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**Content Delivery Network Interconnection (CDNI) Footprint Types:
Subdivision Code and Footprint Union**

## Abstract

Open Caching architecture is a use case of Content Delivery Networks
Interconnection (CDNI) in which the commercial Content Delivery
Network (CDN) is the upstream CDN (uCDN) and the ISP caching layer
serves as the downstream CDN (dCDN). This document supplements the
CDNI Metadata Footprint Types defined in RFC 8006. The Footprint
Types defined in this document can be used for Footprint objects as
part of the Metadata interface (MI) defined in RFC 8006 and for the
Footprint & Capabilities Advertisement interface (FCI) defined in
RFC 8008. By defining the footprint union Footprint Type, this
document updates RFC 8008, allowing an additive semantic over the
narrowing semantics defined in Appendix B of RFC 8008. This document
also supplements RFC 9241 with relevant ALTO entity domain types.
The defined Footprint Types are derived from requirements raised by
Open Caching but are also applicable to CDNI use cases in general.

## Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in BCP 14 [RFC2119]
[RFC8174].

## Status of This Memo

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## 1.  Introduction

The Streaming Video Technology Alliance [SVTA] is a global
association that works to solve streaming video challenges in an
effort to improve end-user experience and adoption. The Open Caching
Working Group [OCWG] of the SVTA is focused on the delegation of
video delivery requests from commercial Content Delivery Networks
(CDNs) to a caching layer at the ISP's network. Open Caching
architecture is a specific use case of Content Delivery Networks
Interconnection (CDNI) where the commercial CDN is the upstream CDN
(uCDN) and the ISP caching layer is the downstream CDN (dCDN). The
Open Caching Request Routing Specification [OC-RR] defines the
Request Routing process and the interfaces that are required for its
provisioning. This document defines and registers CDNI Footprint and
Capabilities objects [RFC8008] that are required for Open Caching
Request Routing.

For consistency with other CDNI documents this document follows the
CDNI convention of uCDN (upstream CDN) and dCDN (downstream CDN) to
represent the commercial CDN and ISP caching layer respectively.

This document registers two CDNI Metadata Footprint Types (section
7.2 of [RFC8006]) for the defined objects:

  *Subdivision Code Footprint Type (e.g., for a dCDN advertising a
   footprint that is specific to a State in the USA)

  *Union Footprint Type (for a dCDN advertising a footprint that
   consists of a group built from multiple Footprints Types, e.g.,
   both IPv4 and IPv6 client subnets)

## 1.1.  Terminology

The following terms are used throughout this document:

  *CDN - Content Delivery Network

Additionally, this document reuses the terminology defined in
[RFC6707], [RFC7336], [RFC8006], and [RFC8008]. Specifically, we use
the following CDNI acronyms:

  *uCDN, dCDN - Upstream CDN and Downstream CDN respectively (see
   [RFC7336] )

## 2.  CDNI Metadata Additional Footprint Types

Section 5 of [RFC8008] describes the Footprint & Capabilities
Advertisement interface (FCI) Capability Advertisement Object, which
includes an array of CDNI Footprint Objects. Each such object has a
footprint-type and a footprint-value, as described in section

4.2.2.2 of [RFC8006]. This document defines additional footprint types, beyond those mentioned in CDNI metadata [RFC8006].

## 2.1. CDNI Metadata Subdivision Code Footprint Type

Section 4.3.8 of [RFC8006] specifies the "Country Code" footprint type for listing [ISO3166-1] alpha-2 codes. Using Footprint Objects of this type, one can define an FCI Capability Advertisement Object footprint constraint that matches a specific country. Herein is defined the subdivisioncode simple data type, as well as a footprint type allowing the dCDN to define constraints matching geographic areas with better granularity, specifically using the [ISO3166-2] Country Subdivision codes.

### 2.1.1. CDNI Metadata Subdivision Code Data Type

The "subdivisioncode" data type specified in Section 2.1.1.1, describes a country specific subdivision using an [ISO3166-2] code. The data type is added to the list of data types described in section 4.3 of [RFC8006] that are used as properties of CDNI Metadata objects.

#### 2.1.1.1. CDNI Metadata Subdivision Code Data Type Description

An [ISO3166-2] code in lowercase. Each code consists of two parts separated by a hyphen. As per [ISO3166-2], the first part is the [ISO3166-1] code of the country, and the second part is a string of up to three alphanumeric characters.

    Type: String

    Example Subdivision Codes:

    "ca-on"

    "us-ny"

### 2.1.2. CDNI Metadata Subdivision Code Footprint Type Description

The "subdivisioncode" simple data type specified in Section 2.1.1, is added to the data types listed as footprint types in section 4.2.2.2 of [RFC8006].

Below is an example using a footprint object of type "subdivisioncode". The Footprint Object in this example creates a constraint matching clients in the states of New Jersey and New York, USA (ISO [ISO3166-2] codes "US-NJ" and "US-NY" respectively).

```
{
  "capabilities": [
    {
      "capability-type": <CDNI capability object type>,
      "capability-value": <CDNI capability object>,
      "footprints": [
          {
              "footprint-type": "subdivisioncode",
              "footprint-value": ["us-nj", "us-ny"]
          }
      ]
    }
  ]
}
```

Figure 1: Illustration of subdivision-code footprint advertisement

## 2.2.  CDNI Metadata Footprint Union Footprint Type

As described in section 5 of [RFC8008], the FCI Capability
Advertisement Object includes an array of CDNI Footprint Objects.
Appendix B of [RFC8008] specifies the semantics of a Footprint
Objects array as a multiple, additive, footprint constraints. This
implies that the advertisement of different footprint types narrows
the dCDN's candidacy cumulatively.

Sections 4.3.5 and 4.3.6 of [RFC8006] specify the "IPv4CIDR" and
"IPv6CIDR" footprint types, respectively, for listing IP unscoped
address blocks. Using Footprint Objects of these types, one can
define FCI Capability Advertisement Object footprint constraints
that match IPv4 or IPv6 clients. However, the described "narrowing"
semantic of the Footprint Objects array, as described in Appendix B
of [RFC8008], prevents the usage of these objects together to create
a footprint constraint that matches IPv4 clients together with IPv6
clients.

Below is an example for an attempt at creating an object matching
IPv4 clients of subnet "192.0.2.0/24", as well as IPv6 clients of
subnet "2001:db8::/32". Such a definition results in an empty list
of clients, as the constraints are additives and a client address
cannot be both IPv4 and IPv6.

```
{
  "capabilities": [
    {
      "capability-type": <CDNI capability object type>,
      "capability-value": <CDNI capability object>,
      "footprints": [
          {
              "footprint-type": "ipv4cidr",
              "footprint-value": ["192.0.2.0/24"]
          },
          {
              "footprint-type": "ipv6cidr",
              "footprint-value": ["2001:db8::/32"]
          }
      ]
    }
  ]
}
```

Figure 2: Example of narrowing semantic illustrating advertisement of a
                              null footprint

   To overcome the described limitation and allow a list of footprint
   constraints that match both IPv4 and IPv6 client subnets, this
   document defines the "footprintunion" footprint type. This footprint
   type allows the collection of multiple footprint-objects into a
   unified object. Therefore it resolves the above limitation and can
   be particularly applicable to unify semantically related objects,
   for example, an ipv4cidr together with an ipv6cidr or a countrycode
   together with a subdivisoncode.

   Note: to avoid implementation complexity, a "footprintunion" MUST
   NOT list any "footprintunion" as a value. As a union of unions is
   simply a union, this syntactic restriction does not result with any
   semantic limitation.

## 2.2.1.  CDNI Metadata Footprint Union Data Type

   The "footprintunion" data type is based on the Footprint Object
   already defined in section 4.2.2.2 of [RFC8006]. The footprint-value
   for a "footprintunion" object is an array of Footprint objects,
   where the Footprint objects MUST be of any Footprint Type other than
   "footprintunion".

### 2.2.2.  CDNI Metadata FootprintUnion Footprint Type Description

The "footprintunion" data type specified in Section 2.2.1, is added
to the data types listed as footprint types in section 4.2.2.2 of
[RFC8006].

Below is an example using a footprint object of type
"footprintunion" combining both IPv4 and IPv6 client subnets.

```
{
  "capabilities": [
    {
      "capability-type": <CDNI capability object type>,
      "capability-value": <CDNI capability object>,
      "footprints": [
        {
          "footprint-type": "footprintunion",
          "footprint-value": [
            {
              "footprint-type": "ipv4cidr",
              "footprint-value": ["192.0.2.0/24"]
            },
            {
              "footprint-type": "ipv6cidr",
              "footprint-value": ["2001:db8::/32"]
            }
          ]
        }
      ]
    }
  ]
}
```

Figure 3: Example of an advertisement of footprint union for multiple
CIDR footprint types

The footprint union also enables composing a countrycode and
subdivisioncode based footprint objects. In the example below we
create a constraint covering autonomous system 64496 within the US
(ISO [ISO3166-1] alpha-2 code "US") and the Ontario province of
Canada (ISO [ISO3166-2] code "CA-ON").

```
{
  "capabilities": [
    {
      "capability-type": <CDNI capability object type>,
      "capability-value": <CDNI capability object>,
      "footprints": [
        {
          "footprint-type": "asn",
          "footprint-value": ["as64496"]
        },
        {
          "footprint-type": "footprintunion",
          "footprint-value": [
            {
              "footprint-type": "countrycode",
              "footprint-value": ["us"]
            },
            {
              "footprint-type": "subdivisioncode",
              "footprint-value": ["ca-on"]
            }
          ]
        }
      ]
    }
  ]
}
```

    Figure 4: Example of an advertisement of footprint union for multiple
                    geographical footprint types

## 3. ALTO Property Map Service Entity

Section 6 of [RFC9241] describes how to represent footprint objects
as entities in the ALTO property map. The approach is to represent
the "footprint-type" as an entity domain type of the ALTO entity,
and the footprint value as its domain-specific identifier. [RFC9241]
further refers to the representation of footprint objects of types
"asn" and "countrycode". Here we extend this definition to the
"subdivisioncode" footprint-type.

### 3.1. SUBDIVISIONCODE Domain

The SUBDIVISIONCODE domain associates property values that defines
codes for the names of the principal subdivisions.

### 3.1.1.  Entity Domain Type

The entity domain type of the SUBDIVISIONCODE domain is
"subdivisioncode" (in lowercase).

### 3.1.2.  Domain-Specific Entity Identifiers

The entity identifier of an entity in a SUBDIVISIONCODE is encoded
as an alpha-2 [ISO3166-1] Country Code, followed by a separator and
up to three alphanumeric characters.

### 3.1.3.  Hierarchy and Inheritance

There is no hierarchy or inheritance for properties associated with
subdivision codes.

## 4.  IANA Considerations

### 4.1.  CDNI Metadata Footprint Types

Section 7.2 of [RFC8006] specifies the "CDNI Metadata Footprint
Types" subregistry within the "Content Delivery Network
Interconnection (CDNI) Parameters" registry.

This document requests the registration of the two additional
Footprint Types as defined in Section 2.1 and Section 2.2 :

| Footprint Type | Description | Reference |
|---|---|---|
| subdivisioncode | [ISO3166-2] ISO 3166-2 country subdivision code: alpha-2 country code, followed by a hyphen-minus, and up to 3 characters from A-Z;0-9 as a code within the country. | RFCthis |
| footprintunion | A combination of other Footprint Objects | RFCthis |

Table 1

[RFC Editor: Please replace RFCthis with the published RFC number
for this document.]

### 4.2.  ALTO Entity Domain Types

Section 12.3 of [RFC9240] creates the "ALTO Entity Domain Types"
registry.

This document requests the registration of an additional ALTO Entity
Domain Types:

| Identifier | Entity Identifier Encoding | Hierarchy and Inheritance | Media Type of Defining Resource | Mapping to ALTO Address Type |
|---|---|---|---|---|
| subdivisioncode | See RFCthis, [Section 3.1.2](#) | None | None | false |

Table 2

[RFC Editor: Please replace RFCthis with the published RFC number for this document.]

## 5.  Security Considerations

This specification is in accordance with the CDNI Metadata and the CDNI Request Routing: Footprint and Capabilities Semantics. As such, it is subject to the security and confidentiality considerations as defined in Section 8 of [RFC8006] and in Section 7 of [RFC8008] respectively.

## 6.  Acknowledgements

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