          Content Distribution Network Interconnection (CDNI) Requirements
                     draft-lefaucheur-cdni-requirements-02

Abstract

   Content Delivery Networks (CDNs) are frequently used for large-scale
   content delivery. As a result, existing CDN providers are scaling up
   their infrastructure and many Network Service Providers (NSPs) are
   deploying their own CDNs. There is a requirement for interconnecting
   standalone CDNs so that their collective CDN footprint can be
   leveraged for the end-to-end delivery of content from Content Service
   Providers (CSPs) to end users. The Content Distribution Network
   Interconnection (CDNI) working group has been chartered to develop an
   interoperable and scalable solution for such CDN interconnection.

   The goal of the present document is to outline the requirements for
   the solution and interfaces to be specified by the CDNI working
   group.

Requirements Language

   The key words "Must", "Should" and "May" in this document are to be
   interpreted in the following way:

   o "Must" indicates requirements that are to be supported by the CDNI
      protocols in the stated scope (aka "within initial CDNI scope" or
      "beyond initial scope"). A requirement is stated as a "Must" when
      it is established by that it can be met without compromising the
      targeted schedule for WG deliverables, or when it is established
      that specifying a solution without meeting this requirement would
      not make sense and would justify re-adjusting the WG schedule, or
      both.

   o "Should" indicates requirements that are to be supported by the
      CDNI protocols in the stated scope (aka "within initial CDNI
      scope" or "beyond initial scope") unless the WG realizes at a

later stage that attempting to meet this requirement would
compromise the overall WG schedule (for example it would involve
complexities that would result in significantly delaying the
deliverables).

o   "May" indicates requirements that are to be supported by the CDNI
    protocols in the stated scope (aka "within initial CDNI scope" or
    "beyond initial scope") provided that dedicating WG resources to
    this work does not prevent addressing "Should" and "Must"
    requirements and that attempting to meet this requirement would
    not compromise the overall WG schedule.

Status of this Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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1. Introduction

   The volume of video and multimedia content delivered over the
   Internet is rapidly increasing and expected to continue doing so in
   the future. In the face of this growth, Content Delivery Networks
   (CDNs) provide numerous benefits: reduced delivery cost for cacheable
   content, improved quality of experience for end users, and increased
   robustness of delivery. For these reasons CDNs are frequently used
   for large-scale content delivery. As a result, existing CDN
   providers are scaling up their infrastructure and many Network
   Service Providers (NSPs) are deploying their own CDNs. It is
   generally desirable that a given content item can be delivered to an
   End User regardless of that End User's location or attachment
   network. However, the footprint of a given CDN in charge of
   delivering a given content may not expand close enough to the End
   User's current location or attachment network to realize the cost
   benefit and user experience that a more distributed CDN would
   provide. This creates a requirement for interconnecting standalone
   CDNs so that their collective CDN footprint can be leveraged for the
   end-to-end delivery of content from Content Service Providers (CSPs)
   to End Users. However, no standards or open specifications currently
   exist to facilitate such CDN interconnection.

   [I-D.jenkins-cdni-problem-statement] outlines the problem area that
   the CDNI working group is chartered to address.
   [I-D.bertrand-cdni-use-cases] discusses the use cases for CDN
   Interconnection. [I-D.davie-cdni-framework] discusses the technology
   framework for the CDNI solution and interfaces.

   The goal of the present document is to document the requirements for
   the CDNI solution and interfaces. In accordance with the working
   group charter, the work is prioritized in a "walk before you run"
   approach: the present document separates the CDNI requirements into a
   set of more urgent requirements that are within the initial scope of
   the CDNI working group, and a set of less urgent additional
   requirements that are left to potential future rechartering of the
   working group.

1.1. Terminology

   This document uses the terminology defined in section 1.1 of
   [I-D.jenkins-cdni-problem-statement].

   This also defined the following additional terms [Editor's Note:
   these definitions may be better located in another document such as
   the Problem Statement]:

o Recursive CDNI request routing: When an Upstream CDN elects to
   redirect a request towards a Downstream CDN, the Upstream CDN can
   query the Downstream CDN Request Routing system via the CDNI
   Request Routing protocol (or use information cached from earlier
   similar queries) to find out how the Downstream CDN wants the
   request to be redirected, which allows the Upstream CDN to factor
   in the Downstream CDN response when redirecting the user agent.
   This approach is referred to as "recursive" CDNI request routing.
   Note that the Downstream CDN may elect to have the request
   redirected directly to a Surrogate inside the Downstream CDN, to
   the Request-Routing System of the Downstream CDN, to another CDN,
   or to any other system that the Downstream CDN sees as fit for
   handling the redirected request.

o Iterative CDNI Request Routing: When an Upstream CDN elects to
   redirect a request towards a Downstream CDN, the Upstream CDN can
   base its redirection purely on a local decision (and without
   attempting to take into account how the Downstream CDN may in turn
   redirect the user agent). In that case, the Upstream CDN
   redirects the request to the request routing system in the
   Downstream CDN, which in turn will decide how to redirect that
   request: this approach is referred to as "iterative" CDNI request
   routing.

2. CDNI Model and CDNI protocols

   For convenience Figure 1 from [I-D.jenkins-cdni-problem-statement]
   illustrating the CDNI problem area and the CDNI protocols is
   replicated below.

```
          --------
         /        \
         |   CSP  |
         \        /
          --------
             *
             *
             *                       /\
             *                      /  \
      --------------------        |CDNI|       ---------------------
     /    Upstream CDN    \       |    |      /   Downstream CDN    \
     |     +------------+ | Control protocol| +------------+       |
     |     |CDN Control |<======|====|======>| CDN Control |       |
     |     +------*-*-*--+ |     |    |      | +-*-*-*------+       |
     |           * * *     |     |    |      |    * * *            |
     |     +------*------+ | Logging protocol| +-----*-------+     |
     | ****| Logging     |<======|====|======>|  Logging     |**** |
     | *   -------------+ |     |    |      | +------------+    *  |
     | *           * *    | Request Routing |   * *            * |
....*...+---------*----+ |    protocol     | +---*---------+...*.....
. | * **|Req-Routing  |<======|====|======>| Req-Routing |** * |  .
. | * * +-------------+.|     |    |      | +------------+ * * |  .
. | * *           *    .  CDNI Metatdata |   *            * * |  .
. | * * +----------*--+ |.   protocol     | +-*-----------+ * * |  .
. | * * |Distribution |<==.===|====|======>| Distribution| * * |  .
. | * * |            | | |  .   \  /      | |            | * * |  .
. | * * |            | | |  .   \/       | |            | * * |  .
. | * ****+---------+ | |    ....Request......+---------+**** * |  .
. | ******|Surrogate|***********************|Surrogate|******  |  .
. |     | +---------+ | | Acquisition   | | +-----*---+ |     |  .
. |    +-------------+ |                 | +-------*-----+    |  .
. \                  /                 \        *          /  .
.  --------------------                 ---------*----------    .
.                                               *              .
.                                             * Delivery       .
.                                               *              .
.                                          +------+           .
...............Request.........................| User |..Request..
.                                          | Agent|           .
.                                          +------+           .
```
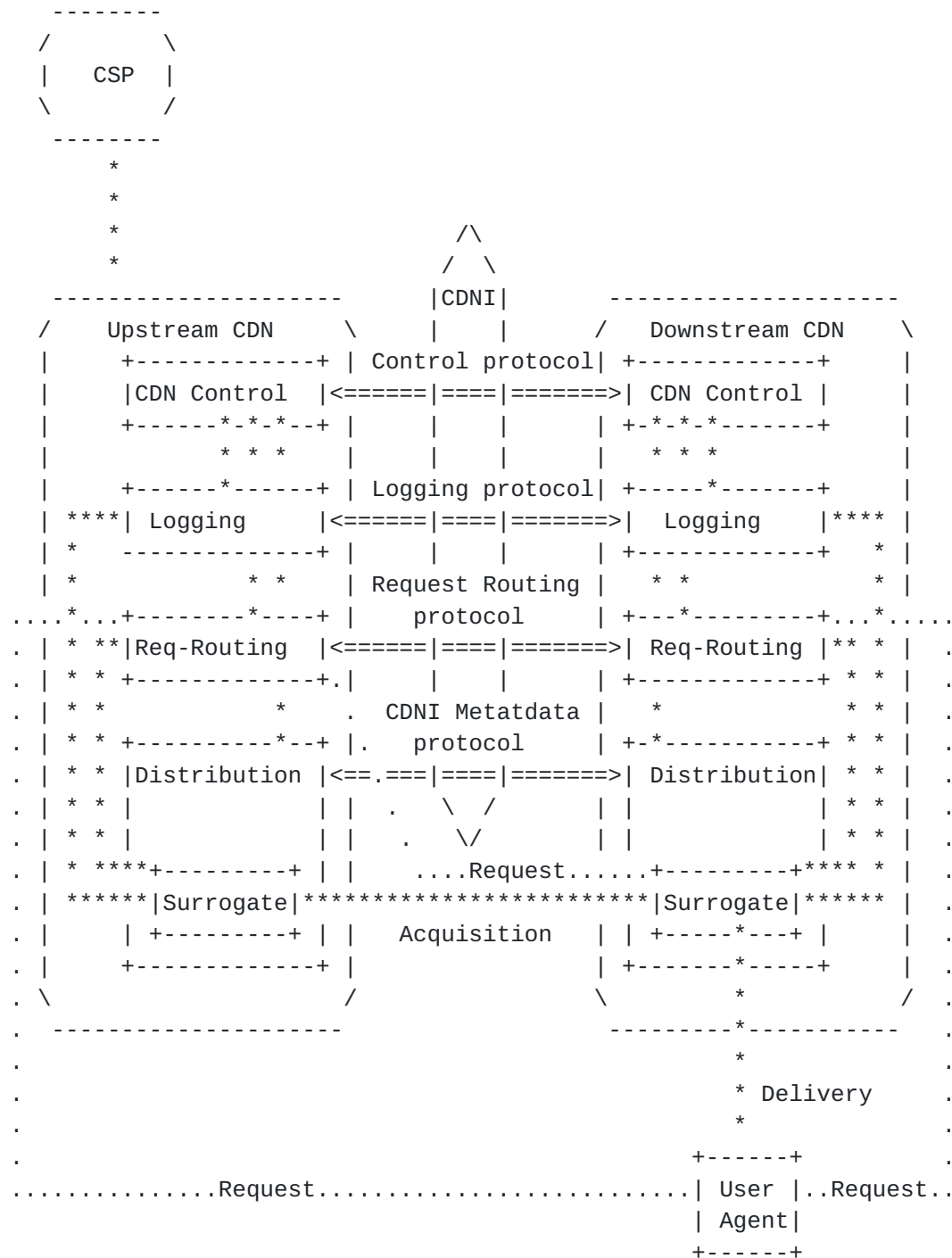
      <==>   interfaces inside the scope of CDNI

      ****   interfaces outside the scope of CDNI
      ....   interfaces outside the scope of CDNI

                    Figure 1: CDNI Model and CDNI APIs

3. Generic Requirements

This section identifies generic requirements independent of the
individual CDNI protocols. Some of those are expected to affect
multiple or all protocols.

3.1. Within Initial CDNI Scope

R1   Wherever possible, the CDNI protocols Should reuse or leverage
      existing IETF protocols.

R2   The CDNI solution Must not require a change, or an upgrade, to
      the User Agent to benefit from content delivery through
      interconnected CDNs.

R3   The CDNI solution Must not require intra-CDN information to be
      exposed to other CDNs for effective and efficient delivery of
      the content. Examples of intra-CDN information include
      surrogate topology, surrogate status, cached content, etc.

R4   The CDNI solution Must support delivery to the user agent based
      on HTTP [RFC2616]. [Note that while delivery and acquisition
      "data plane" protocols are out of the CDNI solution scope, the
      CDNI solution "control plane" protocols are expected to
      participate in enabling, selecting or facilitating operations of
      such acquisition and delivery protocols. Hence it is useful to
      state requirements on the CDNI solution in terms of which
      acquisition and delivery protocols].

R5   The CDNI solution Must support acquisition across CDNs based on
      HTTP [RFC2616].

R6   The CDNI solution May support delivery to the user agent based
      on protocols other than HTTP.

R7   The CDNI solution May support acquisition across CDNs based on
      protocols other than HTTP.

R8   The CDNI solution Should support cascaded CDN redirection (CDN1
      redirects to CDN2 that redirects to CDN3) to an arbitrary number
      of levels.

R9   The CDNI solution Should support an arbitrary topology of
      interconnected CDNs (i.e. the CDN topology cannot be restricted
      to a tree, a loop-free topology, etc.).

R10 The CDNI solution Must prevent looping of any CDNI information
     exchange.

R11 When making use of third party reference, the CDNI solution Must
     consider the potential issues associated with the use of various
     format of third-party references (e.g. NAT or IPv4/IPv6
     translation potentially breaking third-party references based on
     an IP addresses such as URI containing IPv4 or IPv6 address
     litterals, split DNS situations potentially breaking third-party
     references based on DNS fully qualified domain names) and
     wherever possible avoid, minimize or mitigate the associated
     risks based on the specifics of the environments where the
     reference is used (e.g. likely or unlikely presence of NAT in
     the path). In particular, this applies to situations where the
     CDNI solution needs to construct and convey uniform resource
     identifiers for directing/redirecting a content request, as well
     as to situations where the CDNI solution needs to pass on a
     third party reference (e.g. to identify a User Agent) in order
     to allow another entity to make a more informed decision (e.g.
     make a more informed request routing decision by attempting to
     derive location information from the third party reference).

3.2. Beyond Initial CDNI Scope

R12 The CDNI solution Must support cascaded CDN redirection (CDN1
     redirects to CDN2 that redirects to CDN3) to an arbitrary number
     of levels. [Note: this "Must" requirement appeared as a
     "Should" requirement in Section 3.1]

R13 The CDNI solution Must support an arbitrary topology of
     interconnected CDNs (i.e. the CDN topology cannot be restricted
     to a tree, a loop-free topology, etc.). [Note: this "Must"
     requirement appeared as a "Should" requirement in Section 3.1]

R14 The CDNI solution Should support virtualization of the
     Downstream CDN, so that the Downstream CDN can appear as
     multiple logical Downstream CDNs.

4. CDNI Control Protocol Requirements

The primary purpose of the CDNI Control protocol is to initiate the
interconnection across CDNs, bootstrap the other CDNI interfaces and
trigger actions into the Downstream CDN by the Upstream CDN (such as
delete object from caches or trigger pre-positioned content
acquisition). We observe that while the CDNI Control protocol is
currently discussed as a single "protocol", further analysis will
determine whether the corresponding requirements are to be realized

over a single interface and protocol, or over multiple interfaces and
protocols.

4.1. Within Initial CDNI Scope

R15   The CDNI Control protocol Must allow the Upstream CDN to request
      that the Downstream CDN (and, if cascaded CDNs are supported by
      the solution, that the potential cascaded Downstream CDNs)
      perform the following actions on an object or object set:

      *   Mark an object(s) and/or its CDNI metadata as "stale" and
           revalidate them before they are delivered again

      *   Delete an object(s) and/or its CDNI metadata from the CDN
           surrogates and any storage.

R16   The CDNI Control protocol Must allow the downstream CDN to
      report on the completion of these actions (by itself, and if
      cascaded CDNs are supported by the solution, by potential
      cascaded Downstream CDNs), in a manner appropriate for the
      action (e.g. synchronously or asynchronously).

R17   The CDNI Control protocol Must support initiation and control by
      the Upstream CDN of pre-positioned CDNI metadata acquisition by
      the Downstream CDN.

R18   The CDNI Control protocol Should support initiation and control
      by the Upstream CDN of pre-positioned content acquisition by the
      Downstream CDN.[Editor's Note: how much influence the Upstream
      CDN ought to have on pre-positioning of the content on
      surrogates inside the Downstream CDN is TBD].

4.2. Beyond Initial CDNI Scope

R19   The CDNI Control protocol Must support support initiation and
      control by the Upstream CDN of pre-positioned content
      acquisition.[Editor's Note: how much influence the Upstream CDN
      ought to have on pre-positioning of the content on surrogates
      inside the Downstream CDN is TBD]. [Note: this "Must"
      requirement appeared as a "Should" requirement in Section 4.1]

R20   The CDNI Control protocol Must allow a CDN to establish, update
      and terminate a CDN interconnection with another CDN whereby one
      CDN can act as a Downstream CDN for the other CDN (that acts as
      an Upstream CDN).

R21   The CDNI Control protocol Must allow control of the CDNI
      interconnection between any two CDNs independently for each
      direction (i.e. For the direction where CDN1 is the Upstream
      CDN and CDN2 is the Downstream CDN, and for the direction where
      CDN2 is the Upstream CDN and CDN1 is the Downstream CDN).

R22   The CDNI Control protocol Should allow bootstrapping of the
      Request-Routing protocol. For example, this can potentially
      include:

      *   negotiation of the Request-Routing method (e.g. DNS vs
          HTTP, if more than one method is specified)

      *   discovery of the Request-Routing protocol endpoints

      *   information necessary to establish secure communication
          between the Request-Routing protocol endpoints.

R23   The CDNI Control protocol Should allow bootstrapping of the
      Metadata Signaling protocol. This information could, for
      example, include:

      *   discovery of the Metadata Signaling protocol endpoints

      *   information necessary to establish secure communication
          between the Metadata Signaling protocol endpoints.

R24   The CDNI Control protocol Should allow bootstrapping of the
      Content Acquisition protocol. This could, for example, include
      exchange and negotiation of the Content Acquisition protocols to
      be used across the CDNs (e.g. HTTP, HTTPS, FTP, ATIS C2).

R25   The CDNI Control protocol Should allow exchange and negotiation
      of delivery authorization mechanisms to be supported across the
      CDNs (e.g. URI signature based validation).

R26   The CDNI Control protocol Should allow bootstrapping of the CDNI
      Logging protocol. This information could, for example, include:

      *   discovery of the Logging protocol endpoints

      *   information necessary to establish secure communication
          between the Logging protocol endpoints

      *   negotiation/definition of the log file format and set of
          fields to be exported through the Logging protocol, with
          some granularity (e.g. On a per content type basis).

        *   negotiation/definition of parameters related to transaction
            Logs export (e.g., export protocol, file compression, export
            frequency, directory).

5. **CDNI Request Routing Protocol Requirements**

5.1. **Within Initial CDNI Scope**

   The main function of the Request Routing protocol is to allow the
   Request-Routing systems in interconnected CDNs to communicate to
   facilitate redirection of the request across CDNs.

   R27   The CDNI Control protocol Must allow the Downstream CDN to
         communicate to the Upstream CDN coarse information about the
         Downstream CDN ability and/or willingness to handle requests
         from the Upstream CDN. For example, this could potentially
         include a binary signal ("Downstream CDN ready/not-ready to take
         additional requests from Upstream CDN") to be used in case of
         excessive load or failure condition in the Downstream CDN.

   R28   The CDNI Request-Routing protocol Should allow the Downstream
         CDN to communicate to the Upstream CDN aggregate information to
         facilitate CDN selection during request routing, such as
         Downstream CDN capabilities, resources and affinities (i.e.
         Preferences or cost). This information could, for example,
         include:

         *   supported content types and delivery protocols

         *   footprint (e.g. layer-3 coverage)

         *   a set of metrics/attributes (e.g. Streaming bandwidth,
             storage resources, distribution and delivery priority)

         *   a set of affinities (e.g. Preferences, indication of
             distribution/delivery fees)

         *   information to facilitate request redirection (e.g.
             Reachability information of Downstream CDN Request Routing
             system).

         [Note: Some of this information - such as supported content
         types and delivery protocols- may also potentially be taken into
         account by the distribution system in the Upstream CDN for pre-
         positioning of content and/or metadata in the Downstream CDN in
         case of pre-positioned content acquisition and/or pre-positioned
         CDNI metadata acquisition.]

R29 If cascaded redirection is supported by the CDNI solution, the
     CDNI Request-Routing protocol Must allow the Downstream CDN to
     also include in the information communicated to the Upstream
     CDN, information on the capabilities, resources and affinities
     of CDNs to which the Downstream CDN may (in turn) redirect
     requests received by the Upstream CDN. In that case, the CDNI
     Request-Routing protocol Must prevent looping of such
     information exchange.

R30 The CDNI Control protocol May allow the Downstream CDN to
     communicate to the Upstream CDN aggregate information on CDNI
     administrative limits and policy. This information can be taken
     into account by the Upstream CDN Request Routing system in its
     CDN Selection decisions. This information could, for example,
     include:

     *   maximum number of requests redirected by the Upstream CDN to
          be served simultaneously by the Downstream CDN

     *   maximum aggregate volume of content (e.g. in Terabytes) to
          be delivered by the Downstream CDN over a time period.

R31 The CDNI Request-Routing architecture and protocol Must support
     efficient request-routing for small objects. This may, for
     example, call for a mode of operation (e.g. DNS-based request
     routing) where freshness and accuracy of CDN/Surrogate selection
     can be traded-off against reduced request-routing load (e.g.
     Via lighter-weight queries and caching of request-routing
     decisions).

R32 The CDNI Request-Routing architecture and protocol Must support
     efficient request-routing for large objects. This may, for
     example, call for a mode of operation (e.g. HTTP-based request
     routing) where freshness and accuracy of CDN/Surrogate selection
     justifies a per-request decision and a per-request CDNI Request-
     Routing protocol call.

R33 The CDNI Request-Routing architecture Must support recursive
     CDNI request routing.

R34 The CDNI Request-Routing architecture Must support iterative
     CDNI request routing.

R35 In case of detection of a request redirection loop, the CDNI
     Request-Routing loop prevention mechanism Should allow routing
     of the request (as opposed to the request loop being simply
     interrupted without routing the request).

R36   The CDNI Request-Routing protocol Should support an optional
      mechanism allowing enforcment of a limit on the number of
      successive CDN redirections for a given request.

R37   The CDNI Request-Routing protocol May support an optional
      mechanism allowing an upstream CDN to avoid redirecting a
      request to a downstream CDN if that is likely to result in the
      total redirection time exceeding some limit.

R38   The CDNI Request-Routing protocol Must allow the Upstream CDN to
      include, in the query to the Downstream CDN, the necessary
      information to allow the Downstream CDN to process the
      redirection query. This could, for example, include:

      *   information from which the location of the user-agent that
           originated the request can be inferred (e.g. User Agent
           fully qualified domain name in case of HTTP-based Request
           Routing, DNS Proxy fully qualified domain name in case of
           DNS-based Request Routing)

      *   requested resource information (e.g. Resource URI in case
           of HTTP-based Request Routing, Resource hostname in case of
           DNS-based Request Routing)

      *   additional available request information (e.g. request
           headers in case of HTTP-based Request Routing).

R39   The CDNI Request-Routing protocol May also allow the Upstream
      CDN to convey information pointing to CDNI metadata applicable
      (individually or through inheritance) to the requested content.
      For illustration, the CDNI metadata pointed to could potentially
      include metadata that is applicable to any content, metadata
      that is applicable to a content collection (to which the
      requested content belongs) and/or metadata that is applicable
      individually to the requested content.

R40   The CDNI Request-Routing protocol Must allow the Downstream CDN
      to include the following information in the response to the
      Upstream CDN:

      *   status code, in particular indicating acceptance or
           rejection of request (e.g. Because the Downstream CDN is
           unwilling or unable to serve the request). In case of
           rejection, an error code is also to be provided, which
           allows the Upstream CDN to react appropriately (e.g. Select
           another Downstream CDN, or serve the request itself)

*   redirection information (e.g. Resource URI in case of HTTP-
     based Request Routing, equivalent of a DNS record in case of
     DNS-based Request Routing).

5.2. Beyond Initial CDNI Scope

R41 The CDNI Request-Routing protocol Must allow the Downstream CDN
     to communicate to the Upstream CDN aggregate information to
     facilitate CDN selection during request routing, such as
     Downstream CDN capabilities, resources and affinities (i.e.
     Preferences or cost). This information could, for example,
     include:

     *   supported content types and delivery protocols

     *   footprint (e.g. layer-3 coverage)

     *   a set of metrics/attributes (e.g. Streaming bandwidth,
          storage resources, distribution and delivery priority)

     *   a set of affinities (e.g. Preferences, indication of
          distribution/delivery fees)

     *   information to facilitate request redirection (e.g.
          Reachability information of Downstream CDN Request Routing
          system).

     [Note: this "Must" requirement appeared as a "Should"
     requirement in Section 5.1]

R42 The CDNI Request-Routing protocol Must allow the Downstream CDN
     to also include in the information communicated to the Upstream
     CDN, information on the capabilities, resources and affinities
     of CDNs to which the Downstream CDN may (in turn) redirect
     requests received by the Upstream CDN. The CDNI Control
     protocol Must prevent looping of such information exchange.
     [Note: this "Must" requirement appeared as a conditional "Must"
     requirement in Section 5.1]

R43 The CDNI Request-Routing protocol Should allow the Downstream
     CDN to communicate to the Upstream CDN aggregate information on
     CDNI administrative limits and policy. This information can be
     taken into account by the Upstream CDN Request Routing system in
     its CDN Selection decisions. This information could, for
     example, include:

     *   maximum number of requests redirected by the Upstream CDN
          that to be served simultaneously by the Downstream CDN

      *   maximum aggregate volume of content (e.g. in Terabytes) to
          be delivered by the Downstream CDN over a time period

      [Note: this "Should" requirement appeared as a "May" requirement
      in Section 5.1]

   R44 The CDNI Request-Routing loop prevention mechanism Must allow
        routing of the request (as opposed to the request loop being
        simply interrupted without routing the request). [Note: this
        "Must" requirement appeared as a "Should" requirement in
        Section 5.1]

   R45 The CDNI Request-Routing protocol Must support optional
        enforcement of a limit on the number of successive CDN
        redirections for a given request. [Note: this "Must"
        requirement appeared as a "Should" requirement in Section 5.1]

6. CDNI Metadata Distribution Protocol Requirements

   The primary function of the CDNI Metadata Distribution protocol is to
   allow the Distribution system in interconnected CDNs to communicate
   to ensure Content Distribution Metadata with inter-CDN scope can be
   exchanged across CDNs. We observe that while the CDNI Metadata
   Distribution protocol is currently discussed as a single "protocol",
   further analysis will determine whether the corresponding
   requirements are to be realized over a single interface and protocol,
   or over multiple interfaces and protocols. For example, a subset of
   the CDNI metadata might be conveyed in-band along with the actual
   content acquisition across CDNs (e.g. content MD5 in HTTP header)
   while another subset might require an out-of-band interface &
   protocol (e.g. geo-blocking information).

6.1. Within Initial CDNI Scope

   R46 The CDNI Metadata Distribution protocol Must allow the Upstream
        CDN to provide the Downstream CDN with content distribution
        metadata of inter-CDN scope.

   R47 The CDNI Metadata Distribution protocol Must support exchange of
        CDNI metadata for both the dynamic content acquisition model and
        the pre-positioning content acquisition model.

   R48 The CDNI Metadata Distribution protocol Must/Should/May? support
        a mode where no, or a subset of, the Metadata is initially
        communicated to the Downstream CDN along with information about
        how/where to acquire the rest of the CDNI Metadata (i.e.
        Dynamic CDNI metadata acquisition).

R49 The CDNI Metadata Distribution protocol Must/Should/May? support
     a mode where all the relevant Metadata is initially communicated
     to the Downstream CDN (i.e. Pre-positioned CDNI metadata
     acquisition).

R50 Whether in the pre-positioned content acquisition model or in
     the dynamic content acquisition model, the CDNI Metadata
     Distribution protocol Must provide the necessary information to
     allow the Downstream CDN to acquire the content from an upstream
     source (e.g. Acquisition protocol and Uniform Resource
     Identifier in Upstream CDN- or rules to construct this URI).

R51 The CDNI metadata Must allow signaling of one or more upstream
     sources, where each upstream source can be in the Upstream CDN,
     in another CDN, the CSP origin server or any arbitrary source
     designated by the Upstream CDN. Note that some upstream sources
     (e.g. the content origin server) may or may not be willing to
     serve the content to the Downstream CDN, if this policy is known
     to the upstream CDN then it may omit those sources when
     exchanging CDNI metadata.

R52 The CDNI Metadata Distribution protocol Must allow the Upstream
     CDN to request addition and modification of CDNI Metadata into
     the Downstream CDN.

R53 The CDNI Metadata Distribution protocol Must allow removal of
     obsolete CDNI Metadata from the Downstream CDN (this could, for
     example, be achieved via an explicit removal request from the
     Upstream CDN or via expiration of a Time-To-Live associated to
     the Metadata).

R54 The CDNI Metadata Distribution protocol Must allow association
     of CDNI Metadata at the granularity of individual object. This
     is necessary to achieve fine-grain Metadata distribution at the
     level of an individual object when necessary.

R55 The CDNI Metadata Distribution protocol Must allow association
     of CDNI Metadata at the granularity of an object set. This is
     necessary to achieve scalable distribution of metadata when a
     large number of objects share the same distribution policy.

R56 The CDNI Metadata Distribution protocol Must support multiple
     levels of inheritance with precedence to more specific metadata.
     For example, the CDNI Metadata Distribution protocol may support
     metadata that is applicable to any content, metadata that is
     applicable to a content collection and metadata that is
     applicable to an individual content where content level metadata
     overrides content collection metadata that overrides metadata

for any content.

   R57   The CDNI Metadata Distribution protocol Must ensure that
         conflicting metadata with overlapping scope are prevented or
         deterministically handled.

   R58   The CDNI Metadata Distribution protocol Must provide indication
         by the Downstream CDN to the Upstream CDN of whether the CDNI
         metadata (and corresponding future request redirections) is
         accepted or rejected. When rejected, the CDNI Metadata
         Distribution protocol Must allow the Downstream CDN to provide
         information about the cause of the rejection.

   R59   The CDNI Metadata Distribution protocol Must allow signaling of
         content distribution control policies. For example, this could
         potentially include:

         *   geo-blocking information (i.e. Information defining
             geographical areas where the content is to be made available
             or blocked)

         *   availability windows (i.e. Information defining time
             windows during which the content is to be made available or
             blocked)

         *   delegation whitelist/blacklist (i.e. Information defining
             which downstream CDNs the content may/may not be delivered
             through)

   R60   The CDNI Metadata Distribution protocol Must allow signaling of
         authorization checks and validation that are to be performed by
         the surrogate before delivery. For example, this could
         potentially include:

         *   need to validate URI signed information (e.g. Expiry time,
             Client IP address).

6.2. Beyond Initial CDNI Scope

   R61   The CDNI Metadata Distribution protocol Must support a mode
         where no, or a subset of, the Metadata is initially communicated
         to the Downstream CDN along with information about how/where to
         acquire the rest of the CDNI Metadata (i.e. Dynamic CDNI
         metadata acquisition). [Note: this "Must" requirement appeared
         as a "Must/Should/May?" requirement in Section 6.1]

   R62 The CDNI Metadata Distribution protocol Must support a mode
        where all the relevant Metadata is initially communicated to the
        Downstream CDN (i.e.Pre-positioned CDNI metadata acquisition).
        [Note: this "Must" requirement appeared as a "Must/Should/May?"
        requirement in Section 6.1]

   R63 The CDNI Metadata Distribution protocol Must allow signaling of
        CDNI-relevant surrogate cache behavior parameters. For example,
        this could potentially include:

        *   control of whether the query string of HTTP URI is to be
             ignored by surrogate cache

        *   content revalidation parameters (e.g. TTL)

7. CDNI Logging Protocol Requirements

   This section identifies the requirements related to the CDNI Logging
   protocol. We observe that while the CDNI Logging protocol is
   currently discussed as a single "protocol", further analysis will
   determine whether the corresponding requirements are to be realized
   over a single interface and protocol, or over multiple interfaces and
   protocols.

7.1. Within Initial CDNI Scope

   R64 The CDNI logging architecture and protocol Must ensure reliable
        logging of CDNI events.

   R65 The CDNI Logging protocol Must provide logging of deliveries to
        User Agents performed by the Downstream CDN as a result of
        request redirection by the Upstream CDN.

   R66 If cascaded CDNs are supported, the CDNI logging protocol Must
        allow the Downstream CDN to report to the Upstream CDN logging
        for deliveries performed by the Downstream CDN itself as well as
        logging for deliveries performed by cascaded CDNs on behalf of
        the Downstream CDN.

   R67 The CDNI Logging protocol Must provide logging of distribution
        performed by the Upstream CDN as a result of acquisition request
        by the Downstream CDN.

   R68 The CDNI Logging protocol Must support batch/offline exchange of
        logging records.

   R69 The CDNI Logging protocol Should also support additional timing
        constraints for some types of logging records (e.g. near-real
        time for monitoring and analytics applications)

   R70 The CDNI Logging protocol Must define a log file format and a
        set of fields to be exported through the Logging protocol, with
        some granularity (e.g. On a per content type basis).

   R71 The CDNI Logging protocol Must define a transport mechanisms to
        exchange CDNI Logging files.

   [Editor's note: should we add a requirement for support of aggregate/
   summarized logs (e.g. total bytes delivered for a content regardless
   of individual USer Agents to which it was delivered)]

7.2. Beyond Initial CDNI Scope

   R72 The CDNI logging protocol Must allow the Downstream CDN to
        report to the Upstream CDN logging for deliveries performed by
        the Downstream CDN itself as well as logging for deliveries
        performed by cascaded CDNs on behalf of the Downstream CDN.
        [Note: this "Must" requirement appeared as a conditional "Must"
        requirement in Section 7.1]

   R73 The CDNI Logging protocol Must support real-time exchange of
        some types of logging records (e.g. For real-time monitoring of
        deliveries across CDNs). [Note: this "Must" requirement
        appeared as a "Should" requirement in Section 7.1]

   R74 The CDNI Logging protocol Must allow a CDN to query another CDN
        for relevant current logging records (e.g. For on-demand access
        to real-time logging information).

8. CDNI Security Requirements

   This section identifies the requirements related to the CDNI
   security. Some of those are expected to affect multiple or all
   protocols.

8.1. Within Initial CDNI Scope

   R75 All the CDNI protocols Must support secure operation over
        unsecured IP connectivity (e.g. The Internet). This includes
        authentication, confidentiality, integrity protection as well as
        protection against spoofing and replay.

R76   The CDNI solution Must provide sufficient protection against
      Denial of Service attacks. This includes protection against
      spoofed delivery requests sent by user agents directly to a
      Downstream CDN attempting to appear as if they had been
      redirected by a given Upstream CDN when they have not.

R77   The CDNI solution Should be able to ensure that for any given
      request redirected to a Downstream CDN, the chain of CDN
      Delegation (leading to that request being served by that CDN)
      can be established with non-repudiation.

R78   The CDNI solution Should be able to ensure that the Downstream
      CDN cannot spoof a transaction log attempting to appear as if it
      corresponds to a request redirected by a given Upstream CDN when
      that request has not been redirected by this Upstream CDN. This
      ensures non-repudiation by the Upstream CDN of transaction logs
      generated by the Downstream CDN for deliveries performed by the
      Downstream CDN on behalf of the Upstream CDN.

R79   The CDNI solution May provide a mechanism allowing an Upstream
      CDN that has credentials to acquire content from the CSP origin
      server (or another CDN), to allow establishment of credentials
      authorizing the Downstream CDN to acquire the content from the
      CSP origin server (or the other CDN) (e.g. In case the content
      cannot be acquired from the Upstream CDN).

8.2. Beyond Initial CDNI Scope

R80   The CDNI solution Must provide a mechanism allowing an Upstream
      CDN that has credentials to acquire content from the CSP origin
      server (or another CDN), to allow establishment of credentials
      authorizing the Downstream CDN to acquire the content from the
      CSP origin server (or the other CDN) (e.g. In case the content
      cannot be acquired from the Upstream CDN). [Note: this "Must"
      requirement appeared as a "May" requirement in Section 8.1]

9. IANA Considerations

   This document makes no request of IANA.

   Note to RFC Editor: this section may be removed on publication as an
   RFC.

10. Security Considerations

   This document discusses CDNI security requirements in Section 8.

11. Acknowledgements

This document leverages the earlier work of the IETF CDI working group in particular as documented in [I-D.cain-request-routing-req], [I-D.amini-cdi-distribution-reqs] and [I-D.gilletti-cdnp-aaa-reqs].

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