

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: 5 June 2026

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2 December 2025

An Application Layer Interface for Non-Internet-Connected Physical
Components (NIPC)
draft-ietf-asdf-nipc-15

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 deployed for building management, healthcare, workplace, manufacturing, logistics, and hospitality use cases are often resource and battery constrained. Many lack native IP connectivity and instead attach via heterogeneous non-IP operational networks. Common non-IP protocols include BLE [BLE53] and Zigbee [Zigbee22]. When IP is available, constrained application protocols such as CoAP [RFC7252] may be used. These devices still need to exchange data with IP-based applications. Accordingly, applications on the IP network obtain telemetry from and issue operations to such devices through an application-layer gateway. This gateway bridges the application network and one or more separate operational networks where devices are connected, allowing applications on the IP network to perform operations on devices connected to these other operational networks.

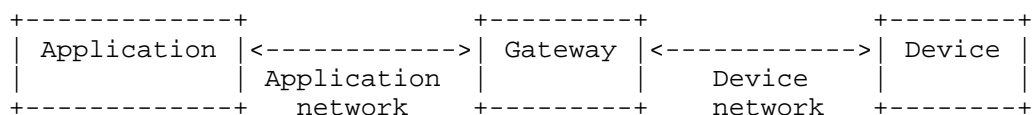


Figure 1: Gateway for non-Internet-Connected Devices

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 devices on other operational networks, bespoke and vendor-specific implementations have proliferated. Each deployment then requires: (1) defining or adapting yet another API, and (2) deploying additional gateway functions, increasing operational and integration cost. This specification defines a single, extensible application layer interface for cross-network and cross-protocol device interaction through a network gateway. The intent is to support multiple network and network protocols (and versions) concurrently, allow incremental addition of new protocols via mapping, and reduce redundant infrastructure by enabling multiple applications to share one standardized gateway function.

A standardized Application Layer Gateway interface has the following benefits:

1. Eliminates repeated bespoke integration effort across deployments.
2. Avoids deploying multiple overlapping gateway functions for different networks, protocols or use cases.
3. Reduces time and operational cost to integrate new networks and devices.

1.2. Non-IP Gateway

A Non-Internet-Connected Physical Components (NIPC) gateway is an application layer gateway (ALG) that implements APIs for applications to communicate with devices on different networks, leveraging different protocols. These NIPC APIs consist of reading or writing properties of devices, invoking 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 is onboarded (its identity and any credentials/trust material are provisioned). Onboarding is out of scope of this document. It may be performed via SCIM [RFC7644] with [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].

Once these prerequisites are met, the gateway can resolve a referenced SDF affordance into the protocol-specific operations required for that device.

A NIPC gateway provides the following functions:

- * Authentication and authorization of application clients that will leverage the NIPC APIs.
- * Maintain a repository of onboarded device objects.
- * Accept and validate SDF interaction model registrations.
- * Expose APIs for property, action, and event operations.
- * Perform implicit connection management to devices where required; optionally support explicit connection management.
- * Stream events (publish/subscribe) to authorized data applications.
- * Proxy payloads between networks without interpreting or modifying application data.
- * Operate one or more channels to supported wired or wireless networks.
- * Optionally provide a bridge between devices on one or more device networks connected to the NIPC-Gateway. This may include translating between different protocols, if multiple protocols are supported on the device network(s).

The gateway's role is to proxy traffic between application and device networks; it is not intended to be middleware that inspects, decodes, or transforms device payloads.

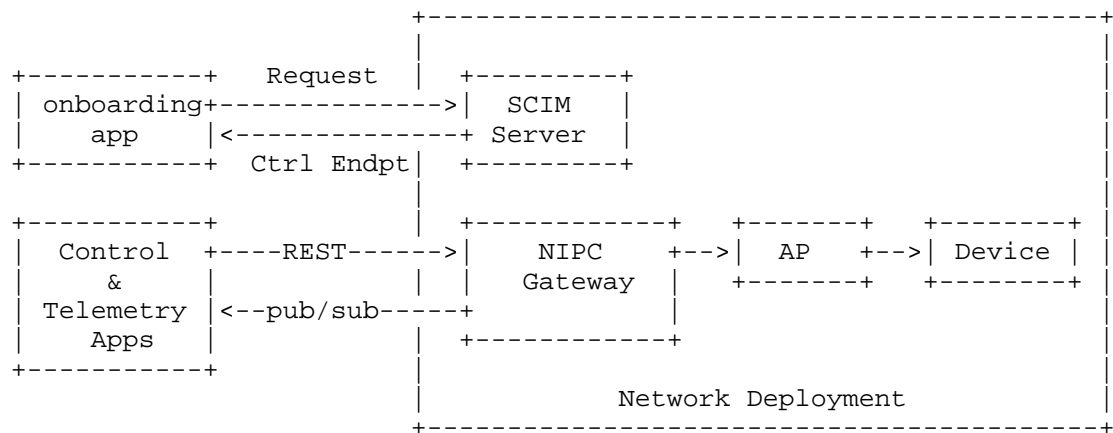


Figure 2: Basic Architecture

Figure 2 illustrates the basic components: applications, the NIPC application-layer gateway (ALG), an access point (AP), and a device (D). The applications, ALG, and AP reside on an IP network; the AP provides a wireless or wired interface to the device. Applications often operate in a different administrative domain than the ALG and AP, so the ALG will have to support authorization. The ALG bridges the IP application domain and the device network, be it an IP-based or non-IP device network. This enables applications to perform operations on devices attached to those device networks. Applications use a JSON-based [RFC8259] RESTful NIPC APIs for property, action, and event operations, and a CBOR-based [RFC8949] publish/subscribe interface for event streaming.

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.
- * IoT: Internet of Things.
- * 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 a radio interface communicating with devices.

2. Architecture

2.1. Overview

A Non-Internet-Connected Physical Components (NIPC) gateway is an application-layer gateway (ALG) that exposes APIs enabling applications to perform operations on devices attached to networks connected to the gateway. NIPC defines two API categories:

- * Registrations: register SDF models for classes of devices and register data applications that receive streaming event data.
- * Operations: perform protocol-neutral device interactions (read/write properties, invoke actions, enable/disable events) across heterogeneous networks and protocols.

To execute NIPC operations on a device, both prerequisites MUST be met:

1. Device onboarding: The device identity and required trust material are provisioned (e.g., via SCIM [RFC7644] with [I-D.ietf-scim-device-model]). This yields the device ID referenced in NIPC API paths.

2. Interaction model: An SDF model [I-D.ietf-asdf-sdf] is registered, providing protocol-neutral affordances and mappings to protocol-specific operations.

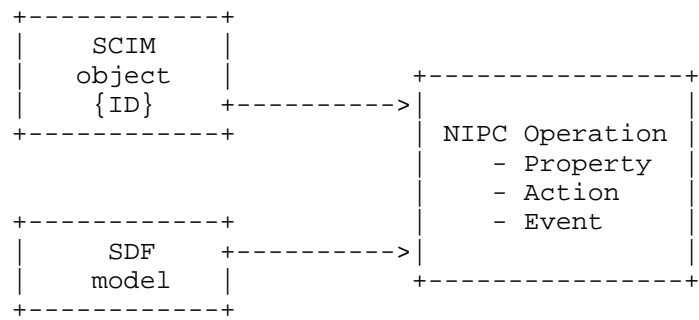


Figure 3: NIPC prerequisites

Once both prerequisites are met, authorized applications can perform NIPC operations on devices identified by their IDs. See Section 10 for authorization details. NIPC operations act on SDF affordances—properties, actions, and events—defined in the registered SDF model. Certain NIPC operations may also be performed on groups of devices identified by a group ID.

2.2. Onboarding

Onboarding is the process of declaring a device’s identity to the NIPC gateway and provisioning the trust material required to communicate with the device. The device object MUST include sufficient information to bootstrap trust and establish connectivity, as NIPC operations assume connectivity can be established without separate API calls. While onboarding can be performed in various ways, it is RECOMMENDED to use SCIM [RFC7644] with the device schema [I-D.ietf-scim-device-model], which defines the necessary attributes and extensions to support NIPC. As per Section 4.2 of [RFC7643], group objects may also be declared, and leveraged in NIPC operations.

2.3. Registrations

NIPC registration APIs allow applications to declare information about a device class or authorize a data application. These APIs do not operate on specific devices or groups of devices.

NIPC supports two registration types:

1. SDF model registration: Registers an SDF interaction model for a class of devices.

2. Data application authorization: Authorizes an application to receive streaming event data. Optionally, the SDF model reference and/or data-app registration MAY be included in the device's SCIM object. See [I-D.ietf-scim-device-model] and [I-D.ietf-asdf-sdf-protocol-mapping] for details.

2.3.1. SDF model registrations

The SDF model for a class of devices determines how a gateway can interact with these devices in a protocol-neutral way. To enable this, the SDF model must contain protocol mappings, mapping protocol-neutral SDF affordances to protocol-specific operations 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 SDF model registration. SDF models are described in [I-D.ietf-asdf-sdf].

2.3.2. Data application registrations

NIPC operations can enable or disable event reporting on a device. Events are reported through a publish-subscribe interface. Applications that are authorized to perform NIPC operations on devices can define which applications are permitted to receive streaming event data for that device. The data-app registrations API maps an event to an application that is authorized to receive that data. The registration also defines what protocol will be used to deliver the data (e.g., MQTT, webhook, websocket). This registration basically allows applications to determine which data-streams are consumed by which data-applications.

2.4. NIPC Operations

2.4.1. Overview

NIPC APIs are exposed over HTTP [RFC9110]. Requests and responses use JSON [RFC8259] unless another media type is negotiated via Content-Type and Accept. A media type for an SDF affordance can also be stipulated in the SDF ContentFormat data quality, as described in Section 4.7 of [I-D.ietf-asdf-sdf]. The default media type is "application/nipc+json" (see Section 11.1). SDF model registrations use "application/sdf+json". Property APIs MAY use other media types appropriate to the property payload.

Failures use Problem Details [RFC9457] with application/problem+json.

NIPC operations are protocol-neutral operations on SDF affordances, more specifically properties, actions & events. NIPC operations can happen against affordances registered in an SDF model. Operations

reference affordances by their SDF global name. If the underlying protocol requires a connection, the gateway establishes and tears down the connection implicitly unless an explicit connection is already in place.

NIPC exposes three operation groups:

- * 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.

2.4.2. Properties

Property operations allow clients to read and write values for SDF properties.

Requests and responses use `application/nipc+json` unless another media type is negotiated via `Content-Type` and `Accept`. When using JSON, binary property values are base64-encoded with padding per Section 5 of [RFC4648]. Multiple properties MAY be read or written in a single request. When a single property is addressed via a query parameter, non-JSON media types MAY be used for the payload. On success, the response returns either 200 with per-property status (JSON) or 204 No Content for single, non-JSON writes.

2.4.3. Actions

Action operations invoke SDF actions on devices.

A successful action request returns 202 Accepted with a `Location` header referencing the action instance. Clients poll the instance URI to obtain status (e.g., `IN_PROGRESS`, `COMPLETED`). Request bodies are optional and MAY carry action input in a media type appropriate to the underlying protocol (e.g., `octet-stream`).

2.4.4. Events

Event operations enable and disable device event reporting.

Enabling an event returns 201 Created with a `Location` header referencing the event instance. Disabling an event uses the instance identifier and returns 204 No Content on success (for a single

device) or a per-device status list (for a group). Event payloads are delivered via the publish/subscribe interface encoded in CBOR [RFC8949].

2.4.5. Groups

Where supported by the underlying protocol, operations MAY target a group of devices identified by a group ID. Responses for group operations return per-device results; failures for individual devices are reported using Problem Details entries within the array.

2.4.6. Connection management for NIPC Operations

For protocols that require connection setup, the gateway performs implicit connection management during an operation (establish on demand; tear down on completion). Gateways MAY support explicit connection management; when an explicit connection is active, operations reuse it and do not tear it down. Explicit connection management is described in Section 4.4.

2.4.7. Extensions

NIPC supports API extensions for compound or specialized operations. Extensions can execute a set of NIPC operations in a single request or provide more efficient mechanisms for specific use cases (e.g., a bulk operation).

Extensions MUST use the “/extensions” path element. To ensure interoperability, extensions MUST be registered with IANA as defined in Section 11.2.

2.5. Events publish subscribe interface

Events are delivered via a publish/subscribe interface. NIPC events are encoded in CBOR ([RFC8949]) and can be transported over MQTT, Webhook or Websocket.

CBOR is used 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.

Event types include:

- * Streaming data from devices: Streaming data is activated/deactivated with the NIPC events API
- * Broadcasts from devices (e.g., advertisements in BLE)

- * Connection events: Devices connecting & disconnecting

2.6. Paths

2.6.1. 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 11.3 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]
}
```

2.6.2. NIPC Registrations

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

paths:

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

2.6.3. NIPC Operations

Every NIPC Operations API pertains to either a device or group of devices, identified by an ID, hence the ID must 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.

2.7. 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.

2.7.1. SDF model registrations

To execute NIPC operations, an SDF interaction model for the device class **MUST** be registered. The model **MUST** include protocol mappings that relate protocol-neutral SDF affordances to protocol-specific operations.

Registration is performed via POST /registrations/models with the SDF model in the request body. A registered model can be retrieved via GET /registrations/models using the model identifier (sdfName).

2.7.2. NIPC Operations

NIPC operations require two parameters:

1. Device ID: the UUID identifying the target device (or group).
2. sdfName: the SDF global name (absolute URI with fragment) of the affordance (property, action, or event) on which the operation acts.

2.7.2.1. 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 [RFC9562].

+=====+=====+=====+=====+=====+		
Attribute	Type	Example
+=====+=====+=====+=====+=====+		
id	uuid	1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
+-----+-----+-----+-----+-----+		

Table 1: Definition of a device or group of devices

ID is a UUID assigned during onboarding (e.g., by a SCIM server). The identifier is returned when the device object is created and is used by both the application and the NIPC gateway. The application must store this UUID in order to use it to identify the device on which it wants to perform NIPC operations. If the NIPC gateway is not co-located with the SCIM server, it retrieves the device object from SCIM using this ID.

2.7.3. SDF Name

Operations act on SDF affordances and reference them by SDF global name—an absolute URI with fragment that includes the namespace. The affordance referenced MAY be a property, action, or event; the reference is carried as a 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

2.7.4. Parameters

To minimize deployment risk arising from inconsistent URI path normalization and handling of percent-encoded reserved characters in path elements (notably “/” encoded as “%2F”) across common HTTP servers and intermediaries (e.g., Jetty, Tomcat, Apache httpd, NGINX), NIPC uses query parameters (except the primary {id} path segment) rather than additional path segments for values that can legitimately contain reserved characters (such as SDF global names). Although [RFC3986] and [RFC9110] require that reserved characters not be normalized or decoded in ways that alter semantics, misinterpretation of these rules has led to security vulnerabilities (path confusion, cache poisoning, authorization bypass) and to conservative default configurations that reject encoded slashes. In proxy deployments, relaxing these defaults often triggers security review friction. Representing such values in the query component

avoids reliance on tolerant path normalization behavior, reduces ambiguity for intermediaries, and aligns with prevailing “safe” operational profiles; a malformed or unsupported parameter can be rejected with a 4xx status without exposing downstream services to traversal or normalization discrepancies.

2.7.5. Responses

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

Exceptions to this are the following:

1. Extensions: Extension APIs (see Section 5.2) execute compound operations and thus require the gateway to execute multiple NIPC operations. On acceptance, the gateway returns 202 Accepted. Clients poll the extension URI (GET) for execution status. If a callback URI was supplied in the request, the gateway MAY send the final result upon completion.
2. Actions: Action requests return 202 Accepted with a Location header pointing to the action instance used for status tracking.

A failure response must contain an HTTP status code of 4xx or 5xx, and use [RFC9457] Problem Details with application/problem+json media type.

All NIPC failure responses must include the following attributes:

- * type: a URI identifying the error (see Section 6)
- * status: the 4xx or 5xx HTTP status code
- * title: a brief, human-readable summary
- * detail: a human-readable explanation specific to this occurrence
Additional attributes MAY be included as permitted by [RFC9457].

===== NOTE: ‘\’ line wrapping per RFC 8792 =====

```
FailureResponse = {  
  ? type: FailureTypeURI,  
  ? status: uint,  
  ? title: text,  
  ? detail: text  
}
```

```
; Enumerated problem type URIs registered for NIPC
FailureTypeURI = (
  "https://www.iana.org/assignments/nipc-problem-types#invalid-id" /
  "https://www.iana.org/assignments/nipc-problem-types#invalid-sdf-u\
rl" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-ope\
ration-not-executed" /
  "https://www.iana.org/assignments/nipc-problem-types#sdf-model-alr\
eady-registered" /
  "https://www.iana.org/assignments/nipc-problem-types#sdf-model-in-\
use" /
  "https://www.iana.org/assignments/nipc-problem-types#property-not-\
readable" /
  "https://www.iana.org/assignments/nipc-problem-types#property-read\
-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#property-not-\
writable" /
  "https://www.iana.org/assignments/nipc-problem-types#property-writ\
e-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#event-already\
-enabled" /
  "https://www.iana.org/assignments/nipc-problem-types#event-not-ena\
bled" /
  "https://www.iana.org/assignments/nipc-problem-types#event-not-reg\
istered" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-already-connected" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-no-connection" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-connection-timeout" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-bonding-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-connection-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-service-discovery-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-invalid-service-or-characteristic" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-z\
igbee-connection-timeout" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-z\
igbee-invalid-endpoint-or-cluster" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-bro\
adcast-invalid-data" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-fir\
mware-rollback" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-fir\
```

```
mware-update-failed" /
  "about:blank"
)
```

Example of a failure response:

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

```
{
  "type": "https://www.iana.org/assignments/nipc-problem-types#inval\
\id-id",
  "status": 400,
  "title": "Invalid Device ID",
  "detail": "Device ID 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30 does not\
\ exist or is not a device"
}
```

Figure 5: Example failure response

3. NIPC Registrations

3.1. SDF model registrations APIs

SDF model registration 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:

- * The SDF document in JSON format containing one or more sdfThings or sdfObjects, similar to the example in Figure 33.
- * The SDF document MUST contain protocol mappings, as described in [I-D.ietf-asdf-sdf-protocol-mapping].

Response:

A list containing objects where each object has an "sdfName" which is the global name of the top-level sdfThing or sdfObject in the SDF model.

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

SdfGlobalName = text      ; absolute URI with fragment referencing an \
sdfThing or sdfObject

SdfReference = {
  sdfName: SdfGlobalName
}

SdfReferenceArray = [* SdfReference]

Example of a response:

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

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

3.1.2. Get all SDF models

Method: GET /registrations/models

Description: Gets all SDF models registered with the gateway.

Response:

A list containing objects where each object has an "sdfName" which is the global name of the top-level sdfThing or sdfObject in the SDF model.

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

SdfGlobalName = text      ; absolute URI with fragment referencing an \
sdfThing or sdfObject

SdfReference = {
  sdfName: SdfGlobalName
}

SdfReferenceArray = [* SdfReference]

Example of a response:
```

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

Figure 7: Example of a response to get all SDF models

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 Figure 33.

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:

- * A list containing objects where each object has an "sdfName" which is the global name of the top-level sdfThing or sdfObject in the SDF model

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

SdfGlobalName = text ; absolute URI with fragment referencing an \sdfThing or sdfObject

```
SdfReference = {  
  sdfName: SdfGlobalName  
}
```

SdfReferenceArray = [* SdfReference]

Example of a response:

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

Figure 8: Example of a response to an SDF model registration

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 Figure 33.

Response:

- * A list containing objects where each object has an "sdfName" which is the global name of the top-level sdfThing or sdfObject in the SDF model

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

SdfGlobalName = text      ; absolute URI with fragment referencing an \
sdfThing or sdfObject

SdfReference = {
  sdfName: SdfGlobalName
}

SdfReferenceArray = [* SdfReference]

Example of a response:

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

Figure 9: Example of a response to an SDF model registration

3.2. Data application registrations APIs

Data-app registration 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 as an authorized endpoint that can receive data for a device. The endpoint app is defined in Section 6 of [I-D.ietf-scim-device-model].

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

- * mqttClient: The data-app is an MQTT client, which means that the NIPC gateway must act as an MQTT broker.
- * mqttBroker: The data-app is an MQTT broker, which means that the NIPC gateway must act as an MQTT client. The MQTT broker configuration data, such as the URI, credentials and MQTT topic must also be provided in the registration API.
- * 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 is authorized for.
- * mqttClient: a boolean that denotes that the data application is an MQTT client.
- * mqttBroker: The data app is an MQTT broker. This object contains the MQTT broker information:
 - 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. In this attribute, a custom topic can be configured (optional).
- * webhook: The data app supports a webhook. This object contains a webhook URL along with any credentials that are required to authenticate the webhook.
 - URI: the webhook URI. The URI 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: The data app supports a websocket. This object 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 URI. The URI 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)

```
DataApp = {
  events: [* EventRef],
  ( DataAppMqttClient //
    DataAppMqttBroker //
    DataAppWebhook //
    DataAppWebsocket )
}

EventRef = {
  event: text      ; SDF global name (absolute URI with fragment)
}

DataAppMqttClient = {
  mqttClient: bool
}

DataAppMqttBroker = {
  mqttBroker: {
    URI: text,
    username: text,
    password: text,
    ? brokerCACert: text,      ; PEM-encoded CA certificate
    ? customTopic: text       ; optional custom MQTT topic
  }
}

DataAppWebhook = {
  webhook: {
    URI: text,
    ? headers: { * text => text }, ; key/value headers
    ? serverCACert: text
  }
}

DataAppWebsocket = {
  websocket: {
    URI: text,
    ? headers: { * text => text }, ; key/value headers
    ? serverCACert: text
  }
}
```

Example of a request body:

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

{
  "events": [
    {
      "event": "https://example.com/hearttrate#/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/hearttrate#/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 registration.

Query Parameters:

- * dataAppId: the ID of the data application

Request Body:

- * The request body is identical to the request body for the register data application API Section 3.2.1.

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 object 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 Section 3.2.1.

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:

- * If successful, the response will be identical to the request body for the register data application API Section 3.2.1.

4. NIPC Operation APIs

The NIPC operation APIs perform protocol-neutral interactions on SDF affordances, properties, events, and actions. This allows applications to read & update device properties, invoke actions, and consume events.

NIPC defines three API collections aligned with the SDF Affordances defined in Section 1.2 of [I-D.ietf-asdf-sdf]:

- * Properties: read and write device properties.
- * Events: enable and disable device event reporting.
- * Actions: invoke device actions.

To invoke NIPC operations APIs on a device, one or more SDF models MUST be registered for that device. The SDF model MAY have a top-level sdfThing (with multiple sdfObjects) or a top-level sdfObject. Operations depend on affordances (sdfProperty, sdfEvent, sdfAction) defined in the registered SDF model and on a device ID (see [I-D.ietf-scim-device-model]). Affordances are referenced by their SDF global name (absolute URI with fragment) as described in Section 4 of [I-D.ietf-asdf-sdf].

The NIPC Gateway must match the SDF global name against the registered SDF model to resolve the protocol mapping (protocolmap) the gateway will execute. When carried in a URI, the SDF global name MUST be percent-encoded per Section 2.1 of [RFC3986].

4.1. NIPC Property APIs

These APIs allow applications to read and update device properties. If the underlying protocol requires a connection, the gateway establishes it implicitly for the operation; when an explicit connection is already active, operations reuse it without modification.

Requests and responses support content negotiation via Content-Type and Accept. When using "application/nipc+json", payloads must follow the examples above. Binary property values must be base64-encoded with padding per Section 5 of [RFC4648] in the "value" field. For other media types, payload semantics must follow the selected media type.

4.1.1. Update one or 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`: Identifies a single property to update. If present, the request body MAY use any media type appropriate to the property payload. -or-
- * If absent, the request body MUST be `application/nipc+json` and contain an array of update items, each with a property and a value.

Request Body:

- * If the query parameter `propertyName` is provided, the request body MAY use any media type appropriate to the property payload. The value is encoded as per the content type of the payload. -or-
- * If the query parameter `propertyName` is NOT provided, the request body must be an array of properties to update, each containing a property and a value. The value attribute contains the raw binary data, which must be encoded in base64 with padding as per Section 5 of [RFC4648].

`PropertyValueArray` = [`* PropertyValue`]

; Minimal `PropertyValue` shape (matches allOf of `Property` + `Value`)

```
PropertyValue = {  
  property: text,           ; SDF global name of the property  
  value: b64text            ; base64-encoded bytes (RFC 4648 Section 5)  
}
```

; Helper type for base64-with-padding encoded text

`b64text` = text

Example body for 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 must 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. The "properties" array must be an array of properties that were updated, each containing a property and a value. -or-
- * If the Accept header is set to any other media type and the propertyName query parameter is provided, the response must be 204 No Content with no body.

```

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

```

```

PropertyValueResponseArray = [* PropertyValueResponseArrayItem]

```

```

PropertyValueResponseArrayItem = ( SuccessResponse // FailureResponse )

```

```

; Minimal success shape (may be extended)

```

```

SuccessResponse = {
  ? status: uint
}

```

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

4.1.2. Read one or 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 must be an array of properties, each containing a property and a value. The value must be the raw binary data read from the property, encoded in base64 with padding as per Section 5 of [RFC4648]. The array must contain objects with 2 attributes: - property: The property that was read. - value: The bytes that were read in base64 encoding -or-

- * If the Accept header is set to any other media type and a single propertyName query parameter is provided, the request body MAY use any media type appropriate to the property payload. The value is encoded as per the content type of the payload.

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

```
PropertyValueReadResponseArray = [* PropertyValueReadResponseArrayItem]
```

```
PropertyValueReadResponseArrayItem = ( PropertyValue // FailureResponse )
```

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

4.2. NIPC Event APIs

Event APIs enable or disable reporting of device events. For certain protocols, a connection may be required. If the underlying protocol requires a connection, the gateway establishes it implicitly for the operation. If an explicitly created connection is already active, it is reused without modification.

Events are referenced by the SDF global name of an sdfEvent. The {id} path segment identifies a device or a group of devices. A group event MAY be enabled only if the underlying protocol supports group activation (e.g., BLE advertisement or connection status events).

If the data application registered for this event is an MQTT broker or client, the event SDF global name may be 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 "0927ce7c-b258-4bfa-a345-bcc9f74385b4" 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/0927ce7c-b258-4bfa-a345-bcc9f74385b4/thermometer/sdfThing/\
thermometer/sdfEvent/isPresent

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

If a customTopic was supplied in the data-app registration (mqttBroker case), that topic MUST be used instead of the constructed default.

4.2.1. Enable event reporting

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

Description: Enables an event on a device

Parameters:

- * id: the ID of the device

Query Parameters:

- * eventName: the event to enable. The eventName must be 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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/events?instanceId=02ee282c-8915-4b2e-bbd2-88966773134a

The Location header must contain the URI for the created event instance, which may be used to check status or disable the event.

4.2.2. Disable event reporting

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

Description: Disables an event on a 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

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: The response must be an array of events, each containing an instanceID and an event. - instanceId: must be the unique instance ID for each enabled event. - event: must be the event URI for each enabled event.

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

```
EventStatusResponseArray = [* EventStatusResponseArrayItem]
```

```
EventStatusResponseArrayItem = ( EventInstanceSuccess // FailureResponse )
```

```
; Success item = { event, instanceId }
EventInstanceSuccess = {
  event: text,           ; SDF global name of the event (absolute URI w\
ith fragment)
  instanceId: text       ; UUID (as text)
}
```

Example of a response:

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

```
[
  {
    "instanceId": "02ee282c-8915-4b2e-bbd2-88966773134a",
    "event": "https://example.com/hearttrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected"
  }
]
```

Figure 15: Example get multiple events status 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:

- * The response must return HTTP status code 201 Created with a Location header pointing to the created event instance. The Location header must contain the URI for the created event instance, which can be used to check status or disable the event.

Example of a successful response:

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

HTTP/1.1 201 Created
Location: /groups/0dc729d7-f6c3-491d-9b9d-e7176d2be243/events?instanceId=f1b9f26b-21ce-4deb-9d57-289ba7e17cce

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: MUST return 200 OK with an array of per-device event status entries. For each device where the event was successfully disabled, the entry MUST include deviceId and event (SDF global name). For each device where disabling failed, the entry MUST be a Problem Details error object for that device.

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

```
GroupEventStatusResponseArray = [* GroupEventStatusResponse]
```

```
GroupEventSuccessResponse = { event: text, deviceId: text }
```

```
; Each item is either an event+deviceId success or a FailureResponse
GroupEventStatusResponse = (GroupEventSuccessResponse // FailureResp\
onse)
```

```
; FailureResponse (Problem Details subset; align with your existing \
definition if present)
```

```
GroupFailureResponse = {
  FailureResponse,
  ? deviceId: text
}
```

Example of a response:

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

```
[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "d62c7fb2-a216-4811-a388-053b17fdbedc"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "01b52a23-b98c-454c-ba9e-086a43bdfd79"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types#eve\
nt-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "9171ec16-e3c1-4ccf-ad23-b92a1a3f069d",
    "detail": "Failed to disable the event for device 9171ec16-e3c1-\
4ccf-ad23-b92a1a3f069d"
  }
]
```

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 for 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: MUST return 200 OK with an array of per-device event status entries. For each device where the event was successfully enabled, the entry MUST include deviceId and event (SDF global name). For each device where enabling failed, the entry MUST be a Problem Details error object for that device.

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

GroupEventStatusResponseArray = [* GroupEventStatusResponse]

GroupEventSuccessResponse = { event: text, deviceId: text }

; Each item is either an event+deviceId success or a FailureResponse
GroupEventStatusResponse = (GroupEventSuccessResponse // FailureResponse)

; FailureResponse (Problem Details subset; align with your existing \ definition if present)

GroupFailureResponse = {
 FailureResponse,
 ? deviceId: text
}

Example of a response:


```

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

[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "d62c7fb2-a216-4811-a388-053b17fdbedc"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsensor/\
sdfEvent/fallDetected",
    "deviceId": "01b52a23-b98c-454c-ba9e-086a43bdfd79"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types#eve\
nt-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "9171ec16-e3c1-4ccf-ad23-b92a1a3f069d",
    "detail": "Failed to disable the event for device 9171ec16-e3c1-\
4ccf-ad23-b92a1a3f069d"
  }
]

```

Figure 16: Example get multiple group events status response

4.3. NIPC Action APIs

NIPC Action APIs invoke device actions. If the underlying protocol requires a connection, the gateway establishes it implicitly for the operation. If an explicitly established connection is already active, the operation MUST reuse it without modification.

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

Example of a successful response:

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

```
HTTP/1.1 202 Accepted
Location: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/actions?inst\
anceId=02ee282c-8915-4b2e-bbd2-88966773134a
```

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: MUST return 200 OK with an action status, which may be "in progress" or "completed".

```
ActionResponse = {
  status: ActionStatus
}
```

```
ActionStatus = (
  "IN_PROGRESS" /
  "COMPLETED"
)
```

Example of a response:

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

Figure 17: Example action status 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": "00001809-0000-1000-8000-00805f9b34fb"
        }
      ],
      "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": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "00001809-0000-1000-8000-00805f9b34fb",
        "characteristics": [
          {
            "characteristicID":
              "00002alc-0000-1000-8000-00805f9b34fb",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "00002902-0000-1000-8000-00805f9b34fb"
              }
            ]
          }
        ]
      }
    ]
  }
}

```

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": "00001809-0000-1000-8000-00805f9b34fb"
        }
      ],
      "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": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "00001809-0000-1000-8000-00805f9b34fb",
        "characteristics": [
          {
            "characteristicID":
              "00002a1c-0000-1000-8000-00805f9b34fb",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "00002902-0000-1000-8000-00805f9b34fb"
              }
            ]
          }
        ]
      }
    ]
  }
}
```

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": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30"
}
```

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": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
  "sdfProtocolMap": {
    "ble": [
      {
        "serviceID": "00001809-0000-1000-8000-00805f9b34fb",
        "characteristics": [
          {
            "characteristicID":
              "00002alc-0000-1000-8000-00805f9b34fb",
            "flags": [
              "read",
              "write"
            ],
            "descriptors": [
              {
                "descriptorID":
                  "00002902-0000-1000-8000-00805f9b34fb"
              }
            ]
          }
        ]
      }
    ]
  }
}

```

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 designed to be extensible in two complementary ways:

- * Protocol mappings: NIPC relies on SDF protocol mappings to relate protocol-neutral affordances to protocol-specific operations. Adding a new mapping enables support for additional device protocols (or versions) without the need to change the NIPC API itself. This allows deployments to evolve as device ecosystems

change, while preserving application portability and gateway interoperability. Protocol mapping is an extension to SDF and described in [I-D.ietf-asdf-sdf-protocol-mapping].

- * API extensions: Extensions compose multiple NIPC operations into a single request or introduce specialized flows optimized for common scenarios (e.g., bulk property updates, conditional reads, firmware operations). Extensions MUST use the “/extensions” path element and SHOULD focus on efficiency, latency reduction, and operational simplicity (fewer round trips, reduced state management). To ensure interoperability and consistent security review, extensions MUST be registered with IANA as defined in Section 11.2.

5.1. Protocol mappings

NIPC relies on SDF protocol mappings [I-D.ietf-asdf-sdf-protocol-mapping] to relate protocol-neutral affordances to protocol-specific operations. In [I-D.ietf-asdf-sdf-protocol-mapping] BLE and Zigbee are used as examples, however the mapping mechanism is extensible; so support for additional protocols (or versions) can be added without changing the NIPC schema or API.

5.2. API extensions

The extension APIs allow for extensibility of the APIs. Extension APIs may 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 may also introduce new functionality that is specific to a use case or protocol, such as the BLE transmit API.

Extensions must be defined under the /extensions path element. The extension name is defined as a path parameter after the /extensions path element. Extensions may define their own request and response payloads, as well as their own query parameters. Extensions must be IANA registered as defined in Section 11.2.

Extensions MAY implement long-running operations (e.g., firmware updates, bulk actions). For such operations, the server SHOULD respond with 202 Accepted and a Location header referencing a status URI. Clients MAY poll the status URI (GET) to obtain progress. While the operation is in progress, the status endpoint SHOULD return 200 OK with status information; upon completion, the server MAY redirect with 303 See Other to the final result resource, or return 200 OK with the completed result from the status endpoint. This pattern minimizes client state, supports retry, and provides a uniform mechanism for tracking asynchronous execution.

In the appendix Appendix C, we have defined a few example extensions.

6. NIPC Error Handling

Error types in NIPC APIs must use URI-based error type identifiers as defined in Section 11.4. 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.

NIPC 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-scheme	Unsupported URI scheme	Generic	
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 Zigbee endpoint or	Protocol	

invalid-endpoint-or-cluster	cluster ID	specific
extension-transmit-invalid-data	Invalid transmit data	Transmit APIs
extension-firmware-rollback	Firmware rollback	Extension APIs
extension-firmware-update-failed	Firmware update failed	Extension APIs

Table 3: Error Codes

The appropriate HTTP status code is returned in the response.

7. Publish/Subscribe Interface

Events are delivered via a publish/subscribe interface. Event types include: (1) streaming data (enabled/disabled via the NIPC Events API), (2) broadcasts (e.g., advertisements), and (3) connection status (device link up/down). Event payloads are encoded in CBOR [RFC8949] and MAY be transported over MQTT, webhook, or websocket. CBOR is used because non-IP device payloads are typically binary; it encodes such data efficiently and is more compact than JSON, reducing bandwidth.

7.1. CDDL Definition

The event streaming format is defined here in CDDL [RFC8610]. A DataSubscription is a CBOR map containing the raw payload (bytes) and a timestamp (epoch seconds). It MAY include deviceID (the SCIM device identifier) when the payload is associated with a known onboarded device. Optional members (e.g., apMacAddress, rssi) MAY be present but can reveal deployment topology and SHOULD be omitted unless required. A choice group within DataSubscription indicates the event type (e.g., advertisement, subscription notification, connection status). An event publication MAY carry one or more DataSubscription entries in an array. Such an array is represented as DataBatch.

```
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 in CBOR diagnostic notation.

```
[
  {
    "data": h'02011A020A0C16FF4C001007721F41B0392078',
    "deviceID": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
    "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": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
    "timestamp": 1727484393,
    "bleSubscription": {
      "serviceID": "a4e649f4-4be5-11e5-885d-feff819cdc9f",
      "characteristicID": "c4c1f6e2-4be5-11e5-885d-feff819cdc9f"
    }
  }
]
```

Figure 28: BLE GATT Notification


```
[
  {
    "deviceID": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
    "timestamp": 1727484393,
    "bleConnectionStatus": {
      "macAddress": "C1:5C:00:00:00:01",
      "connected": true
    }
  }
]
```

Figure 29: BLE Connection status event

```
[
  {
    "data": h'434630374346303739453036',
    "deviceID": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30",
    "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 Figure 33

- * Read a property from the BLE device

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

```
GET /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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 Figure 33

- * Register the data app with the event

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

```
POST /registrations/data-apps?dataAppId=0927ce7c-b258-4bfa-a345-\
bcc9f74385b4
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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/events?in\
stanceId=02ee282c-8915-4b2e-bbd2-88966773134a
```

- * Check the status of the event

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

```
GET /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/events?instance\
Id=02ee282c-8915-4b2e-bbd2-88966773134a
```

```
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 Figure 33

- * Register the data app with the event

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

```
POST /registrations/data-apps?dataAppId=0927ce7c-b258-4bfa-a345-\
bcc9f74385b4
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/0dc729d7-f6c3-491d-9b9d-e7176d2be243/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/0dc729d7-f6c3-491d-9b9d-e7176d2be243/events?in\
stanceId=f1b9f26b-21ce-4deb-9d57-289ba7e17cce
```

- * Check the status of the event

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

```
GET /groups/0dc729d7-f6c3-491d-9b9d-e7176d2be243/events?instance\
Id=f1b9f26b-21ce-4deb-9d57-289ba7e17cce
Host: localhost
```

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

```
[
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "d62c7fb2-a216-4811-a388-053b17fdbedc"
  },
  {
    "event": "https://example.com/heartrate#/sdfObject/healthsen\
sor/sdfEvent/fallDetected",
    "deviceId": "01b52a23-b98c-454c-ba9e-086a43bdfd79"
  },
  {
    "type": "https://www.iana.org/assignments/nipc-problem-types\
#event-not-enabled",
    "status": 400,
    "title": "Event Not Enabled",
    "deviceId": "9171ec16-e3c1-4ccf-ad23-b92a1a3f069d",
    "detail": "Failed to disable the event for device 9171ec16-e\
3c1-4ccf-ad23-b92a1a3f069d"
  }
]
```

9. Implementation Status

This section is to be removed before publishing as an RFC.

This section records the status of known implementations of the protocol defined by this specification at the time of posting of this Internet-Draft, and is based on a proposal described in [RFC7942]. The description of implementations in this section is intended to assist the IETF in its decision processes in progressing drafts to RFCs. Please note that the listing of any individual implementation here does not imply endorsement by the IETF. Furthermore, no effort has been spent to verify the information presented here that was

supplied by IETF contributors. This is not intended as, and must not be construed to be, a catalog of available implementations or their features. Readers are advised to note that other implementations may exist.

According to [RFC7942], "this will allow reviewers and working groups to assign due consideration to documents that have the benefit of running code, which may serve as evidence of valuable experimentation and feedback that have made the implemented protocols more mature. It is up to the individual working groups to use this information as they see fit".

9.1. TieDie IoT

Organization: Cisco Systems, North Carolina State University

Description: Open-source implementation of the NIPC APIs and gateway functionality for BLE. Client libraries and sample application functions for Python and Java are also provided.

Level of maturity: Open-source prototype

Coverage: All NIPC APIs for BLE protocol mapping

Version compatibility: All versions up to draft-15

Licensing: Apache License, Version 2.0

URL: <https://github.com/iot-onboarding/tiedie>

9.2. Cisco Sensor Connect for IoT Services (Catalyst)

Organization: Cisco Systems

Description: Commercial solution that delivers advanced BLE capabilities over Cisco Wireless infrastructure.

Level of maturity: Production

Coverage: All NIPC APIs for BLE protocol mapping

Version compatibility: draft-00

Licensing: Proprietary

URL: <https://developer.cisco.com/docs/spaces-connect-for-iot-services/>

9.3. Cisco Sensor Connect for IoT Services (Meraki)

Organization: Cisco Systems

Description: Commercial solution that delivers advanced BLE capabilities over Cisco Wireless infrastructure.

Level of maturity: Beta

Coverage: All NIPC APIs for BLE protocol mapping

Version compatibility: draft-15

Licensing: Proprietary

9.4. NIPC Prototype

Organization: Ericsson Research

Description: Prototype implementation in C of the NIPC API.

Level of maturity: Research prototype

Coverage: Registration and NIPC operations

Version compatibility: Draft-04

Licensing: Proprietary

Contact: Lorenzo Corneo lorenzo.corneo@ericsson.com
(<mailto:lorenzo.corneo@ericsson.com>)

10. Security Considerations

10.1. Payload Encryption Considerations

Responses to NIPC operations requests may contain sensitive or confidential information. Therefore, application and device implementations should consider payload encryption. NIPC does not provide any payload encryption mechanism. If payload encryption is required, it MUST be provided by the underlying device protocol (e.g., BLE security modes) or by the transport-layer security mechanism (e.g., TLS).

10.2. TLS Support Considerations

NIPC MUST run on top of a transport-layer security mechanism such as TLS. When leveraging TLS, the NIPC gateway MUST support TLS 1.2 [RFC5246] and TLS 1.3 [RFC8446] and MAY support additional transport-layer mechanisms. When using TLS, the client MUST perform a TLS/SSL server identity check, per [RFC6125]. Implementation security considerations for TLS can be found in [RFC7525].

10.3. HTTP Considerations

NIPC runs on top of HTTP and is thus subject to the security considerations of HTTP Section 9 of [RFC7230].

10.4. Authorization Considerations

10.4.1. API authorization Considerations

To enable NIPC gateway functions, the network administrator MUST authorize applications (e.g., via exchange of tokens or public keys). Authorization MAY be role-based. The following baseline roles are RECOMMENDED:

- * Onboarding: permitted to create and manage device and endpoint-app identities via SCIM (typically co-located with the gateway).
- * Control: permitted to invoke NIPC property, action, and event APIs.
- * Data: permitted to receive streamed event data. Deployments MAY further refine authorization at per-API or per-affordance granularity.

10.4.2. Authorization Token/Bearer Token/Cookie Considerations

When using authorization tokens such as those issued by OAuth 2.0 [RFC6749], implementers MUST take into account threats and countermeasures as documented in Section 8 of [RFC7521].

Since the possession of a bearer token, Authorization token, or cookie MAY authorize the holder to perform NIPC Operations on devices, tokens and cookies MUST contain sufficient entropy to prevent random guessing attack; for example, see Section 5.2 of [RFC6750] and Section 5.1.4.2.2 of [RFC6819].

As with all NIPC communications, bearer tokens and HTTP cookies MUST be exchanged using transport-layer security mechanism such as TLS.

Bearer tokens MUST have a limited lifetime that can be determined directly or indirectly (e.g., by checking with a validation service) by the application. By expiring tokens, applications are forced to obtain a new token (which usually involves re-authentication) for continued authorized access. For example, in OAuth 2.0, an application MAY use OAuth token refresh to obtain a new bearer token after authenticating to an authorization server. See Section 6 of [RFC6749]. As with bearer tokens, an HTTP cookie SHOULD last no longer than the lifetime of a browser session. An expiry time should be set that limits session cookie lifetime as per Section 5.2.1 of [RFC6265].

Implementations supporting OAuth bearer tokens need to factor in security considerations of this authorization method [RFC7521]. Implementers also need to consider authentication choices coupled with OAuth bearer tokens. For example, when using OAuth bearer tokens with client authentication via client credentials Section 4.4 of [RFC6749], implementers need to consider the security considerations of client authentication via client credentials as described in Section 3.2 of [RFC6819].

10.5. Other Security Considerations

- * Preventing automated attacks: It is recommended to limit the number of requests that any particular application MAY make in a period of time.
- * Logging and monitoring: It is recommended to log and monitor API usage to detect potential abuse or attacks.
- * Input validation: It is recommended to validate all inputs to prevent injection attacks.
- * Error handling: It is recommended to handle errors gracefully without exposing sensitive information.
- * Least privilege: It is recommended to follow the principle of least privilege when granting access to resources.
- * Storage and handling of sensitive data: Credentials MUST NOT be stored in clear-text, but MUST be stored using an encrypted protection mechanism (e.g., hashing).

11. IANA Considerations

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

11.1. 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 10 section of this document.

Interoperability considerations: none

Published specification: This document, the NIPC API specification.

Applications that use this media type: Applications implementing NIPC APIs for IoT device management.

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

11.2. 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 4

11.3. 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 2.6.1

Table 5

The well-known URI for NIPC is:

`/.well-known/nipc`

11.4. 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 6

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

12. References

12.1. Normative References

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Appendix A. OpenAPI definition

The following non-normative model is provided 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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - 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/PropertyValueResponse'\
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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - name: propertyName
      in: query
      description: Properties to be read
      required: true
      allowReserved: true
      schema:
        type: array
        items:
```

```

        type: string
        example: "https://example.com/heartrate#/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: The ID of the device.
              required: true
              schema:
                  type: string

```

```

        format: uuid
        example: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - 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: The ID of the device.
      required: true
      schema:
        type: string

```

```
        format: uuid
        example: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
- name: instanceId
  in: query
  description: instance id of the event that needs to be disap\
\led
  required: true
  schema:
    type: string
    format: uuid
    example: 02ee282c-8915-4b2e-bbd2-88966773134a
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
- 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: 02ee282c-8915-4b2e-bbd2-88966773134a
  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: 0dc729d7-f6c3-491d-9b9d-e7176d2be243
      - 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: 0dc729d7-f6c3-491d-9b9d-e7176d2be243
      - name: instanceId
        in: query
        description: instance id of the event that needs to be disabled
    \led
      required: true
      schema:
        type: string
        format: uuid
        example: flb9f26b-21ce-4deb-9d57-289ba7e17cce
    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: 0dc729d7-f6c3-491d-9b9d-e7176d2be243
      - name: instanceId
        in: query
        description: |-
          Instance IDs of the events that need to be filtered
        required: false
        schema:
          type: string
          format: uuid
          example: flb9f26b-21ce-4deb-9d57-289ba7e17cce
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - name: actionName
        in: query
        description: action that needs to be performed
        required: true
        allowReserved: true
        schema:
          type: string
          example: "https://example.com/heartrate#/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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
        - name: instanceId
          in: query
          description: |-
            instance id of the action that needs to be checked
          required: true
          schema:
            type: string
            format: uuid
            example: 02ee282c-8915-4b2e-bbd2-88966773134a
      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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
```

```
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/health\
\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/hearttrate#/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: 0927ce7c-b258-4bfa-a345-bcc9f74385b4
    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: 0927ce7c-b258-4bfa-a345-bcc9f74385b4
  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: 0927ce7c-b258-4bfa-a345-bcc9f74385b4
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: 0927ce7c-b258-4bfa-a345-bcc9f74385b4
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30

## A property
  Property:
    required:
      - property
    type: object
    properties:
      property:
        type: string
        example: "https://example.com/hearttrate#/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: 02ee282c-8915-4b2e-bbd2-88966773134a

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/hearttrate#/sdfObject/healths\
\ensor"

SdfModel:
  allOf:
    - type: object
      description: Sample SDF model
      properties:
        namespace:
          type: object
          additionalProperties:
            type: string
          example:
            hearttrate: https://example.com/hearttrate
        defaultNamespace:
          type: string
          example: hearttrate
    - 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: 00001809-0000-1000-8000-00805f9\
\b34fb
            characteristicID: 00002a1c-0000-1000-8000-\
\b00805f9b34fb
      sdfEvent:
        fallDetected:
          sdfOutputData:
            sdfProtocolMap:
              ble:
                serviceID: 00001809-0000-1000-8000-00805\
\b9b34fb
                characteristicID: 00002a1c-0000-1000-800\
\b0-00805f9b34fb
      sdfAction:
        start:
          sdfProtocolMap:
            ble:
              serviceID: 00001809-0000-1000-8000-00805f9\
\b34fb
              characteristicID: 00002a1c-0000-1000-8000-\
\b00805f9b34fb

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: 00001809-0000-1000-8000-00805f9b34fb
                  characteristicID: 00002a1c-0000-1000-8000-0080\
\b5f9b34fb

```



```

      sdfEvent:
        fallDetected:
          sdfOutputData:
            sdfProtocolMap:
              ble:
                type: advertisements
      sdfAction:
        start:
          sdfProtocolMap:
            ble:
              serviceID: 00001809-0000-1000-8000-00805f9b34fb
              characteristicID: 00002a1c-0000-1000-8000-0080\
\5f9b34fb

    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: 00001809-0000-1000-8000-00805f9b34fb
                  characteristicID: 00002a1c-0000-1000-8000-00805f9b\
\34fb

    SdfEvent:
      type: object
      description: Sample SDF property
      properties:
        sdfEvent:
          additionalProperties: #example, this will be the registere\
\d event
      type: object
      properties:
        sdfOutputData:
          allOf:
            - $ref: './protocolmaps/ProtocolMap.yaml#/componen\
\ts/schemas/ProtocolMap-Event'
          example:
            fallDetected:
              sdfOutputData:
                sdfProtocolMap:

```

```
        ble:
          serviceID: 00001809-0000-1000-8000-00805f9b34fb
          characteristicID: 00002a1c-0000-1000-8000-00805f\
\9b34fb

    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: 00001809-0000-1000-8000-00805f9b34fb
                  characteristicID: 00002a1c-0000-1000-8000-00805f9b\
\34fb

# 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 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30 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: 0dc729d7-f6c3-491d-9b9d-e7176d2be243
      - $ref: '#/components/schemas/FailureResponse'

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

```

Figure 31

Appendix B. Protocol mapping

The OpenAPI model for SDF protocol mapping is provided in Appendix B of [I-D.ietf-asdf-sdf-protocol-mapping].

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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - 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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/bulk/status?instanceId=02ee282c-8915-4b2e-bbd2-88966773134a
          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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - name: instanceId
      in: query
      description: Instance ID of the bulk operation
      required: true
      schema:
        type: string
        format: uuid
        example: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  - name: instanceId
    in: query
    description: Instance ID of the bulk operation
    required: true
    schema:
      type: string
      format: uuid
      example: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/bulk?instanceId=02ee282c-8915-4b2e-bbd2-88966773134a
    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}

```

```

        - /extensions/{id}/events/conditional?eventName={event\
ntName}
        - /extensions/{id}/properties/file?propertyName={prop\
pertyName}
        example: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30\
/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30\
/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
        - method: PUT
          path: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
          data:
            value: dGVzdA==
        - method: POST
          path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
          response:
            value: dGVzdA==
        - method: PUT
          path: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2Ftemperature
          response:
            status: 200
        - method: POST
          path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
```

```

Thing%2Fthermometer%2FsdfProperty%2FstartOTA
  data:
    value: dGVzdA==
  - method: POST
    path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/e\
vents/conditional?eventName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfEvent%2FotaStarted
  data:
    value: MQ==
    timeout: 5
  - method: PUT
    path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FfinishOTA
  data:
    value: dGVzdA==
  - method: POST
    path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FstartOTA
      response:

```



```

        status: 200
      - method: POST
        path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/e\
vents/conditional?eventName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfEvent%2FotaStarted
        response:
          value: MQ==
      - method: PUT
        path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/p\
roperties/file?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%\
23%2FsdfThing%2Fthermometer%2FsdfProperty%2Ffirmware
        response:
          status: 204
      - method: PUT
        path: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/prop\
erties?propertyName=https%3A%2F%2Fexample.com%2Fthermometer%23%2Fsdf\
Thing%2Fthermometer%2FsdfProperty%2FfinishOTA
        response:
          status: 200
      - method: POST
        path: /extensions/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/p\
roperties/read/conditional?propertyName=https%3A%2F%2Fexample.com%2F\
thermometer%23%2FsdfThing%2Fthermometer%2FsdfProperty%2FupdateStatus
        response:
          value: MQ==
      - method: PUT
        path: /devices/1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30/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: '\n' 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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - name: propertyName
        in: query
        description: |-
          The SDF property name that needs to be written to.
```

```

    required: true
    schema:
      type: string
      example: "https://example.com/hearttrate#/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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
\32e30/properties/file/status?propertyName=https%3A%2F%2Fexample.com\
\%2Fhearttrate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2Ffirmware&i\
\nstanceId=02ee282c-8915-4b2e-bbd2-88966773134a
          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: 02ee282c-8915-4b2e-bbd2-88966773134a
          property: https://example.com/heartrate#/s\
\dfObject/thermostat/sdfProperty/firmware
      failedResponse:
        summary: Failed
        value:
          id: 02ee282c-8915-4b2e-bbd2-88966773134a
          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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
        - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
\32e30/properties/file?propertyName=https%3A%2F%2Fexample.com%2Fhear\
\trate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2Ffirmware&instance\
\Id=02ee282c-8915-4b2e-bbd2-88966773134a
        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: 02ee282c-8915-4b2e-bbd2-88966773134a
              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/2020-12/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: 0.15.0
externalDocs:
  description: NIPC IETF draft
```

```
url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
- url: "{gw_host}/nipc/draft-15"
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - 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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/properties/read/conditional/status?propertyName=https%3A%2F%2F\
example.com%2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfProperty%2F\
temperature&instanceId=02ee282c-8915-4b2e-bbd2-88966773134a
        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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
                  property: https://example.com/heartrate#/s\
dfObject/thermostat/sdfProperty/temperature
                  value: dGVzdA==
              failedResponse:

```

```
summary: Failed
value:
  id: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  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/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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
```

```
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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/properties/read/conditional?propertyName=https%3A%2F%2Fexample\
.com%2Fheartrate%23%2Fsdfobject%2Fthermostat%2Fsdffproperty%2Ftempera\
ture&instanceId=02ee282c-8915-4b2e-bbd2-88966773134a
      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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
            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/2020-1\
2/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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
        - 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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/events/conditional/status?eventName=https%3A%2F%2Fexample.com%\
2Fheartrate%23%2FsdfObject%2Fthermostat%2FsdfEvent%2Ftemperature&ins\
tanceId=02ee282c-8915-4b2e-bbd2-88966773134a
          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:
                    $ref: '../NIPC.yaml#/components/schemas/FailureResponse'
    callbacks:
        callbackEvent:
            "{$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/FailureResponse'
                    examples:
                        successExample:
                            summary: Success
                            value:
                                id: 02ee282c-8915-4b2e-bbd2-88966773134a
                                event: https://example.com/heartrate#/sdfObject/thermostat/sdfEvent/temperature
                                value: dGVzdA==
                        failedResponse:
                            summary: Failed
                            value:
                                id: 02ee282c-8915-4b2e-bbd2-88966773134a
                                status: 400
                                type: https://www.iana.org/assignments/nipc-problem-types#invalid-id
                                title: Invalid ID
                                detail: "Invalid request"
                                event: https://example.com/heartrate#/sdfObject/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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
  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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
        - 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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      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/1d3b2c36-8a65-45a6-87c1-bcdbe0a\
32e30/events/conditional?eventName=https%3A%2F%2Fexample.com%2Fheart\
rate%23%2FsdfObject%2Fthermostat%2FsdfEvent%2Ftemperature&instanceId\
=02ee282c-8915-4b2e-bbd2-88966773134a
            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: 02ee282c-8915-4b2e-bbd2-88966773134a
                  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: 0.15.0
externalDocs:
  description: NIPC IETF draft
  url: https://datatracker.ietf.org/doc/draft-ietf-asdf-nipc/
servers:
  - url: "{gw_host}/nipc/draft-15"
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
    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: 1d3b2c36-8a65-45a6-87c1-bcdbe0a32e30
      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. NIPC API CDDL Definition

The following is a combined reference of all NIPC API CDDL definitions used in this document.

```

<CODE BEGINS> file "combined.cddl"
===== NOTE: '\ ' line wrapping per RFC 8792 =====

; This file is auto-generated from individual NIPC API CDDL files

; =====
; From: cddl/api/action_response.cddl

```

```

; =====
ActionResponse = {
  status: ActionStatus
}

ActionStatus = (
  "IN_PROGRESS" /
  "COMPLETED"
)
; =====
; From: cddl/api/data_app.cddl
; =====
DataApp = {
  events: [* EventRef],
  ( DataAppMqttClient //
    DataAppMqttBroker //
    DataAppWebhook //
    DataAppWebsocket )
}

EventRef = {
  event: text      ; SDF global name (absolute URI with fragment)
}

DataAppMqttClient = {
  mqttClient: bool
}

DataAppMqttBroker = {
  mqttBroker: {
    URI: text,
    username: text,
    password: text,
    ? brokerCACert: text,    ; PEM-encoded CA certificate
    ? customTopic: text     ; optional custom MQTT topic
  }
}

DataAppWebhook = {
  webhook: {
    URI: text,
    ? headers: { * text => text }, ; key/value headers
    ? serverCACert: text
  }
}

DataAppWebsocket = {
  websocket: {

```

```

    URI: text,
    ? headers: { * text => text }, ; key/value headers
    ? serverCACert: text
  }
}
; =====
; From: cddl/api/event_status_array.cddl
; =====
EventStatusResponseArray = [* EventStatusResponseArrayItem]

EventStatusResponseArrayItem = ( EventInstanceSuccess // FailureResp\
onse )

; Success item = { event, instanceId }
EventInstanceSuccess = {
  event: text, ; SDF global name of the event (absolute URI w\
ith fragment)
  instanceId: text ; UUID (as text)
}

; =====
; From: cddl/api/failure_response.cddl
; =====
FailureResponse = {
  ? type: FailureTypeURI,
  ? status: uint,
  ? title: text,
  ? detail: text
}

; Enumerated problem type URIs registered for NIPC
FailureTypeURI = (
  "https://www.iana.org/assignments/nipc-problem-types#invalid-id" /
  "https://www.iana.org/assignments/nipc-problem-types#invalid-sdf-u\
rl" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-ope\
ration-not-executed" /
  "https://www.iana.org/assignments/nipc-problem-types#sdf-model-alr\
eady-registered" /
  "https://www.iana.org/assignments/nipc-problem-types#sdf-model-in-\
use" /
  "https://www.iana.org/assignments/nipc-problem-types#property-not-\
readable" /
  "https://www.iana.org/assignments/nipc-problem-types#property-read\
-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#property-not-\
writable" /
  "https://www.iana.org/assignments/nipc-problem-types#property-writ\

```



```

e-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#event-already\
-enabled" /
  "https://www.iana.org/assignments/nipc-problem-types#event-not-ena\
bled" /
  "https://www.iana.org/assignments/nipc-problem-types#event-not-reg\
istered" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-already-connected" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-no-connection" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-connection-timeout" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-bonding-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-connection-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-service-discovery-failed" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-b\
le-invalid-service-or-characteristic" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-z\
igbee-connection-timeout" /
  "https://www.iana.org/assignments/nipc-problem-types#protocolmap-z\
igbee-invalid-endpoint-or-cluster" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-bro\
adcast-invalid-data" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-fir\
mware-rollback" /
  "https://www.iana.org/assignments/nipc-problem-types#extension-fir\
mware-update-failed" /
  "about:blank"
)
; =====
; From: cddl/api/group_event_status_response_array.cddl
; =====
GroupEventStatusResponseArray = [* GroupEventStatusResponse]

GroupEventSuccessResponse = { event: text, deviceId: text }

; Each item is either an event+deviceId success or a FailureResponse
GroupEventStatusResponse = (GroupEventSuccessResponse // FailureResp\
onse)

; FailureResponse (Problem Details subset; align with your existing \
definition if present)
GroupFailureResponse = {
  FailureResponse,

```

```

    ? deviceId: text
  }
; =====
; From: cddl/api/property_value_array.cddl
; =====
PropertyValueArray = [* PropertyValue]

; Minimal PropertyValue shape (matches allOf of Property + Value)
PropertyValue = {
  property: text,          ; SDF global name of the property
  value: b64text           ; base64-encoded bytes (RFC 4648 Section 5)
}

; Helper type for base64-with-padding encoded text
b64text = text
; =====
; From: cddl/api/property_value_read_response_array.cddl
; =====
PropertyValueReadResponseArray = [* PropertyValueReadResponseArrayItem]

PropertyValueReadResponseArrayItem = ( PropertyValue // FailureResponse )

; =====
; From: cddl/api/property_value_response_array.cddl
; =====
PropertyValueResponseArray = [* PropertyValueResponseArrayItem]

PropertyValueResponseArrayItem = ( SuccessResponse // FailureResponse )

; Minimal success shape (may be extended)
SuccessResponse = {
  ? status: uint
}

; =====
; From: cddl/api/sdf_reference.cddl
; =====
SdfGlobalName = text      ; absolute URI with fragment referencing an \
sdfThing or sdfObject

SdfReference = {
  sdfName: SdfGlobalName
}

SdfReferenceArray = [* SdfReference]

```

<CODE ENDS>

Figure 32: NIPC API CDDL Definitions

Appendix E. 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 33: Example SDF model with protocol mappings for BLE

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