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**Distribution Requirements for Content Internetworking**  
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Abstract

This document specifies requirements for interconnecting, or peering, the distribution systems of Content Networks (CN). Distribution internetworking requires advertising the capabilities of a CN offering distribution services, moving content from one CN to another, and signaling requirements for consistent storage and delivery of content. This document does not address requirements for directing user agents to distributed content, nor for aggregating access information for distributed content.



## **1. Introduction**

Content Internetworking (CI) assumes an architecture wherein the resources of multiple CNs are combined so as to achieve a larger scale or reach than any of the component CNs could individually [3]. A Content Distribution Network (CDN) is an example of a CN.

At the core of CI are three principal architectural elements. These elements are Request Routing, the Distribution and the Accounting. The focus of this document, the Internetworking Distribution Systems, is responsible for moving content from one Distribution CN to another Distribution CN. Note that the original content provider is considered a degenerate case of a Distribution CN.

In any Distribution Internetworking arrangement, the relationships between Distribution CNs can always be decomposed into one or more pairs of CNs. Each CN pair comprises one CN which has, or has access to, content, and another CN which has, or has access to, systems capable of providing distribution and/or delivery functions for content. The former CN is referred to as the Content Source, while the latter is referred to as the Content Destination.

This document describes the overall architectural structure and building blocks of the internetworked Distribution Systems. It also defines the protocol requirements for interconnecting two or more Distribution CNs via their respective Content Internetworking Gateways (CIG). Specifically, it defines the requirements for:

Distribution Advertising: announcing the distribution capabilities of a Content Destination to potential Content Sources.

Content Signaling: communicating content meta-data to enable consistent storage and delivery of content to user agents.

Content Replication: moving content from a Content Source to a Content Destination.

Although this document does not specifically address requirements for communicating within a CN, it is plausible that protocols developed to meet inter-CN requirements may also be well-suited for intra-CN communications.

Requirements for the remaining CI architectural elements, the Request Routing System, which is responsible for directing user agents to the distributed content, and the Accounting System, which is responsible for aggregating information related to the access of distributed content, are detailed in [6], [7].



## **1.1 Conventions used in this document**

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 [RFC-2119](#) [2].

All other terms in ALL CAPS, except those qualified with explicit citations, are defined in [8].

## **1.2 Change Log**

1. Fixed terminology to comply with updated Models doc.
2. Intro: fixed reach or scale so not synonyms
3. [Section 1](#): clarified definition for Content Signaling
4. [Section 2](#): clarified that fig 1 is a logical view, need not have this strictly hierarchical relationship.
5. [Section 2.1-2.2](#): deleted these sections, feedback indicated they confused more than clarified; material is adequately covered in Models doc.
6. [Section 3](#): change Use-initiated to surrogate initiated.
7. [Section 3](#) (para 2): cig is not necessarily a box, could be functionality (protocol conformance) implemented in multiple boxes.
8. [Section 4.1](#): clarified content signalling example.
9. [Section 4.3](#): clarified common base replication vs. content type specific replication
10. [Section 4.4](#): fixed "extensible model..." wording
11. [Section 5.1](#): clarified that content pull for delivery services preparation is optional.
12. [Section 5.3](#) 3-4: modified, added request for feedback
13. [Section 5.3.5](#): clarified advertisements as optional
14. [Section 5.4](#): dropped requirement for sending data with content signal.
15. [Section 5.4](#) 6: dropped part about source encryption -- if the object is encrypted at source and not decrypted until it



reaches the client, then it is just a (downloadable) blob as far as the dist system is concerned.

16. [Section 5.5](#) 8: dropped subscription fee and next hop.
17. [Section 5.5](#) 8: changed content id to content set id.
18. [Section 5.5](#): added information on relationship to WEBI/RUP.

## 2. Distribution System Overview

In Distribution System Internetworking, even the most complex communication arrangements can be expressed in terms of simple interactions between a Content Source and a Content Destination. Figure 1, for example, shows a relationship between four different administrative authorities. CN A operates a network of SURROGATES, and "CN D" (actually the original content provider, or ORIGIN) has content to be distributed. CN A communicates with CN B, which communicates with CN C, which, in turn, communicates with CN D.

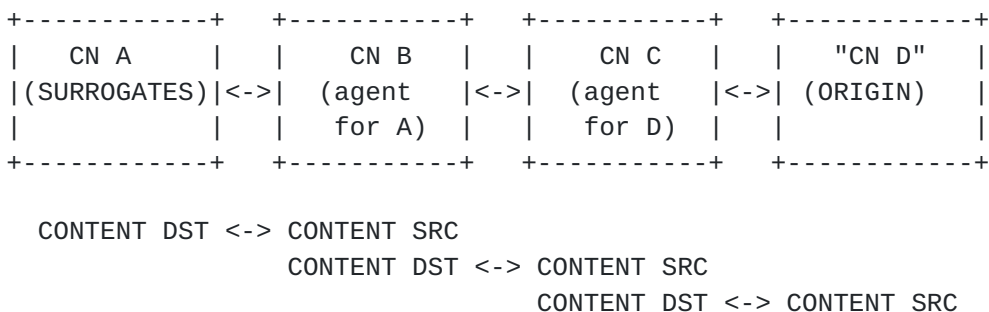


Figure 1: Distribution System Interworking

In each case, one of the parties in the communications has the role of Content Destination, while the other party is the Content Source. Note that a particular CN's role may change, depending on the party with whom it is communicating. CN B, for example, is a Content Source when communicating with CN A, but a Content Destination when communicating with CN C.

Note that a Content Destination which peers directly with the Content ORIGIN, will interface with the ORIGIN just as it interfaces with any other Content Source.

Although Figure 1 provides an example of multiple CNs peered in series, a Distribution CN may serve as the Content Source for multiple Content Destinations. Likewise, a Distribution CN may serve as the Content Destination for multiple Content Sources.

Additionally, it is possible for the internetworking relationship between a single Source-Destination pair to be reciprocal for different content sets. That is, CN A may request distribution services from CN B for Content Set A, while CN B requests distribution services from CN A for Content Set B.

Further, note that Figure 1 is a logical view of the internetworking relationship between several Content Source-Destination pairs; actual communications are not restricted to this pair-wise





hierarchy. For example, CDN D may specify a single authoritative distribution channel from which any distributing CN must retrieve the CONTENT.

### 3. Replication Models

Replication of content may take place using a push model, or a pull model, or a combination of both.

- o SURROGATE-initiated replication of CONTENT, where a SURROGATE retrieves CONTENT based on a cache miss or on a prefetching policy specified at the SURROGATE, represents the pull model. This is the model currently used by caching proxies.
- o ORIGIN-initiated replication of CONTENT to SURROGATES represents the push model. This model is used to preposition CONTENT in anticipation of demand.

Replication, when between the administrative domains of different Distribution CNs must adhere to the CI protocol for content replication. Replication within a single Distribution CN is an intra-CN communication and therefore, need not adhere to CI protocols. Further, the replication model used within a single Distribution CN need not be the same as the model used to replicate CONTENT between CNs.

For both ORIGIN- and SURROGATE- initiated replication, the Content Source may use replication mechanisms beyond a simple transfer. For example, it may be desirable to have the Content Destination join a multicast channel on which a set of content is pushed to all SURROGATES.

Another example is for CONTINUOUS MEDIA. In the case of live broadcasts, the data need not be cached on the SURROGATES. Instead, replication takes the form of "splitting" the live stream at various points in the network. Splitting is also referred to as application layer multicast.

Replication of CONTINUOUS MEDIA streams which are not live, and therefore may be stored on SURROGATES, also benefits from mechanisms beyond in-line replication. For example, CONTINUOUS MEDIA is often delivered to CLIENTS over an unreliable channel. However, a CN distributing this content to many CLIENTS should work with a full replica. Existing proprietary replication protocols enable distribution of CONTINUOUS MEDIA objects in which a full or partial replica can be propagated, the data may be encrypted and/or authenticated, and the SURROGATE can support CONTINUOUS MEDIA-related services such as random access and stream insertion/splicing.

It may be desirable to replicate content to a Distribution CN which has no internal SURROGATES. For example, a Distribution CN may have servers at key exchange points within the network which only serve



content to other distribution systems, and peer with other CNS which provide SURROGATES which deliver content to CLIENTS.

#### **4. Distribution Internetworking Requirements**

This section details general requirements for exchange of inter-domain distribution information.

##### **4.1 General Requirements**

The goal of the Distribution Internetworking is to interconnect the Distribution Systems of multiple CNs. The intent of this interconnection is to effectively position content for fast, reliable access by CLIENTs. Generally this is accomplished by replicating content on SURROGATES. While the communications path from ORIGIN to CLIENTs may traverse a number of links, some within a Distribution CN and some between Distribution CNs, Distribution Internetworking is concerned only with those communications between Distribution CNs.

The three main components of Distribution Internetworking are advertising, replication, and signaling.

Advertising: Distribution CNs MAY advertise their capabilities to potential Content Source CNs.

Replication: Distribution CNs MUST be able to move content from a Content Source to a Content Destination.

Content signaling: Distribution CNs MUST be able to propagate content meta-data. This meta-data includes information such as the immediate invalidation of content or a change in the source or distribution method of content.

Note that these requirements do not necessarily translate directly into three distinct Distribution Internetworking protocols.

##### **4.2 Advertising Requirements**

The following list specifies requirements to enable advertising of distribution capabilities.

1. A common protocol for the Advertisement of distribution capabilities.
2. A common format for the actual distribution capabilities Advertisements in the protocol.
3. Security mechanisms.



### **4.3 Replication Requirements**

The following list specifies requirements to enable content replication.

1. A common base protocol for the replication of content.
2. This common base protocol should specify:
  - \* a common format for the actual content data in the protocol.
  - \* A common format for the content meta-data in the protocol.
3. Alternate content-specific protocols for the replication of content should be enabled. The replication protocol for a particular content set is specified via content signaling.
4. Scalable distribution of the content.
5. Security mechanisms.

### **4.4 Content Signaling Requirements**

The following list specifies requirements to enable content signaling.

1. A common protocol for signaling content meta-data.
2. An extensible format for communicating content metadata. Minimally, support is required for "add," "withdraw," and "expiration time update."
3. Scalable distribution of signals on a scale to enable Internet-wide peering.
4. Security mechanisms.





## **5. Distribution Internetworking Protocol Requirements**

This section defines protocol requirements for each of the advertising, replication and content signaling components of Distribution Internetworking. Note that these requirements do not necessarily translate directly into either one converged or three distinct Distribution Internetworking protocols.

### **5.1 Overview of Distribution Internetworking Flow**

In a Distribution Internetworking arrangement, the following sequence of events is expected:

1. A Content Source may receive distribution capabilities advertisements from one or more Content Destinations. A Content Source may or may not require receipt of distribution capabilities advertisements prior to requesting services. For example, a Content Source may request services based on a contractual agreement negotiated off-line.
2. The Content Source will make a decision to request content distribution services from a Content Destination.
3. The Content Source will send a content signal requesting distribution services.
4. The Content Destination will accept or reject the request; no partial acceptance or negotiation is defined.
  - \* If the request is rejected, the error code SHOULD provide enough information for the Content Source to determine if it should send a request with modified service requirements.
  - \* If the request is accepted, the Content Destination will prepare for distribution services. Generally, this preparation will entail:
    - + optionally retrieving a copy of the object(s),
    - + joining the content update channel (if any), and
    - + preparing to provide access information to the Accounting System
  - \* Each of the above steps are according to the Content Source's specification, and to the Content Destination's policies and configuration.
5. Once the Content Destination is prepared, it will notify the



Request Routing System of the content's availability.

6. The Content Destination will terminate service on first occurrence of either:
  - \* the time frame specified in the Content Source's request for distribution services expires or
  - \* a content signal requesting withdrawal of the content is received.

## **5.2 General Distribution Internetworking Protocol Requirements**

Protocols must be scalable, i.e., support Distribution Internetworking on an Internet-wide scale.

Protocols must prevent looping of advertisements, replication and content signaling.

Protocols must support the ability to optionally conduct authenticated and/or encrypted exchanges.

Protocols must support the ability to optionally exchange credentials.

## **5.3 Advertising Protocol Requirements**

1. Distribution Internetworking protocols MUST enable a Content Destination to advertise the capabilities of its distribution service in a common format. This common format for distribution service capabilities will be referred to as a Service Profile for the remainder of this draft.
2. The advertisement protocol must be extensible with the restriction that implementation-specific capabilities may be safely ignored by Content Source.
3. Distribution Internetworking protocols MUST provide low-overhead, mechanism to notify in-line elements (e.g., proxies) of CI support.
4. [ Editor's Note: prev item can be as simple as having the Content Source include a reference to its CIG so that inline systems could contact the CIG and establish an internetworking arrangement. But the feedback has been lukewarm to bad -- drop? ]
5. Distribution Advertising by a Content Destination must be optional. That is, a Content Source may not require real-time



advertisement of distribution capabilities in order to establish a Distribution Internetworking arrangement. Distribution capabilities may be communicated via Advertisements or some other agreed upon mechanism such as an off-line contract negotiated between the parties.

6. Advertised capabilities are those available to the peer, potentially based on some off-line contractual agreement, and may not necessarily reflect the total capacity of the Content Destination.
7. The protocol MUST enable a Content Destination to advertise multiple service profiles. Each service profile MUST be specifiable by a profile identifier. The profile identifier MAY encode Content Source or Content Destination specific information, but it has local significance only (i.e., it is strictly between the Content Source and Content Destination).
8. The protocol MUST enable a Content Destination to advertise multiple services profiles to the same or different potential Content Sources.
9. A Content Destination with regional capabilities SHOULD advertise capabilities on a per region basis. A Content Destination which advertises regional capabilities MUST minimally be able to identify regions by network addresses/prefixes.
10. By default, advertisements are advisory. A Content Destination SHOULD be able to specify whether the capabilities are advisory or binding.
11. The protocol MUST provide the ability to specify distribution capabilities in terms of one or more of the following attributes:

Profile ID: Identifier for the service profile being advertised. The profile identifier is to be used by the Content Source when requesting service. This attribute is required for all advertisements. The value need not be unique across Distribution CNs, and may be used in advertisements to multiple Content Sources.

FootPrint: The areas served by the CN. Minimally, a Content Destination should support expressing footprint according to IP network addresses/prefixes.

Content Type: The type of content (e.g. static Web pages, streaming media, etc.) that the CN is able to distribute.



Capacity: The storage capacity that the CN can provide.

Bandwidth: Maximum outbound bandwidth available from the CN.

Object Bandwidth: Maximum outbound bandwidth supported for a single object.

Distribution Method: The distribution methods that the CN supports; one or more of push, pull, and alm. "alm" refers to application layer multicast, or splitting, of CONTINUOUS MEDIA; if specified, supported protocols must also be specified.

[ Editor's Note: Specifying support for splitting requires refinement. ]

Request Routing Type: Type(s) of request routing supported for CI Request Routing Systems.

Accounting System Format: Supported protocol(s) and format(s) for sending accounting and access feedback to a specified CI Accounting System.

Time Frame: Time frame for which this advertisement is valid.

Client Protocols: Indicates the client protocols supported. Currently only HTTP and RTSP are valid. However, this field must be further qualified than just the transport or signalling protocol. The protocol must clearly define a level of support implicated by a given Client Protocol value.

Distribution Fee: Indicates the fee charged for distribution services. The value may be expressed in Mbps (megabits/second) or in MB (megabytes of storage).

Advertisement Type: Indicates whether the advertisement is advisory or binding. By default, all advertisements are advisory.

Private Extensions: Additional metrics that the communicating parties may agree to use, but are not part of the IETF standard. Extensions must be defined such that if not understood by the Content Source, they can be safely ignored.





### **5.3.1 Advertising Examples**

To be provided.

## **5.4 Replication Protocol Requirements**

1. A common (base) replication protocol MUST be defined which is supported by all CIGs, for any content type which can be used to transport meta-data and a full replica of content data.
2. Replication MUST support the ability for a Content Source to specify a replication channel from which content may be retrieved.
  1. [ Editors Note: I am using channel as a generic term which would provide a contact point and protocol, and any additional info required to establish a connection. E.g. wcips://invalidation.com/content\_set for signaling; will provide clarification later ]
3. Replication MUST enable specifying optionally supported, alternative replication protocols which may be better suited than the common base protocol for specific content types or configuration scenarios.
4. A Content Source SHOULD be able to specify an authoritative source for content as well as distribution points.
5. The protocol MUST enable replication that is secured (encrypted) across the communications channel.

### **5.4.1 Replication Examples**

To be provided.

## **5.5 Content Signaling Protocol Requirements**

1. A Content Source MUST be able to request distribution services for one or more content objects.
2. A Content Destination MUST explicitly accept or reject a request for distribution services.
3. A Content Source MUST be able to withdraw (cancel) a request for content services for one or multiple content objects.
4. Rejected requests for distribution services MUST include error codes. Partial rejections or negotiations are not supported. A Content Source may follow a rejection with a request for



distribution services under alternate service requirements.

5. A Content Source MUST be able to signal consistency meta-data. Minimally, Content Sources SHOULD support weak consistency mechanisms. Content Sources MAY support mechanisms for strong consistency.
6. Content signaling SHOULD include mechanisms to aggregate content information.
7. Content Signaling SHOULD be decoupled from the content ORIGIN. I.e., a Content Source should be able to specify a content signaling channel.
8. The following attributes are defined for content signals:

Content Set ID: A unique identifier for this specific content set, so that future references (e.g. to modify the content or to withdraw it from distribution) may be resolved. This value can also be used to avoid loops. The Content Set ID MUST be global and unique, i.e., a given content set MUST have the same ID across all Distribution Systems, and this ID MUST be unique across *\*all\** Distribution Systems.

URI: The uniform resource identifier for the content. It identifies how CLIENTS will request delivery services from the Distribution CN. This attribute can support an atomic unit of content or it can be used to generally specify a URI path. For pull distribution, a URI path serves as pattern (e.g. `http://origin/images/*`) to qualify which content should receive the specified service. For push distribution, only URIs which identify an atomic unit of content may be used.

[Ed: The editor would prefer further discussion on whether this attribute must uniquely identify an atomic unit of content or whether it can more generally specify a URI path. Allowing paths may significantly reduce the size of any protocol transfers, but, there are some attributes (e.g. size, content type) that do not apply as cleanly to paths, and some distribution methods (e.g. pull) cannot be easily accommodate paths.]

Authoritative Source: Identifies the channel where the authoritative copy of the content may be retrieved. In the case of live CONTINUOUS MEDIA, this channel may represent where the Content Destination may retrieve meta-data required to provide application layer multicasting services.

Distribution Method: Push, pull, on-demand, alm or withdraw.



Specifies how the Content Destination should retrieve the content. Withdraw is a special case that indicates a Content Destination should cease distribution of previously accepted content.

Service Profile ID: Identifies the service profile to be associated with this request. The Service Profile ID may have been provided by a Content Destination advertisement or some other means (e.g. contractual agreement negotiated off-line). The identifier MAY encode Content Source or Content Destination specific information, but it has local significance only (i.e., it is strictly between the Content Source and Content Destination).

Size: Size of the content.

Time Frame: The period of time for which the Content Source requests distribution.

Request Routing Type: Type of Request Routing requested for this content. Depending on the Request Routing type, an RRS channel may also be supplied.

[ Editor's Note: Request Routing Types to be defined according to [\[6\]](#). ]

Accounting Format: Format for sending accounting and access feedback.

Accounting Type: Accounting/access feedback type desired. Depending on the type requested, an Accounting channel may also be supplied. The information conveyed with this attribute should also indicate whether the Content Destination is required to provide this feedback.

[ Editor's Note: Accounting Formats and Types to be defined according to [\[7\]](#). ]

Distribution Authority: Indicates whether the Content Destination can serve as the Authoritative Source for this content set or if the Authoritative Source attribute must be treated as a global attribute. By default, the Content Destination can serve as Authoritative Source to Content Destinations for which it is the Content Source.

Mirrors: Alternate channels for retrieving the content.

Update Channel: Alternate channels for receiving consistency signals. The information conveyed in this attribute should



also indicate whether the Content Destination is required to subscribe to this channel.

Content Data: The actual content data to be distributed; this is expected to be used for small objects only.

Expires: Indicates the date/time after which this version of the content is considered stale.

Prefetch: If content is to be prefetched, indicates the date/time when the prefetch should be requested.

9. The following table specifies the relationship between content signal types and the defined attributes.

| Attribute<br>-----     | Add<br>----- | Update<br>----- | Withdrawal<br>----- |
|------------------------|--------------|-----------------|---------------------|
| Content Set ID         | required     | required        | required            |
| URI                    | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Service Profile ID     | optional     | optional        | optional            |
| Authoritative Source   | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Distribution Method    | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Time Frame             | required     | optional        | required            |
| Request Routing Type   | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Accounting Format      | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Accounting Type        | required     | optional        |                     |
| unsupported            |              |                 |                     |
| Mirrors                | optional     | optional        |                     |
| unsupported            |              |                 |                     |
| Distribution Authority | optional     | optional        |                     |
| unsupported            |              |                 |                     |
| Update Channel         | optional     | optional        |                     |
| unsupported            |              |                 |                     |
| Content Data           | optional     | optional        |                     |
| unsupported            |              |                 |                     |
| Expires                | optional     | required        |                     |
| unsupported            |              |                 |                     |

#### **5.5.1 Resource Update Protocol (RUP) Relationship**

The IETF Web Intermediaries (WEBI) Working Group is currently



developing requirements for a Resource Update Protocol (RUP) [[10](#)]. RUP defines requirements for a protocol enabling communication about changes to content accessible from caching proxies and surrogates. Operations required by RUP include cache invalidation, content location update, content prefetch hints, removal and addition of resources to a resource group, adjustments to cache consistency parameters.

Several of the RUP defined operations coincide with the requirements listed for CI Distribution Signaling (CI-DS). The intent of this document is to specify those requirements which are specific to the

CI environment. The CI-DS requirements which would be met by a protocol designed to meet the RUP requirements are:

Both RUP and CI-DS require transport of content metadata from a single point of control (RUP Server) to a large number of surrogates (RUP clients).

In the CI-DS environment, the RUP Server and RUP Clients are expected to be in multiple administrative domains. Also, RUP Clients are likely to be CIG responsible for propagating content signals to downstream surrogates which are in the same administrative domain as the CIG. It is anticipated, but not required, the signals relayed to downstream surrogates will also conform to the protocol designed to meet RUP requirements.

The transport defined to carry content metadata must enable enforcing secrecy and authentication for payloads.

The transport must enable the point of control to specify explicit acknowledgement of messages.

The following mapping of metadata fields are anticipated:

CI-DS Content Set ID field maps to RUP Resource Groups.

CI-DS URI field maps to RUP Object ID.

CI-DS Update Channel may reference a RUP server providing cache consistency for this Content Set.

CI-DS Authoritative Source maps to a RUP Content Location.

CI-DS Expires maps to the RUP document expiration time.

CI-DS enables the ability to specify when an object should be prefetched; RUP enables the ability to specify an object should be prefetched.

In addition to the metadata fields which were defined for CI-DS, but not mapped to an RUP field, CI-DS requires the following functionality.

Ability to specifically request a Content Set be added or withdrawn from the list of objects being serviced. This requirement could be covered by adding the ability to dynamically define Resource Groups to RUP.

Specifically, a master Resource Group could be defined which would be used as the channel to communicate which Resource Groups



to be added/withdrawn from service. The CIG would then establish channels to receive cache coherency messages for these Resource Groups.

Ability to update metadata for an object. While it is possible this can be covered by withdrawal and re-add of the Content Set, due to the number and types of fields supported, inability to update would impact efficiency.

#### **5.5.2 Content Signaling Examples**

To be provided.

## References

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