NIPC action APIs to simplify common operations for applications.

5.1. Protocol extensions

NIPC supports mapping protocol specific properties to NIPC properties as described in [I-D.ietf-asdf-sdf-protocol-mapping]. BLE and Zigbee are used as examples, but protocol mapping is extensible to other protocols, so now non-IP protocols can be supported by NIPC without a schema change.

The protocol objects need to be extended with the new protocol as well. Protocol objects will be extended as follows:

Attribute	Type	Example
ble	object	an object with BLE-specific properties
zigbee	object	an object with Zigbee-specific properties
newProtocol	object	an object with newProtocol-specific props

Table 3: Adding Protocol mappings

In the new protocol object, protocol specific properties can be added.

5.2. API extensions

/extensions

The extension APIs allow for extensibility of the APIs. Extensions must be IANA registered. Extension APIs can leverage the basic NIPC defined APIs and combine them in compound statements in order to streamline application operation against devices, make operations more expedient and convenient in one API call. An example of this is the bulk API extension. They can also introduce new functionality that is specific to a use case or protocol, such as the BLE transmit API. the OpenAPI model Appendix C below, we have defined a few example extensions.

The extensions can contain long running operations, such as firmware updates, or other bulk operations that can be performed on a device. For long running operations, the extension API will return a 202 Accepted status code and a location header with the URL to check the

status of the operation. The status of the operation can be checked by calling the status extension API with the same device ID. The status extension API will return a 200 OK status code when the operation is in progress. When the operation is complete, the status extension API will return a 303 See Other status code with a location header with the URL to check the status of the operation. The GET operation on the extension API will return a 200 OK status code with the actual response once the operation is complete.

6. NIPC Error Handling

The error types in the NIPC APIs use URI-based error type identifiers as defined in Section 10.4. The error types can be generic or specific to the API category. The error types are organized into the following categories:

- * Generic: Broadly applicable errors, including authorization, invalid identifiers, and generic failures.
- * Property APIs: Errors related to property APIs (read/write).
- * Event APIs: Errors related to event APIs (enable/disable).
- * Protocol specific: Errors related to protocol-specific operations.
- * Extension APIs: Errors related to extension APIs.

The specific error types are defined in the table below:

Error Type	Description	Category
invalid-id	Invalid device ID or gateway doesn't recognize the ID	Generic
invalid-sdf-url	Invalid SDF URL or SDF affordance not found	Generic
extension-operation-not-executed	Operation was not executed since the previous operation failed	Generic
sdf-model-already-registered	SDF model already registered	Generic
sdf-model-in-use	SDF model in use	Generic
unsupported-uri-	Unsupported URI scheme	Generic

scheme			
property-not-readable	Property not readable	Property APIs	
property-not-writable	Property not writable	Property APIs	
event-already-enabled	Event already enabled	Event APIs	
event-not-enabled	Event not enabled	Event APIs	
event-not-registered	Event not registered for any data application	Event APIs	
protocolmap-ble-already-connected	Device already connected	Protocol specific	
protocolmap-ble-no-connection	No connection found for device	Protocol specific	
protocolmap-ble-connection-timeout	BLE connection timeout	Protocol specific	
protocolmap-ble-bonding-failed	BLE bonding failed	Protocol specific	
protocolmap-ble-connection-failed	BLE connection failed	Protocol specific	
protocolmap-ble-service-discovery-failed	BLE service discovery failed	Protocol specific	
protocolmap-ble-invalid-service-or-characteristic	Invalid BLE service or characteristic ID	Protocol specific	
protocolmap-zigbee-connection-timeout	Zigbee connection timeout	Protocol specific	
protocolmap-zigbee-invalid-endpoint-or-cluster	Invalid Zigbee endpoint or cluster ID	Protocol specific	
extension-transmit-	Invalid transmit data	Transmit	

invalid-data		APIs	
+-----+	+-----+	+-----+	+-----+
extension-firmware-rollback	Firmware rollback	Extension APIs	
+-----+	+-----+	+-----+	+-----+
extension-firmware-update-failed	Firmware update failed	Extension APIs	
+-----+	+-----+	+-----+	+-----+

Table 4: Error Codes

The appropriate HTTP status code is returned in the response.

7. Publish/Subscribe Interface

The publish/subscribe interface, or data streaming interface, is an MQTT publishing interface. Pub/sub topics can be created and managed by means of the `/registrations/data-apps` API.

In this memo, we propose the data format to be CBOR [RFC8949].

7.1. CDDL Definition

We have a CDDL [RFC8610] definition where we define the `DataSubscription` struct that will be used by all the messages published to the MQTT broker.

The `DataSubscription` struct is a CBOR map that will contain the raw data in bytes and a timestamp of the data. Optionally, the message will also have a `deviceId` that corresponds to the SCIM ID of the device if the payload is associated to a known device.

Other fields in the CDDL such as `apMacAddress` and `rsi` can be optionally included but these fields can expose the underlying network topology.

Each message also has a subscription choice group that will define the type of data that is being published.

Each MQTT message can be a collection of `DataSubscription` structs. This collection is represented as `DataBatch` in the CDDL.


```
start = DataBatch

DataBatch = [* DataSubscription]

DataSubscription = {
  ? data: bytes,
  timestamp: float, ; epoch in seconds
  ? deviceID: text,
  ? apMacAddress: text,
  subscription
}

subscription = (
  bleSubscription: BleSubscription //
  bleAdvertisement: BleAdvertisement //
  bleConnectionStatus: BleConnectionStatus //
  zigbeeSubscription: ZigbeeSubscription //
  rawPayload: RawPayload
)

BleSubscription = {
  serviceID: text,
  characteristicID: text
}

BleAdvertisement = {
  macAddress: text,
  ? rssi: nint,
}

BleConnectionStatus = {
  macAddress: text,
  connected: bool,
  ? reason: int
}

ZigbeeSubscription = {
  endpointID: int,
  clusterID: int,
  attributeID: int
  attributeType: int
}

RawPayload = {
  contextID: text
}
```

7.2. CBOR Examples

This section contains a few examples of the DataSubscription struct depicted in CBOR diagnostic notation.

```
[
  {
    "data": h'02011A020A0C16FF4C001007721F41B0392078',
    "deviceID": "75fde96d-886f-4ac0-ald5-df79f76e7c9c",
    "timestamp": 1727484393,
    "bleAdvertisement": {
      "macAddress": "C1:5C:00:00:00:01",
      "rssi": -25
    }
  }
]
```

Figure 26: Onboarded BLE Device Advertisement

```
[
  {
    "data": h'02011A020A0C16FF4C001007721F41B0392078',
    "timestamp": 1727484393,
    "bleAdvertisement": {
      "macAddress": "C1:5C:00:00:00:01",
      "rssi": -25
    }
  }
]
```

Figure 27: Non-onboarded BLE Device Advertisement

```
[
  {
    "data": h'434630374346303739453036',
    "deviceID": "75fde96d-886f-4ac0-ald5-df79f76e7c9c",
    "timestamp": 1727484393,
    "bleSubscription": {
      "serviceID": "a4e649f4-4be5-11e5-885d-feff819cdc9f",
      "characteristicID": "c4c1f6e2-4be5-11e5-885d-feff819cdc9f"
    }
  }
]
```

Figure 28: BLE GATT Notification

```
[
  {
    "deviceID": "75fde96d-886f-4ac0-ald5-df79f76e7c9c",
    "timestamp": 1727484393,
    "bleConnectionStatus": {
      "macAddress": "C1:5C:00:00:00:01",
      "connected": true
    }
  }
]
```

Figure 29: BLE Connection status event

```
[
  {
    "data": h'434630374346303739453036',
    "deviceID": "75fde96d-886f-4ac0-ald5-df79f76e7c9c",
    "timestamp": 1727484393,
    "zigbeeSubscription": {
      "endpointID": 1,
      "clusterID": 6,
      "attributeID": 12,
      "type": 1
    }
  }
]
```

Figure 30: Zigbee Attribute Notification

8. Examples

This section contains a few examples on how applications can leverage NIPC operations to communicate with BLE and Zigbee devices.

8.1. Property Read/Write

In this example, we will connect to a device and read and write from a property.

The sequence of operations for this are:

- * Onboard a device using the SCIM Interface (out of scope of this memo)
- * Register an SDF model for the device

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

```
POST /registrations/models
Content-Type: application/sdf+json
Accept: application/nipc+json
Host: localhost
```

```
{ ... }
```

```
HTTP/1.1 200 OK
content-type: application/nipc+json
```

```
[
  {
    "sdfName": "https://example.com/thermometer#/sdfThing/thermom\
eter"
  }
]
```

Request Body: JSON object with the SDF model, from Appendix D

- * Read a property from the BLE device

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

```
GET /devices/12345678-1234-5678-1234-56789abcdef4/properties?prop\
ertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2FsdfThing%2F\
thermometer%2FsdfProperty%2Fdevice_name
Accept: application/nipc+json
Host: localhost
```

```
HTTP/1.1 200 OK
content-type: application/nipc+json
```

```
[
  {
    "property": "https://example.com/thermometer#/sdfThing/thermo\
meter/sdfProperty/device_name",
    "value": "dGVzdA=="
  }
]
```

- * Write to a property on the BLE device

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

PUT /devices/12345678-1234-5678-1234-56789abcdef4/properties

Content-Type: application/nipc+json

Host: localhost

```
[
  {
    "property": "https://example.com/thermometer#/sdfThing/thermo\
meter/sdfProperty/device_name",
    "value": "dGVzdA=="
  }
]
```

HTTP/1.1 200 OK

content-type: application/nipc+json

```
[
  {
    "property": "https://example.com/thermometer#/sdfThing/thermo\
meter/sdfProperty/device_name",
    "value": "dGVzdA=="
  }
]
```

8.2. Enabling an Event on a Device

In this example, we will onboard a device, and setup an advertisement subscription event for that device.

The sequence of operations for this are:

- * Onboard a device and endpoint app using the SCIM Interface (out of scope of this memo)
- * Register an SDF model for the device

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

```
POST /registrations/models
Content-Type: application/sdf+json
Accept: application/nipc+json
Host: localhost
```

```
{ ... }
```

```
HTTP/1.1 200 OK
content-type: application/nipc+json
```

```
[
  {
    "sdfName": "https://example.com/thermometer#/sdfThing/thermom\
eter"
  }
]
```

Request Body: JSON object with the SDF model, from Appendix D

- * Register the data app with the event

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

POST /registrations/data-apps?dataAppId=23456789-1234-5678-1234-5\6789abcdef4

Content-Type: application/nipc+json

Accept: application/nipc+json

Host: localhost

```
{
  "events": [
    "https://example.com/thermometer#/sdfThing/thermometer/sdfEve\
nt/isPresent"
  ],
  "mqttClient": true
}
```

HTTP/1.1 200 OK

content-type: application/nipc+json

```
{
  "events": [
    "https://example.com/thermometer#/sdfThing/thermometer/sdfEve\
nt/isPresent"
  ],
  "mqttClient": true
}
```

- * Enable the advertisement event

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

POST /devices/12345678-1234-5678-1234-56789abcdef4/events?eventNa\me=https%23%2F%2Fexample.com%2Fthermometer%23%2FsdfThing%2Fthermo\meter%2FsdfEvent%2FisPresent

Host: localhost

Content-Length: 0

HTTP/1.1 201 Created

Location: /devices/12345678-1234-5678-1234-56789abcdef4/events?in\stanceId=87654321-4321-8765-4321-fedcba9876543

- * Check the status of the event

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

```
GET /devices/12345678-1234-5678-1234-56789abcdef4/events?instance\
Id=87654321-4321-8765-4321-fedcba9876543
```

```
Host: localhost
```

```
HTTP/1.1 200 OK
```

```
content-type: application/nipc+json
```

```
{
  "event": "https://example.com/thermometer#/sdfThing/thermometer\
/sdfEvent/isPresent"
}
```

8.3. Enabling an Event on a Group of Devices

In this example, we will enable an advertisement subscription event for a group of devices.

The sequence of operations for this are:

- * Onboard devices and endpoint app using the SCIM Interface (out of scope of this memo)
- * Register an SDF model for the devices

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

```
POST /registrations/models
```

```
Content-Type: application/sdf+json
```

```
Accept: application/nipc+json
```

```
Host: localhost
```

```
{ ... }
```

```
HTTP/1.1 200 OK
```

```
content-type: application/nipc+json
```

```
[
  {
    "sdfName": "https://example.com/thermometer#/sdfThing/thermom\
eter"
  }
]
```

Request Body: JSON object with the SDF model, from Appendix D

- * Register the data app with the event

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

POST /registrations/data-apps?dataAppId=23456789-1234-5678-1234-5\6789abcdef4

Content-Type: application/nipc+json

Accept: application/nipc+json

Host: localhost

```
{
  "events": [
    "https://example.com/thermometer#/sdfThing/thermometer/sdfEve\
nt/isPresent"
  ],
  "mqttClient": true
}
```

HTTP/1.1 200 OK

content-type: application/nipc+json

```
{
  "events": [
    "https://example.com/thermometer#/sdfThing/thermometer/sdfEve\
nt/isPresent"
  ],
  "mqttClient": true
}
```

- * Enable the advertisement event on a group of devices

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

POST /groups/87654321-4321-8765-4321-fedcba9876543/events?eventNa\me=https%23%2F%2Fexample.com%2Fthermometer%23%2FsdfThing%2Fthermo\meter%2FsdfEvent%2FisPresent

Host: localhost

Content-Length: 0

HTTP/1.1 201 Created

Location: /groups/87654321-4321-8765-4321-fedcba9876543/events?in\stanceId=11223344-5566-7788-99aa-bbccddeeff00

- * Check the status of the event

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

```
GET /groups/87654321-4321-8765-4321-fedcba9876543/events?instance\
Id=11223344-5566-7788-99aa-bbccddeeff00
```

```
Host: localhost
```

```
HTTP/1.1 200 OK
```

```
content-type: application/nipc+json
```

```
[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef4"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef5"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "12345678-1234-5678-1234-56789abcdef6"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types\
#event-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "12345678-1234-5678-1234-56789abcdef7",
    "detail": "Failed to disable the event for device 12345678-1\
234-5678-1234-56789abcdef7"
  }
]
```

9. Security Considerations

9.1. API authorization

In order to enable a network wishing to offer NIPC ALG functions, the network administrator authorizes application(s) to perform operations on the Gateway. This happens out of band and may be accomplished by means of exchanging tokens or public keys. Authorization can be role-based. The 3 primary roles are:

1. Onboarding: Authorize an onboarding application against a SCIM server co-located with the gateway.

2. Control: Authorize applications that may control devices.
3. Data: Authorize applications that may receive telemetry.
It is possible to further refine roles down to an API basis.

10. IANA Considerations

This section provides guidance to the Internet Assigned Numbers Authority (IANA) regarding registration of values related to NIPC, in accordance with [RFC8126].

10.1. Media Type Registration

This document registers the "application/nipc+json" media type for messages of the NIPC APIs defined in this document carrying parameters encoded in JSON.

Type name: application

Subtype name: nipc+json

Required parameters: none

Optional parameters: none

Encoding considerations: Encoding considerations are identical to those specified for the "application/json" media type.

Security considerations: See the Section 9 section of this document.

Interoperability considerations: none

Published specification: This document, the NIPC API specification.

Applications that use this media type:

Fragment identifier considerations: none

Additional information:

- * Deprecated alias names for this type: none
- * Magic number(s): none
- * File extension(s): none
- * Macintosh file type code(s): none

Person & email address to contact for further information:

Intended usage: LIMITED USE

Restrictions on usage: To be used for NIPC APIs as defined in this document.

Author:

Change controller: IETF

10.2. API extensions

IANA is requested to create a new registry called "NIPC API extensions".

The registry must contain following attributes:

- * Extension URI
- * Extension name
- * Description
- * Openapi model describing the extension. This model must be reviewed by an expert.

Following API extensions are described in this document:

Extension URI	Extension name	Description	Model reference
/extensions/{id}/bulk	Bulk API	Call multiple NIPC's in a single request	Appendix C
/extensions/{id}/properties/file	File write API	Write a file with multiple property ops	Appendix C
/extensions/{id}/properties/blob	Binary write API	Write a binary blob with multiple property ops	Appendix C
/extensions/{id}/properties/read/conditional	Read conditional API	Read a property until a condition is fulfilled	Appendix C
/extensions/{id}/events/conditional	Event conditional API	Enable an event until a condition is fulfilled	Appendix C
/extensions/{id}/transmit	Transmit API	Transmits a payload to a device	Appendix C

Table 5

10.3. Well-known URIs

IANA is requested to register the following well-known URI in the "Well-Known URIs" registry as defined by [RFC8615]:

URI Suffix	Change Controller	Specification Document
nipc	IETF	This document, Section 2.7.1

Table 6

The well-known URI for NIPC is:

`/.well-known/nipc`

10.4. Problem Details for NIPC APIs

IANA is requested to create a new registry, the "NIPC Problem Type" registry, with following URL: <https://www.iana.org/assignments/nipc-problem-types>.

Registrations MUST use the prefix "<https://iana.org/assignments/nipc-problem-types#>" for the type URI.

The registration requests MUST use the template defined in Section 4.2 of [RFC9457].

IANA is requested to register the following URIs in the "NIPC Problem Type" registry:

Problem Type URI	Description	Reference
https://www.iana.org/assignments/nipc-problem-types#invalid-id	Invalid device ID or gateway doesn't recognize the ID	This document
https://www.iana.org/assignments/nipc-problem-types#invalid-sdf-url	Invalid SDF URL or SDF affordance not found	This document
https://www.iana.org/assignments/nipc-problem-types#extension-operation-not-executed	Operation was not executed since the previous operation failed	This document
https://www.iana.org/assignments/nipc-problem-types#sdf-model	SDF model already	This document

already-registered	registered	
https://www.iana.org/assignments/nipc-problem-types#sdf-model-in-use	SDF model in use	This document
https://www.iana.org/assignments/nipc-problem-types#unsupported-uri-scheme	Unsupported URI scheme	This document
https://www.iana.org/assignments/nipc-problem-types#property-not-readable	Property not readable	This document
https://www.iana.org/assignments/nipc-problem-types#property-read-failed	Property read failed	This document
https://www.iana.org/assignments/nipc-problem-types#property-not-writable	Property not writable	This document
https://www.iana.org/assignments/nipc-problem-types#property-write-failed	Property write failed	This document
https://www.iana.org/assignments/nipc-problem-types#event-already-enabled	Event already enabled	This document
https://www.iana.org/assignments/nipc-problem-types#event-not-enabled	Event not enabled	This document
https://www.iana.org/assignments/nipc-problem-types#event-not-registered	Event not registered for any data application	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-already-connected	Device already connected	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-no-connection	No connection found for device	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-no-connection	BLE connection	This

nipc-problem-types#protocolmap-ble-connection-timeout	timeout	document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-bonding-failed	BLE bonding failed	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-connection-failed	BLE connection failed	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-service-discovery-failed	BLE service discovery failed	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-ble-invalid-service-or-characteristic	Invalid BLE service or characteristic ID	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-zigbee-connection-timeout	Zigbee connection timeout	This document
https://www.iana.org/assignments/nipc-problem-types#protocolmap-zigbee-invalid-endpoint-or-cluster	Invalid Zigbee endpoint or cluster ID	This document
https://www.iana.org/assignments/nipc-problem-types#extension-broadcast-invalid-data	Invalid transmit data	This document
https://www.iana.org/assignments/nipc-problem-types#extension-firmware-rollback	Firmware rollback	This document
https://www.iana.org/assignments/nipc-problem-types#extension-firmware-update-failed	Firmware update failed	This document

Table 7

Each Problem Type URI is intended for use as the "type" member in Problem Details responses as described.

11. References

11.1. Normative References

[I-D.ietf-asdf-sdf]

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Appendix A. OpenAPI definition

The following non-normative model is provide for convenience of the implementor.

```
<CODE BEGINS> file "openapi.yml"
===== NOTE: '\\\ ' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-1\
\2/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API
  description: |-
    This API specifies RESTful application layer interface for
    gateways providing operations against non-IP devices. The
    described interface is extensible. The examples includes
    leverage Bluetooth Low Energy and Zigbee as they are commonly
    deployed.
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.14.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-14"
    variables:
      gw_host:
        default: localhost
        description: Gateway Host
tags:
  - name: NIPC property APIs
    description: |-
      APIs that allow apps to get and update device properties.
```

If the underlying protocol requires connection management, it will be performed as part of the API call.

- name: NIPC event APIs
description: |-
APIs that allow apps to enable or disable event reporting on devices. If the underlying protocol requires connection management, it will be performed as part of the API call.
- name: NIPC action APIs
description: |-
APIs that perform actions on devices.
- name: NIPC management APIs
description: |-
APIs that manage device connections.
- name: NIPC registration APIs
description: |-
APIs that register sdf models or data applications

paths:

NIPC Property APIs

/devices/{id}/properties:

put:

tags:

- NIPC property APIs

summary: Update a value of one or more properties on a device

description: |-

Write a value to a property or multiple properties to a device. If underlying protocol requires a connection to be set up, this API call will perform the necessary connection management. If a connection is already active for this device, the existing connection will be leveraged without modifying it.

operationId: UpdateProperties

parameters:

- name: id
in: path
description: The ID of the device. Group ID is not allowed.
required: true
schema:
 type: string
 format: uuid
 example: 12345678-1234-5678-1234-56789abcdef4
- name: propertyName
in: query
description: |-
 The SDF property name that needs to be written to.
required: false
allowReserved: true
schema:

```

    type: string
    example: "https://example.com/heartrate#/sdfObject/thermos\
\tat/sdfProperty/temperature"
    requestBody:
      description: |-
        The value to be written to the property or properties.
        If multiple properties are specified, the request body
        should be application/nipc+json.
      content:
        application/nipc+json:
          schema:
            $ref: '#/components/schemas/PropertyValueArray'
        "*/*":
          schema:
            description: |-
              Any other content type, such as
              application/octet-stream, application/json that will
              be written to the device.
      required: true
    responses:
      '204':
        description: |-
          Success, no content, used for a single property write
      '200':
        description: Success, used for multiple property writes
        content:
          application/nipc+json:
            schema:
              allOf:
                - $ref: '#/components/schemas/PropertyValueRespon\
s\eArray'
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'

get:
  tags:
    - NIPC property APIs
  summary: |-
    Read a value from one or multiple properties on a device
  description: |-
    Read a value to a property or multiple properties from a
    device. If underlying protocol requires a connection to be
    set up, this API call will perform the necessary connection
    management. If a connection is already active for this

```

```

    device, the existing connection will be leveraged without
    modifying it.
  operationId: GetProperties
  parameters:
    - name: id
      in: path
      description: The ID of the device. Group ID is not allowed.
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    - name: propertyName
      in: query
      description: Properties to be read
      required: true
      allowReserved: true
      schema:
        type: array
        items:
          type: string
          example: "https://example.com/hearttrate#/sdfObject/therm\
\ostat/sdfProperty/temperature"
  responses:
    '200':
      description: Success
      content:
        application/nipc+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/Id'
              - $ref: '#/components/schemas/PropertyValueReadRes\
\ponseArray'
            "*/*":
              schema:
                type: string
                description: |-
                  Any other content type, such as
                  application/octet-stream, application/json that
                  will be read from the device.
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'

```

NIPC Event APIs

```

/devices/{id}/events:
  post:
    tags:
      - NIPC event APIs
    summary: Enable an event on a specific device
    description: |-
      Enable an event on a specific device or for a group of
      devices. If the underlying protocol requires a connection to
      be set up, this API call will perform the necessary
      connection management. If a connection is already active for
      this device, the existing connection will be leveraged
      without modifying it.
    operationId: EnableEvent
    parameters:
      - name: id
        in: path
        description: device id or group id
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
      - name: eventName
        in: query
        description: event that needs to be enabled
        required: true
        allowReserved: true
        schema:
          type: string
          example: "https://example.com/heartrate#/sdfObject/healths\
\ensor/sdfEvent/fallDetected"
    responses:
      '201':
        description: Success
        headers:
          Location:
            description: Location of the created event
            schema:
              type: string
              format: uri
              example: "/devices/{id}/events?instanceId={instanceI\
\d}"
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '#/components/schemas/FailureResponse'

```

```
delete:
  tags:
    - NIPC event APIs
  summary: Disable an event on a specific device
  description: |-
    Disable an event on a specific device or a group of devices.
    If the underlying protocol requires a connection to be set
    up, this API call will perform the necessary connection
    management. If a connection is already active for this
    device, the existing connection will be leveraged without
    modifying it.
  operationId: DisableEvent
  parameters:
    - name: id
      in: path
      description: device id or group id
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    - name: instanceId
      in: query
      description: instance id of the event that needs to be disab\
\led
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '204':
      description: Success, no content
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '#/components/schemas/FailureResponse'

get:
  tags:
    - NIPC event APIs
  summary: Get status of events on a device
  description: |-
    Get status of an event or multiple events on a specific devi\
\ce
  operationId: GetEvents
```



```
parameters:
- name: id
  in: path
  description: The ID of the device.
  required: true
  schema:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
- name: instanceId
  in: query
  description: |-
    Instance ID of the events that need to be filtered
  required: false
  schema:
    type: array
    items:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
responses:
  '200':
    description: Success
    content:
      application/nipc+json:
        schema:
          $ref: '#/components/schemas/EventStatusResponseArray'
  default:
    description: Error response
    content:
      application/problem+json:
        schema:
          $ref: '#/components/schemas/FailureResponse'

/groups/{id}/events:
  post:
    tags:
      - NIPC event APIs
    summary: Enable an event on a group of devices
    description: |-
      Enable an event on a group of devices.
      If the underlying protocol requires a connection to be set
      up, this API call will perform the necessary connection
      management. If a connection is already active for this
      device, the existing connection will be leveraged without
      modifying it.
    operationId: EnableGroupEvent
    parameters:
```

```

- name: id
  in: path
  description: |-
    group id for which the event needs to be enabled
  required: true
  schema:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
- name: eventName
  in: query
  description: event that needs to be enabled
  required: true
  allowReserved: true
  schema:
    type: string
    example: "https://example.com/hearttrate#/sdfObject/healths\
\ensor/sdfEvent/fallDetected"
responses:
  '201':
    description: Success, event enabled
    headers:
      Location:
        description: Location of the created event
        schema:
          type: string
          format: uri
          example: "/groups/{id}/events?instanceId={instanceId\
\}"
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '#/components/schemas/FailureResponse'
delete:
  tags:
    - NIPC event APIs
  summary: Disable an event on a group of devices
  description: |-
    Disable an event on a group of devices. If the underlying
    protocol requires a connection to be set up, this API call
    will perform the necessary connection management.
    If a connection is already active for this device, the
    existing connection will be leveraged without modifying it.
  operationId: DisableGroupEvent
  parameters:
    - name: id

```

```

    in: path
    description: |-
      group id for which the event needs to be disabled
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
  - name: instanceId
    in: query
    description: instance id of the event that needs to be disab\
\led
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success, event disabled
      content:
        application/nipc+json:
          schema:
            $ref: '#/components/schemas/GroupEventStatusResponse\
\Array'
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'
  get:
    tags:
      - NIPC event APIs
    summary: Get status of events on a group of devices
    description: |-
      Get status of an event or multiple events on a group of devi\
\ces.
    operationId: GetGroupEvents
    parameters:
      - name: id
        in: path
        description: group id of the SCIM group
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4

```

```
- name: instanceId
  in: query
  description: |-
    Instance IDs of the events that need to be filtered
  required: false
  schema:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
responses:
  '200':
    description: Success, events retrieved
    content:
      application/nipc+json:
        schema:
          $ref: '#/components/schemas/GroupEventStatusResponse\
\Array'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '#/components/schemas/FailureResponse'

### NIPC action APIs
/devices/{id}/actions:
  post:
    tags:
      - NIPC action APIs
    summary: Perform an action on a device
    description: |-
      Perform an action on a device.
      If the underlying protocol requires a connection to be set
      up, this API call will perform the necessary connection
      management. If a connection is already active for this
      device, the existing connection will be leveraged without
      modifying it.
    operationId: ActionProperty
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
      - name: actionName
```

```

    in: query
    description: action that needs to be performed
    required: true
    allowReserved: true
    schema:
      type: string
      example: "https://example.com/hearttrate#/sdfObject/healths\
\ensor/sdfAction/start"
    requestBody:
      content:
        application/octet-stream:
          schema:
            type: string
            format: binary
      required: false
    responses:
      '202':
        description: Accepted, action is being performed
        headers:
          Location:
            description: Location of the action
            schema:
              type: string
              format: uri
              example: "/devices/{id}/actions?instanceId={instance\
\Id}"
        default:
          description: Error response
          content:
            application/problem+json:
              schema:
                $ref: '#/components/schemas/FailureResponse'
    get:
      tags:
        - NIPC action APIs
      summary: Get status of an action on a device
      description: |-
        Get status of an action on a specific device or a group of
        devices. Success is action is active, failure if action not
        active.
      operationId: GetAction
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string

```

```
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
  - name: instanceId
    in: query
    description: |-
      instance id of the action that needs to be checked
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success, action is active
      content:
        application/nipc+json:
          schema:
            $ref: '#/components/schemas/ActionResponse'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '#/components/schemas/FailureResponse'

/devices/{id}/connections:
  post:
    tags:
      - NIPC management APIs
    summary: Connect a device
    description: |-
      Connect a device. 3 retries by default, optionally retry
      policy can be defined in the API body. If the protocol
      requires service discovery, full service discovery will be
      performed, unless specific services are described in the API
      body.
    operationId: ActionCreateConnection
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
    requestBody:
      content:
```

```

    application/nipc+json:
      schema:
        anyOf:
          - $ref: '#/components/schemas/Connection'
          - $ref: './protocolmaps/ProtocolMap.yaml#/components\
\schemas/ProtocolMap-ServiceList'
      required: false
      responses:
        '200':
          description: Success
          content:
            application/nipc+json:
              schema:
                allOf:
                  - $ref: '#/components/schemas/Id'
                  - $ref: './protocolmaps/ProtocolMap.yaml#/componen\
\ts/schemas/ProtocolMap-ServiceMap'
          default:
            description: Error response
            content:
              application/problem+json:
                schema:
                  $ref: '#/components/schemas/FailureResponse'

  put:
    tags:
      - NIPC management APIs
    summary: Update cached ServiceMap for a device.
    description: |-
      Update cached ServiceMap for a device. Full service discovery
      will be performed, unless specific services are described in
      the API body.
    operationId: ActionUpdateServiceMap
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
    requestBody:
      content:
        application/nipc+json:
          schema:
            $ref: './protocolmaps/ProtocolMap.yaml#/components/sch\
\emas/ProtocolMap-ServiceList'

```

```
    required: false
  responses:
    '200':
      description: Success
      content:
        application/nipc+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/Id'
              - $ref: './protocolmaps/ProtocolMap.yaml#/componen\
\ts/schemas/ProtocolMap-ServiceMap'
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'

  delete:
    tags:
      - NIPC management APIs
    summary: Disconnect a device
    description: |-
      Disconnect a device.
    operationId: ActionDeleteConnection
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
    responses:
      '200':
        description: Success
        content:
          application/nipc+json:
            schema:
              allOf:
                - $ref: '#/components/schemas/Id'
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'
```



```
get:
  tags:
    - NIPC management APIs
  summary: Get connection state for a device
  description: |-
    Get connection status for a device. Success when device(s)
    is/are connected, includes service map for the device if
    available. Failure when a device is not connected
  operationId: ActionGetConnection
  parameters:
    - name: id
      in: path
      description: The ID of the device. Group ID is not allowed.
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success
      content:
        application/nipc+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/Id'
              - $ref: './protocolmaps/ProtocolMap.yaml#/componen\
\ts/schemas/ProtocolMap-ServiceMap'
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '#/components/schemas/FailureResponse'

### Registrations
/registrations/models:
  post:
    tags:
      - NIPC registration APIs
    summary: Register an sdfObject
    description: |-
      Register an sdfObject, including Properties, Events and
      actions
    operationId: registerSdfObject
    requestBody:
      content:
```

```
    application/sdf+json:
      schema:
        $ref: '#/components/schemas/SdfModel'
    required: true
  responses:
    '200':
      description: Success
      content:
        application/nipc+json:
          schema:
            type: array
            items:
              allOf:
                - $ref: '#/components/schemas/SdfReference'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/FailureResponse'

get:
  tags:
    - NIPC registration APIs
  summary: Get all registered SDF model names
  description: |-
    Get all registered SDF model names.
  operationId: getSdfRefs
  parameters:
    - name: sdfName
      in: query
      description: |-
        sdfName can be a reference to an sdfThing or sdfObject
      required: false
      allowReserved: true
      schema:
        type: string
        example: "https://example.com/hearttrate#/sdfObject/heart\
hsensor"
  responses:
    '200':
      description: Success
      content:
        application/sdf+json:
          schema:
            $ref: '#/components/schemas/SdfModel'
    default:
```

```
    description: Error response
    content:
      application/problem+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/FailureResponse'
  put:
    tags:
      - NIPC registration APIs
    summary: Update an SDF model
    description: |-
      Update an SDF model, including Properties, Events and
      actions
    operationId: updateSdf
    parameters:
      - name: sdfName
        in: query
        description: |-
          sdfName can be a reference to an sdfThing or sdfObject
        required: true
        allowReserved: true
        schema:
          type: string
          example: "https://example.com/heartrate#/sdfObject/health\
\hsensor"
    requestBody:
      content:
        application/sdf+json:
          schema:
            $ref: '#/components/schemas/SdfModel'
      required: true
    responses:
      '200':
        description: Success
        content:
          application/nipc+json:
            schema:
              allOf:
                - $ref: '#/components/schemas/SdfReference'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/FailureResponse'

  delete:
```

```
tags:
  - NIPC registration APIs
summary: Delete an sdfObject
description: |-
  Delete an sdfObject, including Properties, Events and
  actions
operationId: deleteSdfObject
parameters:
  - name: sdfName
    in: query
    description: sdfObject name
    required: true
    schema:
      type: string
      example: "https://example.com/hearttrate#/sdfObject/health\
\hsensor"
responses:
  '200':
    description: Success
    content:
      application/nipc+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/SdfReference'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/FailureResponse'

/registrations/data-apps:
  post:
    tags:
      - NIPC registration APIs
    summary: Register a dataApp
    description: |-
      Register a dataApp that is able to receive device data.
    operationId: registerDataApp
    parameters:
      - name: dataAppId
        in: query
        description: id of the data app that will be registered
        required: true
        schema:
          type: string
          format: uuid
```

```
        example: 12345678-1234-5678-1234-56789abcdef4
requestBody:
  content:
    application/nipc+json:
      schema:
        $ref: '#/components/schemas/DataApp'
      required: true
responses:
  '200':
    description: Success
    content:
      application/nipc+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/DataApp'
  default:
    description: Error response
    content:
      application/problem+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/FailureResponse'

put:
  tags:
    - NIPC registration APIs
  summary: Update registration of a dataApp
  description: |-
    Update registration of a dataApp that is able to receive dev\
\ice data.
  operationId: UpdateDataApp
  parameters:
    - name: dataAppId
      in: query
      description: id of the data app that will be updated
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  requestBody:
    content:
      application/nipc+json:
        schema:
          $ref: '#/components/schemas/DataApp'
      required: true
  responses:
    '200':
```

```
    description: Success
    content:
      application/nipc+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/DataApp'
  default:
    description: Error response
    content:
      application/problem+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/FailureResponse'

delete:
  tags:
    - NIPC registration APIs
  summary: Delete registration of a dataApp
  description: |-
    Delete registration of a dataApp that is able to receive
    device data.
  operationId: DeleteDataApp
  parameters:
    - name: dataAppId
      in: query
      description: id of the data app that will be updated
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success
      content:
        application/nipc+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/DataApp'
  default:
    description: Error response
    content:
      application/problem+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/FailureResponse'

get:
```

```
tags:
  - NIPC registration APIs
summary: Get registration of a dataApp
description: |-
  Get registrationdetails of a dataApp that is able to receive
  device data.
operationId: GetDataApp
parameters:
  - name: dataAppId
    in: query
    description: id of the data app that will be updated
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
responses:
  '200':
    description: Success
    content:
      application/nipc+json:
        schema:
          allOf:
            - $ref: '#/components/schemas/DataApp'
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            allOf:
              - $ref: '#/components/schemas/FailureResponse'

components:
  schemas:
# Base objects
## A SCIM id, can be a device or a group
  Id:
    required:
      - id
    type: object
    properties:
      id:
        type: string
        format: uuid
        description: |-
          A SCIM-generated UUID, can be a device or group
        example: 12345678-1234-5678-1234-56789abcdef4
```

```
## A property
  Property:
    required:
      - property
    type: object
    properties:
      property:
        type: string
        example: "https://example.com/heartrate#/sdfObject/thermos\
\tat/sdfProperty/temperature"
```

```
  ActionResponse:
    required:
      - action
    type: object
    properties:
      status:
        type: string
        example: COMPLETED
        description: |-
          Status of the action, can be IN_PROGRESS or COMPLETED
```

```
## A value
  Value:
    required:
      - value
    type: object
    properties:
      value:
        type: string
        format: byte
        example: dGVzdA==
```

```
## A value of an property of an Device
  PropertyValue:
    allOf:
      - $ref: '#/components/schemas/Property'
      - $ref: '#/components/schemas/Value'
```

```
## An array of Property values
  PropertyValueArray:
    type: array
    items:
      $ref: '#/components/schemas/PropertyValue'
```

```
## Event
  Event:
    required:
```



```
- event
type: object
properties:
  event:
    type: string
    description: |-
      percent-encoded JSON pointer to the SDF event object
    example: https://example.com/hearttrate#/sdfObject/healthse\
\nsor/sdfEvent/fallDetected
```

```
InstanceId:
  type: object
  properties:
    instanceId:
      type: string
      format: uuid
      description: |-
        A SCIM-generated UUID for the event instance
      example: 12345678-1234-5678-1234-56789abcdef4
```

A Connection

```
Connection:
  type: object
  properties:
    retries:
      type: integer
      format: int32
      example: 3
    retryMultipleAPs:
      type: boolean
      example: true
```

DataApp

```
DataApp:
  oneOf:
    - $ref: '#/components/schemas/DataAppMqttClient'
    - $ref: '#/components/schemas/DataAppMqttBroker'
    - $ref: '#/components/schemas/DataAppWebhook'
    - $ref: '#/components/schemas/DataAppWebsocket'
  type: object
  properties:
    events:
      type: array
      items:
        $ref: '#/components/schemas/Event'
```

```
DataAppMqttClient:
```

```
    type: object
    properties:
      mqttClient:
        type: boolean

DataAppMqttBroker:
  type: object
  properties:
    mqttBroker:
      type: object
      required:
        - URI
        - username
        - password
      properties:
        URI:
          type: string
          example: mqtt.broker.com:8883
        username:
          type: string
          example: user1
        password:
          type: string
          example: password1
        brokerCACert:
          description: PEM encoded CA certificate
          type: string
        customTopic:
          type: string
          description: custom MQTT topic to publish to
          example: custom/topic

DataAppWebhook:
  type: object
  properties:
    webhook:
      type: object
      properties:
        URI:
          type: string
          example: webhook.com:443
        headers:
          type: object
          additionalProperties:
            type: string
          example:
            x-api-key: fjelk-3dl33f-2wdsd
        serverCACert:
```

```
        type: string

DataAppWebsocket:
  type: object
  properties:
    websocket:
      type: object
      properties:
        URI:
          type: string
          example: websocket.com:443
        headers:
          type: object
          additionalProperties:
            type: string
          example:
            x-api-key: fjelk-3dl33f-2wdsd
        serverCACert:
          type: string

## sdfObject registration definition
SdfReference:
  type: object
  description: SDF URL referring to the sdfobject
  properties:
    sdfName:
      type: string
      example: "https://example.com/heartrate#/sdfObject/healths\
\ensor"

SdfModel:
  allOf:
    - type: object
      description: Sample SDF model
      properties:
        namespace:
          type: object
          additionalProperties:
            type: string
          example:
            heartrate: https://example.com/heartrate
        defaultNamespace:
          type: string
          example: heartrate
    - oneOf:
      - $ref: '#/components/schemas/SdfThing'
      - $ref: '#/components/schemas/SdfObject'
```

```

SdfThing:
  type: object
  description: Sample SDF thing
  properties:
    sdfThing:
      additionalProperties:
        anyOf:
          - $ref: '#/components/schemas/SdfProperty'
          - $ref: '#/components/schemas/SdfEvent'
          - $ref: '#/components/schemas/SdfAction'
          - $ref: '#/components/schemas/SdfObject'
      example:
        multipleSensor:
          sdfEvent:
            isPresent:
              sdfOutputData:
                sdfProtocolMap:
                  ble:
                    type: advertisement
          sdfObject:
            healthsensor:
              sdfProperty:
                heartrate:
                  sdfProtocolMap:
                    ble:
                      serviceID: 12345678-1234-5678-1234-56789ab\
\cdef4
                      characteristicID: 12345678-1234-5678-1234-\
\56789abcdef4
          sdfEvent:
            fallDetected:
              sdfOutputData:
                sdfProtocolMap:
                  ble:
                    serviceID: 12345678-1234-5678-1234-56789\
\abcdef4
                    characteristicID: 12345678-1234-5678-123\
\4-56789abcdef4
          sdfAction:
            start:
              sdfProtocolMap:
                ble:
                  serviceID: 12345678-1234-5678-1234-56789ab\
\cdef4
                  characteristicID: 12345678-1234-5678-1234-\
\56789abcdef4
        SdfObject:

```

```

    type: object
    description: Sample SDF object
    properties:
      sdfObject:
        additionalProperties:
          anyOf:
            - $ref: '#/components/schemas/SdfProperty'
            - $ref: '#/components/schemas/SdfEvent'
            - $ref: '#/components/schemas/SdfAction'
        example:
          healthsensor:
            sdfProperty:
              heartrate:
                sdfProtocolMap:
                  ble:
                    serviceID: 12345678-1234-5678-1234-56789abcdef4
                    characteristicID: 12345678-1234-5678-1234-5678\
\9abcdef4
            sdfEvent:
              fallDetected:
                sdfOutputData:
                  sdfProtocolMap:
                    ble:
                      serviceID: 12345678-1234-5678-1234-56789abcd\
\ef4
                      characteristicID: 12345678-1234-5678-1234-56\
\789abcdef4
            sdfAction:
              start:
                sdfProtocolMap:
                  ble:
                    serviceID: 12345678-1234-5678-1234-56789abcdef4
                    characteristicID: 12345678-1234-5678-1234-5678\
\9abcdef4

    SdfProperty:
      type: object
      description: Sample SDF property
      properties:
        sdfProperty:
          additionalProperties:
            allof:
              - $ref: './protocolmaps/ProtocolMap.yaml#/components/s\
\chemas/ProtocolMap-Property'
          example:
            heartrate:
              sdfProtocolMap:
                ble:

```

```
        serviceID: 12345678-1234-5678-1234-56789abcdef4
        characteristicID: 12345678-1234-5678-1234-56789abc\
\def4

    SdfEvent:
      type: object
      description: Sample SDF property
      properties:
        sdfEvent:
          additionalProperties: #example, this will be the registere\
\def4 event
          type: object
          properties:
            sdfOutputData:
              allOf:
                - $ref: './protocolmaps/ProtocolMap.yaml#/componen\
\ts/schemas/ProtocolMap-Event'
          example:
            fallDetected:
              sdfOutputData:
                sdfProtocolMap:
                  ble:
                    serviceID: 12345678-1234-5678-1234-56789abcdef4
                    characteristicID: 12345678-1234-5678-1234-56789a\
\bcdef4

    SdfAction:
      type: object
      description: Sample SDF property
      properties:
        sdfAction:
          additionalProperties:
            allOf:
              - $ref: './protocolmaps/ProtocolMap.yaml#/components/s\
\chemas/ProtocolMap-Property'
          example:
            start:
              sdfProtocolMap:
                ble:
                  serviceID: 12345678-1234-5678-1234-56789abcdef4
                  characteristicID: 12345678-1234-5678-1234-56789abc\
\def4

# responses

    SuccessResponse:
      type: object
      properties:
```

```
    status:
      type: integer
      format: int32
      example: 200
      description: HTTP status code

## Error 500 application Failure response
FailureResponse:
  type: object
  properties:
    type:
      type: string
      description: URI to the error type
      enum:
        - https://www.iana.org/assignments/nipc-problem-types#in\
\valid-id
        - https://www.iana.org/assignments/nipc-problem-types#in\
\valid-sdf-url
        - https://www.iana.org/assignments/nipc-problem-types#ex\
\tension-operation-not-executed
        - https://www.iana.org/assignments/nipc-problem-types#sd\
\f-model-already-registered
        - https://www.iana.org/assignments/nipc-problem-types#sd\
\f-model-in-use
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\operty-not-readable
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\operty-read-failed
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\operty-not-writable
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\operty-write-failed
        - https://www.iana.org/assignments/nipc-problem-types#ev\
\ent-already-enabled
        - https://www.iana.org/assignments/nipc-problem-types#ev\
\ent-not-enabled
        - https://www.iana.org/assignments/nipc-problem-types#ev\
\ent-not-registered
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-already-connected
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-no-connection
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-connection-timeout
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-bonding-failed
        - https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-connection-failed
```

```
- https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-service-discovery-failed
- https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-ble-invalid-service-or-characteristic
- https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-zigbee-connection-timeout
- https://www.iana.org/assignments/nipc-problem-types#pr\
\otocolmap-zigbee-invalid-endpoint-or-cluster
- https://www.iana.org/assignments/nipc-problem-types#ex\
\tension-broadcast-invalid-data
- https://www.iana.org/assignments/nipc-problem-types#ex\
\tension-firmware-rollback
- https://www.iana.org/assignments/nipc-problem-types#ex\
\tension-firmware-update-failed
- about:blank
status:
  type: integer
  format: int32
  example: 400
  description: HTTP status code
title:
  type: string
  example: Invalid Device ID
  description: Human-readable error title
detail:
  type: string
  example: |-
    Device ID 12345678-1234-5678-1234-56789abcdef4 does not
    exist or is not a device
  description: Human-readable error message
```

Property operations responses

PropertyValueResponseArrayItem:

oneOf:

- \$ref: '#/components/schemas/SuccessResponse'
- \$ref: '#/components/schemas/FailureResponse'

PropertyValueResponseArray:

type: array

items:

\$ref: '#/components/schemas/PropertyValueResponseArrayItem'

PropertyValueReadResponseArrayItem:

oneOf:

- \$ref: '#/components/schemas/PropertyValue'
- \$ref: '#/components/schemas/FailureResponse'


```
PropertyValueReadResponseArray:
  type: array
  items:
    allOf:
      - $ref: '#/components/schemas/PropertyValueReadResponseArr\
\ayItem'

## Event operations responses
EventStatusResponseArrayItem:
  oneOf:
    - allOf:
      - $ref: '#/components/schemas/Event'
      - $ref: '#/components/schemas/InstanceId'
    - $ref: '#/components/schemas/FailureResponse'

EventStatusResponseArray:
  type: array
  items:
    $ref: '#/components/schemas/EventStatusResponseArrayItem'

GroupEventStatusResponse:
  type: object
  oneOf:
    - allOf:
      - $ref: '#/components/schemas/Event'
      - type: object
        properties:
          deviceId:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
    - $ref: '#/components/schemas/FailureResponse'

GroupEventStatusResponseArray:
  type: array
  items:
    $ref: '#/components/schemas/GroupEventStatusResponse'
<CODE ENDS>
```

Figure 31

Appendix B. Protocol mapping

NIPC requires that a protocol mapping be provided as part of the SDF model for a device or have one provided using the NIPC action APIs with embedded protocol mapping. The protocol mapping is a JSON object that describes the underlying technology used to communicate with the device along with any additional information needed to communicate with the device.

The JSON format of the protocol mapping is provided as a non-normative OpenAPI model for the convenience of the implementor.

B.1. Protocol mapping OpenAPI model

```
<CODE BEGINS> file "ProtocolMap.yaml"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) Protocol Mapping
  description: |-
    Non IP Device Control (NIPC) Protocol Mapping. When adding a
    new protocol mapping pls add a reference to the protocol map
    for all the schemas in this file.
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.10.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/

components:
  schemas:
# Protocol Mapping
## Protocol Map for Service Discovery
    ProtocolMap-ServiceList:
      type: object
      properties:
        sdfProtocolMap:
          oneOf:
            - $ref: './ProtocolMap-BLE.yaml#/components/schemas/Prot\
ocolMap-BLE-ServiceList'

## Protocol Map for Service Discovery result
```

```

ProtocolMap-ServiceMap:
  type: object
  properties:
    sdfProtocolMap:
      oneOf:
        - $ref: './ProtocolMap-BLE.yaml#/components/schemas/Prot\
ocolMap-BLE-ServiceMap'
        - $ref: './ProtocolMap-Zigbee.yaml#/components/schemas/P\
rotocolMap-Zigbee-ServiceMap'

## Protocol Map for Broadcasts
ProtocolMap-Broadcast:
  type: object
  properties:
    sdfProtocolMap:
      oneOf:
        - $ref: './ProtocolMap-BLE.yaml#/components/schemas/Prot\
ocolMap-BLE-Broadcast'
        - $ref: './ProtocolMap-Zigbee.yaml#/components/schemas/P\
rotocolMap-Zigbee-Broadcast'

## Protocol Map for a property
ProtocolMap-Property:
  type: object
  properties:
    sdfProtocolMap:
      oneOf:
        - $ref: './ProtocolMap-BLE.yaml#/components/schemas/Prot\
ocolMap-BLE-Propmap'
        - $ref: './ProtocolMap-Zigbee.yaml#/components/schemas/P\
rotocolMap-Zigbee-Propmap'

## Protocol Map for an event
ProtocolMap-Event:
  type: object
  properties:
    sdfProtocolMap:
      oneOf:
        - $ref: './ProtocolMap-BLE.yaml#/components/schemas/Prot\
ocolMap-BLE-Event'
        - $ref: './ProtocolMap-Zigbee.yaml#/components/schemas/P\
rotocolMap-Zigbee-Event'
<CODE ENDS>

```

Figure 32

B.2. Protocol map for BLE

```
<CODE BEGINS> file "ProtocolMap-BLE.yaml"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) BLE Protocol Mapping
  description: |-
    Non IP Device Control (NIPC) BLE Protocol Mapping.
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.10.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/

components:
  schemas:
# BLE Protocol Mapping
## A Service is a device with optional service IDs
    ProtocolMap-BLE-ServiceList:
      type: object
      properties:
        ble:
          type: object
          properties:
            services:
              type: array
              items:
                type: object
                properties:
                  serviceID:
                    type: string
                    format: uuid
                    example: 12345678-1234-5678-1234-56789abcdef4
      cached:
        description: |-
          If we can cache information, then device doesn't need
          to be rediscovered before every connected.
        type: boolean
        default: false
      cacheIdlePurge:
        description: cache expiry period, when device allows
        type: integer
        example: 3600 # default 1 hour
```

```
    autoUpdate:
      description: |-
        autoupdate services if device supports it (default)
      type: boolean
      example: true
    bonding: #optional, by default defined in SCIM object
      type: string
      example: default
      enum:
        - default
        - none
        - justworks
        - passkey
        - oob
```

Protocol Mapping for BLE Service Map

ProtocolMap-BLE-ServiceMap:

```
  required:
    - services
  type: object
  properties:
    ble:
      type: array
      items:
        $ref: '#/components/schemas/ProtocolMap-BLE-Service'
```

ProtocolMap-BLE-Service:

```
  required:
    - serviceID
    - characteristics
  type: object
  properties:
    serviceID:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
    characteristics:
      type: array
      items:
        $ref: '#/components/schemas/ProtocolMap-BLE-Characterist\
```

ic'

ProtocolMap-BLE-Characteristic:

```
  required:
    - characteristicID
    - flags
    - descriptors
  type: object
```

```
properties:
  characteristicID:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
  flags:
    type: array
    example:
      - read
      - write
    items:
      type: string
      enum:
        - read
        - write
        - notify
  descriptors:
    type: array
    items:
      $ref: '#/components/schemas/ProtocolMap-BLE-Descriptor'
```

```
ProtocolMap-BLE-Descriptor:
  required:
    - descriptorID
  type: object
  properties:
    descriptorID:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
```

Protocol Mapping for BLE Broadcast

```
ProtocolMap-BLE-Broadcast:
  required:
    - ble
  type: object
  properties:
    ble:
      type: object
      properties:
        connectable:
          type: boolean
```

Protocol Mapping for BLE Property

```
ProtocolMap-BLE-Propmap:
  required:
    - ble
  type: object
```

```

    properties:
      ble:
        required:
          - serviceID
          - characteristicID
        type: object
        properties:
          serviceID:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
          characteristicID:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4

## Defines different types of BLE events
ProtocolMap-BLE-Event:
  required:
    - ble
  type: object
  properties:
    ble:
      required:
        - type
      type: object
      properties:
        type:
          type: string
          example: gatt
          enum:
            - gatt
            - connection_events
            - advertisements
        serviceID:
          type: string
          example: 12345678-1234-5678-1234-56789abcdef0
        characteristicID:
          type: string
          example: 12345678-1234-5678-1234-56789abcdef1
<CODE ENDS>

```

Figure 33

B.3. Protocol map for Zigbee

```
<CODE BEGINS> file "ProtocolMap-Zigbee.yaml"
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) Zigbee Protocol Mapping
  description: |-
    Non IP Device Control (NIPC) Zigbee Protocol Mapping.
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.10.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/

components:
  schemas:
# Zigbee Protocol Mapping
## Protocol Mapping for Zigbee Service Map
    ProtocolMap-Zigbee-ServiceMap:
      required:
        - zigbee
      type: object
      properties:
        zigbee:
          type: array
          items:
            $ref: '#/components/schemas/ProtocolMap-Zigbee-Endpoint'

    ProtocolMap-Zigbee-Endpoint:
      required:
        - endpointID
        - clusters
      type: object
      properties:
        endpointID:
          type: integer
          format: int32
          example: 10
        clusters:
          type: array
          items:
            $ref: '#/components/schemas/ProtocolMap-Zigbee-Cluster'

    ProtocolMap-Zigbee-Cluster:
      required:
```



```
- clusterID
- properties
type: object
properties:
  clusterID:
    type: integer
    format: int32
    example: 0
  properties:
    type: array
    items:
      $ref: '#/components/schemas/ProtocolMap-Zigbee-Property'
```

ProtocolMap-Zigbee-Property:

```
required:
  - attributeID
  - propertyType
type: object
properties:
  attributeID:
    type: integer
    format: int32
    example: 1
  propertyType:
    type: integer
    format: int32
    example: 32
```

Protocol Mapping for Zigbee broadcast

ProtocolMap-Zigbee-Broadcast:

```
required:
  - zigbee
type: object
properties:
  zigbee:
    type: object
```

Protocol mapping for Zigbee property

ProtocolMap-Zigbee-Propmap:

```
required:
  - zigbee
type: object
properties:
  zigbee:
    required:
      - endpointID
      - clusterID
      - attributeID
```

```

    type: object
    properties:
      endpointID:
        type: integer
        format: int32
        example: 1
      clusterID:
        type: integer
        format: int32
        example: 6
      attributeID:
        type: integer
        format: int32
        example: 16
      type:
        type: integer
        format: int32
        example: 1

ProtocolMap-Zigbee-Event:
  allOf:
    - $ref: '#/components/schemas/ProtocolMap-Zigbee-Propmap'
<CODE ENDS>

```

Figure 34

Appendix C. NIPC API extensions

The following OpenAPI models define a few example extensions to the NIPC API.

C.1. NIPC API write binary blob extension

```

<CODE BEGINS> file "Extension-Blob.yaml"
===== NOTE: '\' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-12/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API write binary blob extension
  description: |-
    Non IP Device Control (NIPC) API write binary blob extension
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD

```

```
    url: TBD
    version: 0.14.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-14"
    variables:
      gw_host:
        default: localhost
        description: Gateway Host
tags:
  - name: NIPC API extensions
    description: |-
      APIs that simplify application interaction by implementing
      one or more basic APIs into a single API call.

paths:
  ### Extensions
  /extensions/{id}/properties/blob:
    put:
      tags:
        - NIPC API extensions
      summary: Write a binary blob to a property on a device
      description: |-
        Write a binary blob to a property on a device. Will chunk up
        the binary blob and perform multiple writes. If the
        underlying protocol requires a connection to be set up,
        this API call will perform the necessary connection
        management. If a connection is already active for this
        device, the existing connection will be leveraged without
        modifying it. ID cannot be a group-id.
      operationId: writeBlob
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
        - name: propertyName
          in: query
          description: |-
            The SDF property name that needs to be written to.
          required: true
          schema:
```

```

        type: string
        example: "https://example.com/heartrate#/sdfObject/thermos\
tat/sdfProperty/firmware"
      requestBody:
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Extension-Blob'
        required: true
      responses:
        '204':
          description: Success, no content
        'default':
          description: Error response
          content:
            application/json:
              schema:
                $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
nse'

components:
  schemas:
# Extensions
## A binary blob Extension
    Extension-Blob:
      required:
        - blob
      type: object
      properties:
        blob:
          type: string
          format: byte
          chunksize:
            type: integer
<CODE ENDS>

```

C.2. NIPC API bulk operations extension

```

<CODE BEGINS> file "Extension-Bulk.yaml"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-1\
2/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API bulk extension
  description: |-
    Non IP Device Control (NIPC) API bulk extension

```

```
termsOfService: http://swagger.io/terms/
contact:
  email: bbrinckm@cisco.com
license:
  name: TBD
  url: TBD
version: 0.14.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
- url: "{gw_host}/nipc/draft-14"
  variables:
    gw_host:
      default: localhost
      description: Gateway Host
tags:
- name: NIPC API extensions
  description: |-
    APIs that simplify application interaction by implementing
    one or more basic APIs into a single API call.

paths:
  ### Extensions
  /extensions/{id}/bulk:
    post:
      tags:
        - NIPC API extensions
      summary: Compound operations on a device
      description: Compound operations on a device
      operationId: Bulk
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
      requestBody:
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/Extension-Bulk"
            examples:
              bulkRequest:
                $ref: "#/components/examples/bulkRequest"
```

```

        firmwareUpgradeRequest:
          $ref: "#/components/examples/firmwareUpgradeRequest"
      required: true
    responses:
      "202":
        description: Accepted
        headers:
          Location:
            schema:
              type: string
              example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/bulk/status?instanceId=12345678-1234-5678-1234-56789abcdef4
          description: URL to get the bulk status response
      "401":
        description: Unauthorized
      "405":
        description: Invalid request
      "500":
        description: Server-side failure
        content:
          application/json:
            schema:
              $ref: "../NIPC.yaml#/components/schemas/FailureRespo\
nse"
    callbacks:
      bulkEvent:
        "{$request.body#/callback.url}":
          post:
            description: Callback for bulk response
            operationId: bulkCallback
            requestBody:
              content:
                application/json:
                  schema:
                    allOf:
                      - $ref: "../NIPC.yaml#/components/schemas/Id"
                      - $ref: "#/components/schemas/Extension-Bulk\
Response"
    responses:
      "200":
        description: OK
      "400":
        description: Bad request
      "401":
        description: Unauthorized
      "405":
        description: Invalid request
      "500":

```

```

        description: Server-side failure
get:
  tags:
    - NIPC API extensions
  summary: Get Bulk response
  description: Get Bulk response
  operationId: getBulkResponse
  parameters:
    - name: id
      in: path
      description: The ID of the device. Group ID is not allowed.
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    - name: instanceId
      in: query
      description: Instance ID of the bulk operation
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    "200":
      description: OK
      headers:
      content:
        application/json:
          schema:
            allOf:
              - $ref: "../NIPC.yaml#/components/schemas/Id"
              - $ref: "../components/schemas/Extension-BulkRespon\
se"
          examples:
            bulkResponse:
              $ref: "../components/examples/bulkResponse"
            firmwareUpgradeResponse:
              $ref: "../components/examples/firmwareUpgradeRespon\
se"
            errorBulkResponse:
              $ref: "../components/examples/errorBulkResponse"

/extensions/{id}/bulk/status:
  get:
    tags:
      - NIPC API extensions

```

```
summary: Get Bulk status
description: Get Bulk status
operationId: getBulkStatus
parameters:
  - name: id
    in: path
    description: The ID of the device. Group ID is not allowed.
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
  - name: instanceId
    in: query
    description: Instance ID of the bulk operation
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
responses:
  "200":
    description: OK
    headers:
    content:
      application/json:
        schema:
          allOf:
            - $ref: "../Extension-Async.yaml#/components/schema\
s/Extension-StatusResponse"
  "303":
    description: See Other
    headers:
      Location:
        schema:
          type: string
          example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/bulk?instanceId=12345678-1234-5678-1234-56789abcdef4
    description: URL to get the bulk response
    content:
      application/json:
        schema:
          allOf:
            - $ref: "../Extension-Async.yaml#/components/schema\
s/Extension-StatusResponse"
    examples:
      successExample:
        summary: Success
```



```

        value:
          status: COMPLETED

components:
  schemas:
    # Extensions
    ## Bulk schema Extension
    Extension-Bulk:
      allOf:
        - $ref: "../Extension-Async.yaml#/components/schemas/Extension-Callback"
        - type: object
          properties:
            operations:
              type: array
              items:
                $ref: "#/components/schemas/Extension-BulkOperation"
            trigger:
              type: string
              description: |-
                When to trigger the operations. If not specified, the operations are triggered immediately.
              default: immediate
              enum:
                - immediate
                - advertisement

    ## Extension that defines an operation in a bulk API
    Extension-BulkOperation:
      required:
        - method
        - path
      allOf:
        - type: object
          properties:
            method:
              type: string
              enum:
                - POST
                - PUT
                - GET
            path:
              type: string
              enum:
                - /devices/{id}/properties?propertyName={propertyName}
                - /devices/{id}/actions/?actionName={actionName}
                - /extensions/{id}/properties/read/conditional?propertyName={propertyName}

```

```

    rtyName={propertyName}
      - /extensions/{id}/events/conditional?eventName={eve\
ntName}
      - /extensions/{id}/properties/file?propertyName={pro\
pertyName}
      example: /devices/12345678-1234-5678-1234-56789abcdef4\
/properties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%\
2FsdfThing%2Fthermometer%2FsdfProperty%2Ftemperature
      data:
        type: object
        oneOf:
          - $ref: "../NIPC.yaml#/components/schemas/Value"
          - $ref: "../Extension-ReadConditional.yaml#/component\
s/schemas/Extension-ConditionalRead"

## Multiple returns for a bulk operation
Extension-BulkResponse:
  type: object
  properties:
    operations:
      type: array
      items:
        $ref: "#/components/schemas/Extension-OperationResponse"

## Return for an operation
Extension-OperationResponse:
  allOf:
    - type: object
      properties:
        method:
          type: string
          enum:
            - POST
            - PUT
            - GET
        path:
          type: string
          enum:
            - /devices/{id}/properties?propertyName={propertyNam\
e}
            - /devices/{id}/actions/?actionName={actionName}
            - /extensions/{id}/properties/read/conditional?prope\
rtyName={propertyName}
            - /extensions/{id}/events/conditional?eventName={eve\
ntName}
      example: /devices/12345678-1234-5678-1234-56789abcdef4\
/properties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%\
2FsdfThing%2Fthermometer%2FsdfProperty%2Ftemperature

```

```
    response:
      anyOf:
        - $ref: "../NIPC.yaml#/components/schemas/Value"
        - $ref: "../NIPC.yaml#/components/schemas/SuccessRes\
ponse"
        - $ref: "../NIPC.yaml#/components/schemas/FailureRes\
ponse"

  examples:
    bulkRequest:
      summary: Bulk request example
      value:
        operations:
          - method: GET
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
          - method: PUT
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
            data:
              value: dGVzdA==
          - method: POST
            path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ftemperature
            data:
              value: dGVzdA==
              maxRepeat: 5
              retryTime: 1
    bulkResponse:
      summary: Bulk response example
      value:
        operations:
          - method: GET
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
            response:
              value: dGVzdA==
          - method: PUT
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
            response:
              status: 200
          - method: POST
```

```
      path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
properties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ftemperature
      response:
        value: dGVzdA==
    errorBulkResponse:
      summary: Error Bulk response example
      value:
        operations:
          - method: GET
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
            response:
              type: https://www.iana.org/assignments/nipc-problem-ty\
pes#property-not-readable
              status: 400
              title: Property not readable
              detail: Property https://example.com/thermometer#/sdfT\
hing/thermometer/sdfProperty/temperature is not readable
          - method: PUT
            path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
            response:
              type: https://www.iana.org/assignments/nipc-problem-ty\
pes#extension-operation-not-executed
              status: 400
              title: Operation not executed
              detail: Operation was not executed since the previous \
operation failed
          - method: POST
            path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ftemperature
            response:
              type: https://www.iana.org/assignments/nipc-problem-ty\
pes#extension-operation-not-executed
              status: 400
              title: Operation not executed
              detail: Operation was not executed since the previous \
operation failed
      firmwareUpgradeRequest:
        summary: Firmware upgrade request example
        value:
          operations:
            - method: PUT
              path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
```

```
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FstartOTA
  data:
    value: dGVzdA==
  - method: POST
    path: /extensions/12345678-1234-5678-1234-56789abcdef4/e\
vents/conditional?eventName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfEvent%2FotaStarted
  data:
    value: MQ==
    timeout: 5
  - method: PUT
    path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/file?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ffirmware
  data:
    fileURL: https://example.com/firmware.bin
    chunkSize: 20
    sha256Checksum: abcdef1234567890abcdef1234567890abcdef\
1234567890abcdef1234567890
  - method: PUT
    path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FfinishOTA
  data:
    value: dGVzdA==
  - method: POST
    path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2FupdateStatus
  data:
    value: MQ==
    maxRepeat: 5
    retryTime: 1
  - method: PUT
    path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FactivateOTA
  data:
    value: dGVzdA==
firmwareUpgradeResponse:
  summary: Firmware upgrade response example
  value:
    operations:
      - method: PUT
        path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FstartOTA
```

```

        response:
          status: 200
      - method: POST
        path: /extensions/12345678-1234-5678-1234-56789abcdef4/e\
vents/conditional?eventName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfEvent%2FotaStarted
        response:
          value: MQ==
      - method: PUT
        path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/file?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ffirmware
        response:
          status: 204
      - method: PUT
        path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FfinishOTA
        response:
          status: 200
      - method: POST
        path: /extensions/12345678-1234-5678-1234-56789abcdef4/p\
roperties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2FupdateStatus
        response:
          value: MQ==
      - method: PUT
        path: /devices/12345678-1234-5678-1234-56789abcdef4/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FactivateOTA
        data:
          status: 200
<CODE ENDS>

```

C.3. NIPC API write file extension

```

<CODE BEGINS> file "Extension-File.yaml"
===== NOTE: '\\\ ' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-1\
\2/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API write file extension
  description: |-
    Non IP Device Control (NIPC) API write file extension
  termsOfService: http://swagger.io/terms/
  contact:

```

```
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.14.0
  externalDocs:
    description: NIPC IETF draft
    url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
  servers:
    - url: "{gw_host}/nipc/draft-14"
      variables:
        gw_host:
          default: localhost
          description: Gateway Host
  tags:
    - name: NIPC API extensions
      description: |-
        APIs that simplify application interaction by implementing
        one or more basic APIs into a single API call.

  paths:
    ### Extensions
    /extensions/{id}/properties/file:
      put:
        tags:
          - NIPC API extensions
        summary: Write a file to a property on a device
        description: |-
          Write a file to a property on a device. Will chunk up the
          file and perform multiple writes. If the underlying protocol
          requires a connection to be set up, this API call will
          perform the necessary connection management. If a connection
          is already active for this device, the existing connection
          will be leveraged without modifying it. ID cannot be a
          group-id.
        operationId: writeFile
        parameters:
          - name: id
            in: path
            description: The ID of the device. Group ID is not allowed.
            required: true
            schema:
              type: string
              format: uuid
              example: 12345678-1234-5678-1234-56789abcdef4
          - name: propertyName
            in: query
            description: |-
```

```

    The SDF property name that needs to be written to.
    required: true
    schema:
      type: string
      example: "https://example.com/heartrate#/sdfObject/thermos\
\tat/sdfProperty/firmware"
    requestBody:
      content:
        application/json:
          schema:
            allOf:
              - $ref: '#/components/schemas/Extension-File'
              - $ref: './Extension-Async.yaml#/components/schemas/\
\Extension-Callback'
            required: true
    responses:
      '202':
        description: Accepted
        headers:
          Location:
            schema:
              type: string
              example: /extensions/12345678-1234-5678-1234-56789ab\
\cdef4/properties/file/status?propertyName=https%3A%2F%2Fexample.com\
\%2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2Ffirmware&i\
\nstanceId=12345678-1234-5678-1234-56789abcdef4
              description: |-
                URL to get the file write status
        Retry-After:
          schema:
            type: integer
          description: |-
            Time in seconds to wait before retrying
      'default':
        description: Error response
        content:
          application/json:
            schema:
              $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
\nse'
    callbacks:
      callbackEvent:
        "{$request.body#/callback.url}":
          post:
            requestBody:
              content:
                application/json:
                  schema:

```



```

      anyOf:
        - allof:
          - $ref: '../NIPC.yaml#/components/schemas/\
\Id'
          - $ref: '../NIPC.yaml#/components/schemas/\
\PropertyValue'
          - $ref: '../NIPC.yaml#/components/schemas/Fa\
\ilureResponse'
      examples:
        successExample:
          summary: Success
          value:
            id: 12345678-1234-5678-1234-56789abcdef4
            property: https://example.com/heartrate#/s\
\dfObject/thermostat/sdfProperty/firmware
        failedResponse:
          summary: Failed
          value:
            id: 12345678-1234-5678-1234-56789abcdef4
            status: 400
            type: https://www.iana.org/assignments/nip\
\c-problem-types#invalid-id
            title: Invalid ID
            detail: "Invalid request"
            property: https://example.com/heartrate#/s\
\dfObject/thermostat/sdfProperty/firmware
      responses:
        '200':
          description: Success
    get:
      tags:
        - NIPC API extensions
      summary: Get the status of a file write operation
      description: |-
        Get the status of a file write operation. This will return
        the status of the file write operation, including any errors
        that may have occurred.
      operationId: getFileWriteStatus
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
        - name: propertyName

```

```

    in: query
    description: |-
      The SDF property name that needs to be written to.
    required: true
    schema:
      type: string
      example: "https://example.com/heartrate#/sdfObject/thermos\
\tat/sdfProperty/firmware"
  - name: instanceId
    in: query
    description: |-
      The Instance ID for the file write operation.
    required: true
    schema:
      type: string
      format: uuid
      example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '204':
      description: Success, no content
    default:
      description: Error response
      content:
        application/json:
          schema:
            $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
\nse'
  /extensions/{id}/properties/file/status:
    get:
      tags:
        - NIPC API extensions
      summary: Get the status of a file write operation
      description: |-
        Get the status of a file write operation. This will return
        the status of the file write operation, including any errors
        that may have occurred.
      operationId: getFileWriteStatus
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
        - name: propertyName
          in: query

```

```
description: |-
  The SDF property name that needs to be written to.
required: true
schema:
  type: string
  example: "https://example.com/heartrate#/sdfObject/thermos\
\tat/sdfProperty/firmware"
- name: instanceId
  in: query
  description: |-
    The Instance ID for the file write operation.
  required: true
  schema:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
responses:
  '200':
    description: Success, returns the status of the file write\
\ operation.
    content:
      application/json:
        schema:
          $ref: './Extension-Async.yaml#/components/schemas/Ex\
\tension-StatusResponse'
  '303':
    description: See Other
    headers:
      Location:
        schema:
          type: string
          example: /extensions/12345678-1234-5678-1234-56789ab\
\cdef4/properties/file?propertyName=https%3A%2F%2Fexample.com%2Fhear\
\trate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2Ffirmware&instance\
\Id=12345678-1234-5678-1234-56789abcdef4
    description: URL to get the file write response
    content:
      application/json:
        schema:
          $ref: './Extension-Async.yaml#/components/schemas/Ex\
\tension-StatusResponse'
    examples:
      successExample:
        summary: Completed
        value:
          id: 12345678-1234-5678-1234-56789abcdef4
          status: COMPLETED
```

```
components:
  schemas:
# Extensions
## A File Extension
  Extension-File:
    required:
      - fileURL
    type: object
    properties:
      fileURL:
        type: string
        example: "https://domain.com/firmware.dat"
        description: |-
          URL to the firmware file.
          The HTTP method is assumed to be a GET.
      chunkSize:
        type: integer
      sha256Checksum:
        type: string
        description: firmware checksum
      headers:
        type: object
        additionalProperties:
          type: string
        example:
          x-api-key: fjelk-3dl33f-2wdsd
<CODE ENDS>
```

C.4. NIPC API conditional read extension

```
<CODE BEGINS> file "Extension-ReadConditional.yaml"
===== NOTE: '\' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-1\
2/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API read conditional extension
  description: |-
    Non IP Device Control (NIPC) API read conditional extension
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.14.0
externalDocs:
```

```
description: NIPC IETF draft
url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
- url: "{gw_host}/nipc/draft-14"
  variables:
    gw_host:
      default: localhost
      description: Gateway Host
tags:
- name: NIPC API extensions
  description: |-
    APIs that simplify application interaction by implementing
    one or more basic APIs into a single API call.

paths:
### Extensions
/extensions/{id}/properties/read/conditional:
  post:
    tags:
      - NIPC API extensions
    summary: Conditional read of a property
    description: Conditional read of a property
    operationId: conditionalRead
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
      - name: propertyName
        in: query
        description: |-
          The SDF property name that needs to be read conditionally.
        required: true
        allowReserved: true
        schema:
          type: string
          example: "#/sdfObject/thermostat/sdfProperty/temperature"
    requestBody:
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Extension-ConditionalRead'
          required: true
    responses:
```

```

    '202':
      description: Accepted
      headers:
        Location:
          schema:
            type: string
            example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/properties/read/conditional/status?propertyName=https%3A%2F%2F\
example.com%2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2F\
temperature&instanceId=12345678-1234-5678-1234-56789abcdef4
          description: |-
            URL to get the conditional read status
      Retry-After:
        schema:
          type: integer
          description: |-
            Time in seconds to wait before retrying
    'default':
      description: Error response
      content:
        application/json:
          schema:
            $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
nse'
      callbacks:
        callbackEvent:
          "{$request.body#/callback.url}":
            post:
              requestBody:
                content:
                  application/json:
                    schema:
                      anyOf:
                        - allof:
                          - $ref: '../NIPC.yaml#/components/schemas/\
Id'
                          - $ref: '../NIPC.yaml#/components/schemas/\
PropertyValue'
                        - $ref: '../NIPC.yaml#/components/schemas/Fa\
ilureResponse'
                examples:
                  successExample:
                    summary: Success
                    value:
                      id: 12345678-1234-5678-1234-56789abcdef4
                      property: https://example.com/heartrate#/s\
dfObject/thermostat/sdfProperty/temperature
                      value: dGVzdA==

```

```
      failedResponse:
        summary: Failed
        value:
          id: 12345678-1234-5678-1234-56789abcdef4
          status: 400
          type: https://www.iana.org/assignments/nip\
c-problem-types#invalid-id
          title: Invalid ID
          detail: "Invalid request"
          property: https://example.com/hearttrate#/s\
dfObject/thermostat/sdfProperty/temperature
          value: dGVzdA==

      responses:
        '200':
          description: Success

get:
  tags:
    - NIPC API extensions
  summary: Get Conditional read response of a property
  description: Conditional read response of a property
  operationId: getConditionalRead
  parameters:
    - name: id
      in: path
      description: The ID of the device. Group ID is not allowed.
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    - name: propertyName
      in: query
      description: |-
        The SDF property name that needs to be read conditionally.
      required: true
      allowReserved: true
      schema:
        type: string
        example: "#/sdfObject/thermostat/sdfProperty/temperature"
    - name: instanceId
      in: query
      description: |-
        Instance ID of the conditional read operation
      required: true
      schema:
        type: string
        format: uuid
```

```
    example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success
      headers:
      content:
        application/json:
          schema:
            allOf:
              - $ref: '../NIPC.yaml#/components/schemas/Value'
        application/octet-stream:
          schema:
            type: string
            format: binary
          description: Binary data of the property value
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              allOf:
                - $ref: '../NIPC.yaml#/components/schemas/FailureR\
response'
  /extensions/{id}/properties/read/conditional/status:
    get:
      tags:
        - NIPC API extensions
      summary: Get Conditional read status of a property
      description: Conditional read status of a property
      operationId: getConditionalReadStatus
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
        - name: propertyName
          in: query
          description: |-
            The SDF property name that needs to be read conditionally.
          required: true
          allowReserved: true
          schema:
            type: string
            example: "#/sdfObject/thermostat/sdfProperty/temperature"
```



```
- name: instanceId
  in: query
  description: Instance ID of the conditional read operation
  required: true
  schema:
    type: string
    format: uuid
    example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: OK
      headers:
      content:
        application/json:
          schema:
            $ref: './Extension-Async.yaml#/components/schemas/Ex\
tension-StatusResponse'
    '303':
      description: See Other
      headers:
        Location:
          schema:
            type: string
            example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/properties/read/conditional?propertyName=https%3A%2F%2Fexample\
.com%2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2Ftempera\
ture&instanceId=12345678-1234-5678-1234-56789abcdef4
      description: URL to get the conditional read response
      content:
        application/json:
          schema:
            $ref: './Extension-Async.yaml#/components/schemas/Ex\
tension-StatusResponse'
      examples:
        successExample:
          summary: Completed
          value:
            id: 12345678-1234-5678-1234-56789abcdef4
            status: COMPLETED

components:
  schemas:
# Extensions
  Extension-ConditionalRead:
    allOf:
      - $ref: './NIPC.yaml#/components/schemas/Value'
      - $ref: './Extension-Async.yaml#/components/schemas/Extensio\
n-Callback'
```

```
- type: object
  properties:
    maxRepeat:
      description: |-
        maximum time the conditional read should repeat
        (default 5, max 10)
      type: integer
      example: 5
    retryTime:
      description: |-
        time between reads in seconds (default 1, max 10)
      type: integer
      example: 1
```

<CODE ENDS>

C.5. NIPC API conditional event extension

```
<CODE BEGINS> file "Extension-EventConditional.yaml"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-12/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API event conditional extension
  description: |-
    Non IP Device Control (NIPC) API event conditional extension
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.14.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
- url: "{gw_host}/nipc/draft-14"
  variables:
    gw_host:
      default: localhost
      description: Gateway Host
tags:
- name: NIPC API extensions
  description: |-
    APIs that simplify application interaction by implementing
    one or more basic APIs into a single API call.
```

```
paths:
### Extensions
/extensions/{id}/events/conditional:
  post:
    tags:
      - NIPC API extensions
    summary: Enable an event until a condition is met
    description: Enable an event until a condition is met
    operationId: conditionalEvent
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
      - name: eventName
        in: query
        description: |-
          The SDF event name that needs to be enabled.
        required: true
        allowReserved: true
        schema:
          type: string
          example: "#/sdfObject/thermostat/sdfEvent/temperature"
    requestBody:
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Extension-ConditionalEvent'
          required: true
    responses:
      '202':
        description: Accepted
        headers:
          Location:
            schema:
              type: string
              example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/events/conditional/status?eventName=https%3A%2F%2Fexample.com%\
2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfEvent%2Ftemperature&ins\
tanceId=12345678-1234-5678-1234-56789abcdef4
        description: |-
          URL to get the conditional event status
        Retry-After:
          schema:
```

```

        type: integer
        description: |-
            Time in seconds to wait before retrying
    'default':
        description: Error response
        content:
            application/json:
                schema:
                    $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
nse'
    callbacks:
        callbackEvent:
            "{$request.body#/callback.url}":
                post:
                    requestBody:
                        content:
                            application/json:
                                schema:
                                    anyOf:
                                        - allOf:
                                            - $ref: '../NIPC.yaml#/components/schemas/\
Id'
                                            - $ref: '../NIPC.yaml#/components/schemas/\
PropertyValue'
                                        - $ref: '../NIPC.yaml#/components/schemas/Fa\
ilureResponse'
                                examples:
                                    successExample:
                                        summary: Success
                                        value:
                                            id: 12345678-1234-5678-1234-56789abcdef4
                                            event: https://example.com/heartrate#/sdfO\
bject/thermostat/sdfEvent/temperature
                                            value: dGVzdA==
                                    failedResponse:
                                        summary: Failed
                                        value:
                                            id: 12345678-1234-5678-1234-56789abcdef4
                                            status: 400
                                            type: https://www.iana.org/assignments/nip\
c-problem-types#invalid-id
                                            title: Invalid ID
                                            detail: "Invalid request"
                                            event: https://example.com/heartrate#/sdfO\
bject/thermostat/sdfEvent/temperature
                                            value: dGVzdA==

    responses:
```

```
        '200':
          description: Success
get:
  tags:
    - NIPC API extensions
  summary: Get Conditional event response
  description: Conditional event response
  operationId: getConditionalEvent
  parameters:
    - name: id
      in: path
      description: The ID of the device. Group ID is not allowed.
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    - name: eventName
      in: query
      description: |-
        The name of the SDF event that is enabled.
      required: true
      allowReserved: true
      schema:
        type: string
        example: "#/sdfObject/thermostat/sdfEvent/temperature"
    - name: instanceId
      in: query
      description: |-
        Instance ID of the conditional event operation
      required: true
      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
  responses:
    '200':
      description: Success
      headers:
      content:
        application/json:
          schema:
            allOf:
              - $ref: '../NIPC.yaml#/components/schemas/Value'
        application/octet-stream:
          schema:
            type: string
            format: binary
```

```
        description: Binary data of the event value
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            allOf:
              - $ref: '../NIPC.yaml#/components/schemas/FailureR\
esponse'
  /extensions/{id}/events/conditional/status:
    get:
      tags:
        - NIPC API extensions
      summary: Get Conditional event status
      description: Conditional event status
      operationId: getConditionalEventStatus
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
        - name: eventName
          in: query
          description: |-
            The name of the SDF event that is enabled.
          required: true
          allowReserved: true
          schema:
            type: string
            example: "#/sdfObject/thermostat/sdfEvent/temperature"
        - name: instanceId
          in: query
          description: Instance ID of the conditional event operation
          required: true
          schema:
            type: string
            format: uuid
            example: 12345678-1234-5678-1234-56789abcdef4
      responses:
        '200':
          description: OK
          headers:
          content:
            application/json:
```

```

      schema:
        $ref: './Extension-Async.yaml#/components/schemas/Ex\
tension-StatusResponse'
      '303':
        description: See Other
        headers:
          Location:
            schema:
              type: string
              example: /extensions/12345678-1234-5678-1234-56789ab\
cdef4/events/conditional?eventName=https%3A%2F%2Fexample.com%2Fheart\
rate%23%2FsdfObject%2Fthermostat%2FsdfEvent%2Ftemperature&instanceId\
=12345678-1234-5678-1234-56789abcdef4
            description: URL to get the conditional event response
        content:
          application/json:
            schema:
              $ref: './Extension-Async.yaml#/components/schemas/Ex\
tension-StatusResponse'
            examples:
              successExample:
                summary: Completed
                value:
                  id: 12345678-1234-5678-1234-56789abcdef4
                  status: COMPLETED

components:
  schemas:
    # Extensions
    Extension-ConditionalEvent:
      allOf:
        - $ref: './Extension-Async.yaml#/components/schemas/Extensio\
n-Callback'
        - $ref: './NIPC.yaml#/components/schemas/Value'
        - type: object
          properties:
            timeout:
              description: |-
                Time in seconds to keep the event enabled.
                If the event condition is not met within this time,
                the event will be disabled and marked as failed.
              type: integer
              example: 5

```

<CODE ENDS>

C.6. NIPC API property extensions

```
<CODE BEGINS> file "Extension-Property.yaml"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

# yaml-language-server: $schema=https://json-schema.org/draft/2020-12/schema
openapi: 3.0.3
info:
  title: Non IP Device Control (NIPC) API read conditional extension
  description: |-
    Non IP Device Control (NIPC) API read conditional extension
  termsOfService: http://swagger.io/terms/
  contact:
    email: bbrinckm@cisco.com
  license:
    name: TBD
    url: TBD
  version: 0.14.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-14"
    variables:
      gw_host:
        default: localhost
        description: Gateway Host
tags:
  - name: NIPC API extensions
    description: |-
      APIs that simplify application interaction by implementing
      one or more basic APIs into a single API call.

paths:
  ### Extensions
  /extensions/{id}/transmit:
    post:
      tags:
        - NIPC API extensions
      summary: Transmit to a device
      description: |-
        Transmit a payload to a device. The transmission is performed on the AP where the device was last seen
      operationId: ActionTransmit
      parameters:
        - name: id
          in: path
          description: The ID of the device. Group ID is not allowed.
          required: true
```



```

      schema:
        type: string
        format: uuid
        example: 12345678-1234-5678-1234-56789abcdef4
    requestBody:
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Transmit'
      required: true
    responses:
      '200':
        description: Success
      default:
        description: Error response
        content:
          application/problem+json:
            schema:
              $ref: '../NIPC.yaml#/components/schemas/FailureResponse'

/extensions/{id}/properties/write:
  post:
    tags:
      - NIPC API extensions
    summary: Write a value to an property using protocol mapping
    description: |-
      Write a value to an unregistered property, embedding property
      protocol mapping in the API, this does not require
      property registration. You cannot write to a group id.
    operationId: ActionPropWrite
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
    requestBody:
      content:
        application/json:
          schema:
            allOf:
              - $ref: '../NIPC.yaml#/components/schemas/Value'
              - $ref: '../protocolmaps/ProtocolMap.yaml#/components/schemas/ProtocolMap-Property'

```

```

    required: true
  responses:
    '204':
      description: Success, no content
    default:
      description: Error response
      content:
        application/problem+json:
          schema:
            $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
nse'

/extensions/{id}/properties/read:
  post:
    tags:
      - NIPC API extensions
    summary: Read a value to an property using protocol mapping
    description: |-
      Read a value from an unregistered property, embedding
      property protocol mapping in the API, this does not require
      property registration. You cannot read from a group id.
    operationId: ActionPropRead
    parameters:
      - name: id
        in: path
        description: The ID of the device. Group ID is not allowed.
        required: true
        schema:
          type: string
          format: uuid
          example: 12345678-1234-5678-1234-56789abcdef4
    requestBody:
      content:
        application/json:
          schema:
            $ref: '../protocolmaps/ProtocolMap.yaml#/components/sc\
hemas/ProtocolMap-Property'
      required: true
    responses:
      '200':
        description: Success
        content:
          application/json:
            schema:
              allOf:
                - $ref: '../NIPC.yaml#/components/schemas/Value'
    default:
      description: Error response

```

```

        content:
          application/problem+json:
            schema:
              $ref: '../NIPC.yaml#/components/schemas/FailureRespo\
nse'

components:
  schemas:
    Transmit:
      allOf:
        - $ref: '../protocolmaps/ProtocolMap.yaml#/components/schema\
s/ProtocolMap-Broadcast'
      required:
        - cycle
      type: object
      properties:
        cycle:
          type: string
          example: single
          enum:
            - single
            - repeat
        # transmit time in ms
        transmitTime:
          type: integer
          example: 3000
        # interval between transmits in ms
        transmitInterval:
          type: integer
          example: 500
        payload:
          type: string
          format: byte
          example: AgEaAgoMFv9MABAHch9BsDkgeA==
<CODE ENDS>

```

Appendix D. Example SDF model with protocol mappings for BLE

```

<CODE BEGINS> file "thermometer.sdf.json"
{
  "namespace": {
    "thermometer": "https://example.com/thermometer"
  },
  "defaultNamespace": "thermometer",
  "sdfThing": {
    "thermometer": {
      "sdfObject": {
        "health_thermometer": {

```

```
"description": "Health Thermometer",
"sdfProperty": {
  "temperature_type": {
    "description": "Temperature Type",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "1809",
        "characteristicID": "2A1D"
      }
    }
  },
  "measurement_interval": {
    "description": "Measurement Interval",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "1809",
        "characteristicID": "2A21"
      }
    }
  }
},
"sdfEvent": {
  "temperature_measurement": {
    "description": "Temperature Measurement",
    "sdfOutputData": {
      "sdfProtocolMap": {
        "ble": {
          "type": "gatt",
          "serviceID": "1809",
          "characteristicID": "2A1C"
        }
      }
    }
  },
  "intermediate_temperature": {
    "description": "Intermediate Temperature",
    "sdfOutputData": {
      "sdfProtocolMap": {
        "ble": {
          "type": "gatt",
          "serviceID": "1809",
          "characteristicID": "2A1E"
        }
      }
    }
  }
}
```

```

    }
  }
}
},
"description": "Generic Access, Device Information",
"sdfProperty": {
  "device_name": {
    "description": "Device Name",
    "observable": false,
    "writable": true,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "1800",
        "characteristicID": "2A00"
      }
    }
  },
  "appearance": {
    "description": "Appearance",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "1800",
        "characteristicID": "2A01"
      }
    }
  },
  "manufacturer_name_string": {
    "description": "Manufacturer Name String",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "180A",
        "characteristicID": "2A29"
      }
    }
  },
  "model_number_string": {
    "description": "Model Number String",
    "observable": false,

```

```
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "180A",
        "characteristicID": "2A24"
      }
    }
  },
  "hardware_revision_string": {
    "description": "Hardware Revision String",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "180A",
        "characteristicID": "2A27"
      }
    }
  },
  "firmware_revision_string": {
    "description": "Firmware Revision String",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "180A",
        "characteristicID": "2A26"
      }
    }
  },
  "system_id": {
    "description": "System ID",
    "observable": false,
    "writable": false,
    "readable": true,
    "sdfProtocolMap": {
      "ble": {
        "serviceID": "180A",
        "characteristicID": "2A23"
      }
    }
  }
},
"sdfEvent": {
  "isPresent": {
```

```
    "description": "BLE advertisements",
    "sdfOutputData": {
      "sdfProtocolMap": {
        "ble": {
          "type": "advertisements"
        }
      }
    },
    "isConnected": {
      "description": "BLE connection events",
      "sdfOutputData": {
        "sdfProtocolMap": {
          "ble": {
            "type": "connection_events"
          }
        }
      }
    }
  }
}
<CODE ENDS>
```

Figure 35: Example SDF model with protocol mappings for BLE

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