

---

Stream: Internet Engineering Task Force (IETF)  
RFC: [9388](#)  
Updates: [8008](#)  
Category: Standards Track  
Published: July 2023  
ISSN: 2070-1721  
Authors: N. Sopher S. Mishra  
Qwilt Verizon

# RFC 9388

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

---

### Abstract

Open Caching architecture is a use case of Content Delivery Network 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). RFC 8006 defines footprint types that are used for footprint objects as part of the Metadata interface (MI). The footprint types are also used for the Footprint & Capabilities Advertisement interface (FCI) as defined in RFC 8008. This document defines two new footprint types. The first footprint type defined is an ISO 3166-2 country subdivision code. Defining this country subdivision code improves granularity for delegation as compared to the ISO 3166-1 country code footprint type defined in RFC 8006. The ISO 3166-2 country subdivision code is also added as a new entity domain type in the "ALTO Entity Domain Types" registry defined in Section 7.4 of RFC 9241. The second footprint type defines a footprint union to aggregate footprint objects. This allows for additive semantics over the narrowing semantics defined in Appendix B of RFC 8008 and therefore updates RFC 8008. The two new footprint types are based on the requirements raised by Open Caching but are also applicable to CDNI use cases in general.

### Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at <https://www.rfc-editor.org/info/rfc9388>.

## Copyright Notice

Copyright (c) 2023 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust's Legal Provisions Relating to IETF Documents (<https://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Revised BSD License text as described in Section 4.e of the Trust Legal Provisions and are provided without warranty as described in the Revised BSD License.

## Table of Contents

1. Introduction
  - 1.1. Terminology
  - 1.2. Requirements Language
2. CDNI Metadata Additional Footprint Types
  - 2.1. CDNI Metadata "subdivisioncode" Footprint Type
    - 2.1.1. CDNI Metadata "subdivisioncode" Data Type
      - 2.1.1.1. CDNI Metadata "subdivisioncode" Data Type Description
    - 2.1.2. CDNI Metadata "subdivisioncode" Footprint Type Description
  - 2.2. CDNI Metadata "footprintunion" Footprint Type
    - 2.2.1. CDNI Metadata "footprintunion" Data Type
    - 2.2.2. CDNI Metadata "footprintunion" Footprint Type Description
3. ALTO Property Map Service Entity
  - 3.1. SUBDIVISIONCODE Domain
    - 3.1.1. Entity Domain Type
    - 3.1.2. Domain-Specific Entity Identifiers
    - 3.1.3. Hierarchy and Inheritance
4. IANA Considerations
  - 4.1. CDNI Metadata Footprint Types
  - 4.2. ALTO Entity Domain Types

## [5. Security Considerations](#)

## [6. References](#)

### [6.1. Normative References](#)

### [6.2. Informative References](#)

## [Acknowledgements](#)

## [Authors' Addresses](#)

# 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 Network 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 Functional 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 using "uCDN" and "dCDN" 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:

- Country subdivision code footprint type (e.g., for a dCDN advertising a footprint that is specific to a state in the United States of America)
- Footprint union footprint type (for a dCDN advertising a footprint that consists of a group built from multiple footprint 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 abbreviations:

uCDN: upstream CDN (see [RFC7336])

dCDN: downstream CDN (see [\[RFC7336\]](#))

## 1.2. Requirements Language

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.

## 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 [\[RFC8006\]](#).

### 2.1. CDNI Metadata "subdivisioncode" Footprint Type

[Section 4.3.8](#) of [\[RFC8006\]](#) specifies the "countrycode" 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. This document defines the "subdivisioncode" simple data type as well as a footprint type, allowing the dCDN to define constraints that match geographic areas with better granularity, specifically using the [\[ISO3166-2\]](#) country subdivision codes.

#### 2.1.1. CDNI Metadata "subdivisioncode" Data Type

The "subdivisioncode" data type specified in [Section 2.1.1.1](#) describes a country-specific subdivision using a code as defined in [\[ISO3166-2\]](#). 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 "subdivisioncode" 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 country subdivision codes:

- "ca-on"
- "us-ny"

##### 2.1.2. CDNI Metadata "subdivisioncode" 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 [\[RFC8006\]](#).

[Figure 1](#) is an example using a footprint object of type "subdivisioncode". The footprint object in this example creates a constraint that matches clients in the state of either New Jersey or 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 Country Subdivision Code Footprint Advertisement*

## 2.2. CDNI Metadata "footprintunion" 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 for Footprint Advertisement such that multiple footprint constraints are additive. 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 the "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 either IPv4 or IPv6 clients, but not both. This is due to the described "narrowing" semantic of the Footprint Objects array, as described in Appendix B of [\[RFC8008\]](#), that prevents the usage of these objects together to create a footprint constraint that matches IPv4 clients with IPv6 clients.

[Figure 2](#) is an example attempting to create an object that matches 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 IPv4 CIDR together with an IPv6 CIDR or a country code together with a country subdivision code.

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 "footprintunion" 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 [\[RFC8006\]](#).

[Figure 3](#) is an example using a footprint union 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 Classless Inter-Domain Routing (CIDR) Footprint Types*

The footprint union also enables composing of footprint objects based on the country code and country subdivision code. In [Figure 4](#), we create a constraint covering autonomous system 64496 within the USA (ISO alpha-2 code "US" as described in [\[ISO3166-1\]](#)) and the Ontario province of Canada (ISO code "CA-ON" as described in [\[ISO3166-2\]](#)).

```
{
  "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 define 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 country 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 registers two footprint types in that subregistry as defined in Sections 2.1 and 2.2:

Footprint Type	Description	Reference
subdivisioncode	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	RFC 9388
footprintunion	A combination of other footprint objects	RFC 9388

Table 1: Additions to the CDNI Metadata Footprint Types Subregistry

### 4.2. ALTO Entity Domain Types

Section 12.3 of [RFC9240] creates the "ALTO Entity Domain Types" subregistry within the "Application-Layer Traffic Optimization (ALTO) Protocol" registry.

This document registers an additional ALTO Entity Domain Type within that subregistry:

Identifier	Entity Identifier Encoding	Hierarchy and Inheritance	Media Type of Defining Resource	Mapping to ALTO Address Type
subdivisioncode	See RFC 9388, Section 3.1.2	None	None	false

Table 2: Additions to the ALTO Entity Domain Types Subregistry

## 5. Security Considerations

This specification is in accordance with "[Content Delivery Network Interconnection \(CDNI\) Metadata](#)" and "[Content Delivery Network Interconnection \(CDNI\) 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. References

### 6.1. Normative References

- [ISO3166-1] ISO, "Codes for the representation of names of countries and their subdivisions -- Part 1: Country code", ISO 3166-1:2020, Edition 4, August 2020, <<https://www.iso.org/standard/72482.html>>.
- [ISO3166-2] ISO, "Codes for the representation of names of countries and their subdivisions -- Part 2: Country subdivision code", ISO 3166-2:2020, Edition 4, August 2020, <<https://www.iso.org/standard/72483.html>>.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC8006] Niven-Jenkins, B., Murray, R., Caulfield, M., and K. Ma, "Content Delivery Network Interconnection (CDNI) Metadata", RFC 8006, DOI 10.17487/RFC8006, December 2016, <<https://www.rfc-editor.org/info/rfc8006>>.
- [RFC8008] Seedorf, J., Peterson, J., Previdi, S., van Brandenburg, R., and K. Ma, "Content Delivery Network Interconnection (CDNI) Request Routing: Footprint and Capabilities Semantics", RFC 8008, DOI 10.17487/RFC8008, December 2016, <<https://www.rfc-editor.org/info/rfc8008>>.
- [RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.
- [RFC9240] Roome, W., Randriamasy, S., Yang, Y., Zhang, J., and K. Gao, "An Extension for Application-Layer Traffic Optimization (ALTO): Entity Property Maps", RFC 9240, DOI 10.17487/RFC9240, July 2022, <<https://www.rfc-editor.org/info/rfc9240>>.
- [RFC9241] Seedorf, J., Yang, Y., Ma, K., Peterson, J., and J. Zhang, "Content Delivery Network Interconnection (CDNI) Footprint and Capabilities Advertisement Using Application-Layer Traffic Optimization (ALTO)", RFC 9241, DOI 10.17487/RFC9241, July 2022, <<https://www.rfc-editor.org/info/rfc9241>>.

### 6.2. Informative References

- [OC-RR]** Finkelman, O., Ed., Zurat, B., Sahar, D., Klein, E., Hofmann, J., Ma, K.J., Stock, M., Mishra, S., and Y. Gressel, "Open Caching - Request Routing Functional Specification", Version 2.0, 15 January 2021, <<https://www.svta.org/product/open-cache-request-routing-functional-specification/>>.
- [OCWG]** SVTA, "Open Caching", <<https://opencaching.svta.org/>>.
- [RFC6707]** Niven-Jenkins, B., Le Faucheur, F., and N. Bitar, "Content Distribution Network Interconnection (CDNI) Problem Statement", RFC 6707, DOI 10.17487/RFC6707, September 2012, <<https://www.rfc-editor.org/info/rfc6707>>.
- [RFC7336]** Peterson, L., Davie, B., and R. van Brandenburg, Ed., "Framework for Content Distribution Network Interconnection (CDNI)", RFC 7336, DOI 10.17487/RFC7336, August 2014, <<https://www.rfc-editor.org/info/rfc7336>>.
- [SVTA]** SVTA, "Streaming Video Technology Alliance", <<https://www.svta.org/>>.

## Acknowledgements

The authors would like to express their gratitude to Ori Finkelman and Kevin J. Ma for their guidance and reviews throughout the development of this document. We would also like to thank all the Area Directors for their review and feedback in improving this document.

## Authors' Addresses

### Nir B. Sopher

Qwilt  
6, Ha'harash  
Hod HaSharon 4524079  
Israel  
Email: [nir@apache.org](mailto:nir@apache.org)

### Sanjay Mishra

Verizon  
13100 Columbia Pike  
Silver Spring, MD 20904  
United States of America  
Email: [sanjay.mishra@verizon.com](mailto:sanjay.mishra@verizon.com)