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Technical Specification

**Media Content Distribution (MCD);
CDN Interconnection, use cases and requirements**

Reference

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Media Content Distribution (MCD).

Introduction

Content Delivery Networks (CDN) are a solution to efficiently deliver content Consumers, including file-based and streaming video and multimedia content. An IPTV Service Provider uses CDN technology for content delivery to its own Consumer customers, see TS 182 019 [1]. A CDN Service Provider uses CDN technology to deliver content to Consumers on behalf of a Content Provider, see TR 102 688-9 [i.2].

Annex A of the present document presents several use cases where different CDN Service Provider would collaborate and interconnect to provide a better and more efficient CDN service to their Content Provider customers. Annex C uses the metaphor of newspaper distribution where Printer Companies collaborate to achieve a better and more efficient newspaper distribution service to Newspaper Companies.

Based on those use cases, the present document specifies functional roles and CDN relationships, service requirements and technical requirements for CDN interconnection.

1 Scope

The present document specifies the (stage-1) service- and technical requirements for CDN interconnection services. The requirements are based on the use cases described in annex A of the present document.

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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2.1 Normative references

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 182 019: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Content Delivery Network (CDN) Architecture".

[2] ETSI TS 184 009: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Rules covering the use of TV URIs for the Identification of Television Channels".

2.2 Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] IETF Use Cases for Content Distribution Network Interconnection: draft-ietf-cdni-use-cases.

NOTE: Available at http://tools.ietf.org/wg/cdni/draft-ietf-cdni-use-cases/

[i.2] ETSI TR 102 688-9: "Media Content Distribution (MCD); MCD framework; Part 9: Content Delivery Infrastructures (CDI)".

[i.3] ISO/IEC 23009-1:2012 "Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

The following definitions are from TS 182 019 [1]:

content delivery: act of delivering deployed content to a user

Content Delivery Network (CDN): set of functions managing content acquired from content sources, through delivery to the user

content acquisition: act of acquiring content from a content source

content deployment: act of moving ingested content to one or more network entities, based on content deployment policies

content distribution: act of moving content in and between CDNs

CDN interconnection: interconnection between two CDNs, enabling the controlled distribution of content between those CDNs

The following definitions are from TR 102 688-9 [i.2]:

content ingestion: act of introducing content (and associated data) into the Content Delivery Infrastructure

segmented content: consisting of multiple mutually associated content files and/or - streams

NOTE: The association between the segments are typically communicated through a manifest file.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CDN   Content Delivery Network

NOTE: Industry uses sometimes "Content Distribution Network".

DRM   Digital Rights Management
FTP   File Transfer Protocol
GB   GigaByte
HAS   HTTP-based Adaptive Streaming
HTTP   HyperText Transfer Protocol
IPTV   Internet Protocol TeleVision
OIPF   Open IPTV Forum
RTP   Real-time Transport Protocol
RTCP   RTP Control Protocol
SLA   Service Level Agreement
SVC   Scalable Video Coding
URI   Uniform Resource Identifier

4 Overview of CDN interconnection services

4.1 Functional roles and CDN Relationships

For the purpose of the present document, concepts of domains, functional roles and CDN relationships are defined in this clause and are illustrated in figure 4.1.1.

Figure 4.1.1: Functional roles, domains and CDN Provider relationships for CDN interconnection

Functional roles are defined with respect to a given delivery act (i.e. the actual delivery of a given piece of content to a given user at a given time). The functional roles are described as follows:

The **Ingesting CDN provider** is the entity that ingests the content ("mastercopy") into the CDN Domain. It has a CDN interconnection with the Delivering CDN Provider (or a Transiting CDN Provider) that enables the controlled distribution of content from the ingesting CDN to the delivering CDN.

The **Delivering CDN provider** is the entity that delivers the content ("consumable") into the Consumer Domain. It has a CDN interconnection with the Ingesting CDN Provider (or a Transiting CDN Provider) that enables the controlled distribution of content from the ingesting CDN to the delivering CDN.

A **Transiting CDN provider** is an entity that distributes the content ("replica") from a CDN (that maybe the Ingesting CDN or a Transiting CDN) to another CDN (that may be the Delivering CDN or a Transiting CDN). For a given delivery act zero, one or more Transiting CDNs may be involved.

NOTE: The terms "mastercopy", "replica" and "consumable" relate to the role of the content throughout the process (see also annex C).

The **Consumer** is the entity where the content is consumed. The content is delivered through the CDN domain.

The **Content Provider** is the entity that owns or is licensed to sell content or content assets. The content is delivered to a user through the CDN Domain. The Content Provider is authoritative with respect to control of consumer access to the content (i.e. whether a given delivery request from a consumer is to be honoured by the CDN domain or not).

The present document focuses on the CDN interconnection between CDN Providers collaborating to achieve content delivery. The present document defines the following relationships between two CDN Providers participating in a given delivery act:

A CDN Provider is **Upstream** of another CDN Provider if the content is distributed from that CDN to the other CDN.

A CDN Provider is **Downstream** of another CDN Provider if the content is obtained by that CDN from the other CDN.

Because functional roles are relative to a given delivery act, in practice, a given entity may be performing more than one functional role. For example, a given administrative entity could be operating as the Ingesting CDN Provider for a given delivery act, operating as the Delivering CDN Provider for another delivery act and operating as a Transiting CDN Provider for yet another delivery act. Similarly, it could also be operating as the Content Provider or Consumer for some other delivery act. For the same reason, a CDN Provider that is Upstream of another CDN Provider for a given delivery act could be Downstream of this other CDN Provider for another delivery act, and may have no Upstream/Downstream relationship with that same other CDN Provider for yet another delivery act.

The following business- and/or technical relationships are outside the scope of the present document.

- Consumer - Content Provider: e.g. content selection and content purchase/rental

- CDN Provider - Content Provider: e.g. content ingestion

- Consumer - CDN Provider: e.g. redirection instructions and the actual content delivery

4.2 MCD CDN Interconnection services

4.2.1 General

This clause describes CDN interconnection services at a high level. It focuses on the CDN interconnection services delivered between the Upstream CDN Provider and the Downstream CDN Provider. Services to the Consumer and Content Provider are outside the scope of the present document.

4.2.2 Upstream CDN Provider CDN interconnection services

The following is a list CDN interconnection services that could be provided by the Upstream CDN Provider.

- Content acquisition and distribution services:

  - Ingest or acquire content on behalf of a Downstream CDN Provider, in association with a Content Provider or Transiting CDN

  - Distribute content to the Downstream CDN Provider, in association with a Content Provider

- Delivery Control Services:

  - Establish agreements on delivery attributes, with the Downstream CDN Provider

  - Provide real-time control over ongoing deliveries, in association with the Downstream CDN Provider

- Reporting services:

  - Report on the distributed content to the Downstream Content Provider

    - E.g. GB stored, GB distributed, traffic over time

  - Support of reporting by the Downstream CDN Provider

    - E.g. storage, processing and relay of reports to the content provider

- Transit services

4.2.3   Downstream CDN Provider CDN interconnection services

The following is a list CDN interconnection services that could be provided by the Downstream CDN Provider.

- Content delivery services:

  - Provide access for content distribution to the Upstream CDN Provider

  - Deliver content on behalf of the Upstream CDN Provider

- Delivery Control Services:

  - Establish agreements on delivery attributes, with the Upstream CDN Provider

  - Provide real-time control over ongoing deliveries, in association with the Upstream CDN Provider

- Reporting services:

  - Report on the delivered content to the Upstream CDN Provider

    - E.g. GB stored, GB distributed, traffic over time

- Transit services

4.2.4   Guiding principle for CDN Interconnection

Acceptance of CDN interconnection by the Content Provider is essential to successful deployment of CDN interconnection services. The following are guiding principles to highlight that the Content Provider is in control of anything that happens with or around the Content Provider's content within the interconnected CDN as if it were the Content Provider's own distribution network. Subject to business agreements between service providers, as well as local and regional regulatory requirements, in general, the principle of "as if it were the Content Provider's own distribution network" may apply to the following aspects:

- Ownership of the content

- Distribution of the content

- Delivery of the content

- Reporting on ongoing and past deliveries of the content

- Guaranteeing the integrity of the Content Provider's content

- Satisfying local and regional regulatory requirements on user privacy

- Satisfying local and regional regulatory requirements on legal intercept

4.3   Compliance

A CDN interconnection solution is compliant to the present document if the following points are fulfilled.

- All mandatory ("shall") services and features are implemented as specified in the associated architecture and protocol documents.

- If an optional service ("should") or feature is implemented, then it is implemented as specified in the associated architecture and protocol documents.

- If an optional service or feature is implemented, and the associated architecture and protocol documents specify multiple options, then it is implemented according to at least one or those options.

5 Service requirements

5.1 General

[5.1.1] The CDN interconnection shall enable controlled distribution of content between two CDNs.

[5.1.2] The CDN interconnection shall support enforcement of the Consumer access control policy defined by the Content Provider. In other words, the CDN interconnection solution shall ensure that any delivery request is honoured, or rejected, in accordance with the access control policy defined by the Content Provider. The Content Provider access control policy may depend, in particular, on the content item, on the Consumer, on the Consumer location and on the request time.

5.2 Service Types

[5.2.1] The CDN interconnection solution shall support content distributions services required for file-based content (used e.g. for CoD) and stream-based content (used e.g. for Broadcast).

[5.2.2] The CDN interconnection solution shall support delivery format adaptation in the downstream CDNs.

NOTE: Delivery format adaptation includes, but is not limited to, conversion to adaptive streaming, the transport format conversion, code type conversion, content encapsulation conversion.

6 Technical requirements

6.1 General

[6.1.1] The CDN interconnection solution shall be able to distribute content from an Upstream CDN to a Downstream CDN.

[6.1.2] The CDN interconnection solution shall be able to distribute content from an Upstream CDN to multiple Downstream CDNs.

[6.1.3] The CDN interconnection solution shall enable an Upstream CDN to push content to a Downstream CDN.

[6.1.4] The CDN interconnection solution shall enable a Downstream CDN to pull content from an Upstream CDN.

[6.1.5] The CDN interconnection solution shall enable the Downstream CDN to dynamically discover the content location information in order to pull content from an Upstream CDN in line with the content policy requirements by the Content Provider.

[6.1.6] The CDN interconnection solution shall enable an Upstream CDN to delete content from a Downstream CDN, but only for content that was distributed by the Upstream CDN to the Downstream CDN.

[6.1.7] The CDN interconnection solution shall support distribution and delivery of content transparently from its format, e.g. codec.

NOTE: This does not exclude the possibility that content is transcoded in one of the CDNs, see clause 6.3.

[6.1.8] The CDN interconnection solution shall be independent of the hardware or software of the content consumer.

[6.1.9] The CDN interconnection solution shall be independent of the CDN technologies deployed by the Upstream CDN and the Downstream CDN.

[6.1.10]   The CDN interconnection solution shall provide support for delivery format adaptation by the Downstream CDN according to the UE's capability and conforming to content policy and rights.

[6.1.11]   The CDN interconnection solution shall not implicate dependencies between the delivery mechanisms used by Upstream CDN and the Downstream CDN.

[6.1.12]   The CDN interconnection solution shall support that one CDN selects its Downstream CDN independently.

[6.1.13]   The CDN interconnection solution may support an arrangement where the Upstream CDN Service Provider agrees with a Downstream CDN Service Provider to use a specific CDN further downstream.

6.2   CDN interconnection interfacing between Upstream CDN Provider and Downstream CDN Provider

[6.2.1]   The CDN interconnection solution shall have one or more technical interfaces for content distribution that enable streaming distribution of live and stored content.

NOTE 1:   Examples of candidate interface for streaming content distribution is RTP/RTCP and HTTP.

[6.2.2]   The CDN interconnection solution should have one or more technical interfaces for request routing and content distribution of stream-based unicast content from Upstream CDN to Downstream CDN that enable the Downstream CDN to deliver the stream-based content (obtained from the CDN interconnection) through multicast to the Consumer.

NOTE 2:   Generally, multicast does not support reporting on connected users. An Upstream CDN could use client/player statistics instead.

[6.2.3]   For scenarios where the streaming content is pulled by the Downstream CDN in case of cache miss, the CDN interconnection solution should support a technical interface allowing the Downstream CDN to control the rate at which the streaming content is distributed to the Downstream CDN.

[6.2.4]   The CDN interconnection solution shall have one or more technical interfaces for content distribution that enable file transfer of stored content.

NOTE 3:   Examples of interfaces for file transfer are FTP and HTTP.

[6.2.5]   The CDN interconnection solution shall support transfer of segmented content between CDNs. The following types of segmented content shall be supported:

- Content composed of multiple files.

- Content composed of multiple streams.

- Content composed of one or more files and one or more streams.

NOTE 4:   An example of content composed of multiple files is HTTP adaptive streaming. An example of content composed of multiple streams is tiled video, i.e. a high-resolution video composed of spatially separate lower-resolution video streams. Another example of content composed of multiple streams is scalable video coding (SVC).

[6.2.6]   The CDN interconnection solution shall support transfer of partial sets of individual content segments between CDNs.

[6.2.7]   The CDN interconnection solution should support efficient delivery of segmented content when different content segments are delivered from different CDNs.

[6.2.8]   The CDN interconnection solution shall allow interfaces between Upstream CDN and Downstream CDN to be realised over a managed network, e.g. a leased lined or a managed IP network.

[6.2.9]   The CDN interconnection solution shall allow interfaces between Upstream CDN and
                        Downstream CDN to be realised over an unmanaged network, e.g. the internet.

[6.2.10]   The CDN interconnection solution should allow one or more control-plane interfaces between
                        Upstream CDN and Downstream CDN, for establishing agreement over desired delivery attributes
                        among associated CDNs.

NOTE 5:   Examples of desired delivery attributes can be, but not limited to, reach ability/route characteristics,
           delivery related service level agreements, QoS attributes, performance thresholds, supported content
           lookup methods, content type and related attributes, supported failover abilities.

6.3   Transcoding

[6.3.1]   The CDN interconnection solution shall support distribution of content that is transcoded or
                        processed by the Upstream CDN.

[6.3.2]   The CDN interconnection solution shall support distribution of content that is transcoded or
                        processed by the Downstream CDN.

NOTE 1:   Transcoding or processing of content may be useful to make content better suited for distribution over
           access networks with a small bandwidth (e.g. a mobile network), or with an unknown and widely varying
           available bandwidth (e.g. the internet).

NOTE 2:   The transcoding or processing of content itself is not a requirement of the present document.

6.4   CDN-I Security Requirements

6.4.1   Integrity Requirements

[6.4.1.1]   The CDN interconnection solution shall enable the Upstream CDN to validate the integrity of the
                        content.

[6.4.1.2]   The CDN interconnection solution shall enable the Downstream CDN to validate the integrity of
                        the content.

[6.4.1.3]   The CDN interconnection solution shall assign unique and non-forgeable identities to all CDN
                        content that are verifiable for users. The uniqueness shall be guaranteed for a period of time of
                        more than one year.

6.4.2   Authenticity Requirements

[6.4.2.1]   The CDN interconnection solution shall enable the Upstream CDN verify the authenticity of the
                        source (origin) of content.

[6.4.2.2]   The CDN interconnection solution shall enable the Downstream CDN verify the authenticity of the
                        source (origin) of content.

[6.4.2.3]   The CDN interconnection solution shall enable the Upstream CDN to authenticate communication
                        from the Downstream CDN and vice versa.

6.4.3   Authorization Requirements

[6.4.3.1]   The CDN interconnection solution shall enable access to requested content only to authorized
                        users, subscribers and devices.

[6.4.3.2]   The CDN interconnection solution shall deny access to requested content by unauthorized users,
                        subscribers and devices.

[6.4.3.3]   The CDN interconnection content protection functions shall provide a means for protecting time-
                        restricted content usage.

[6.4.3.4]   The CDN interconnection solution shall allow the Content Provider to explicitly authorize individual Consumer content request before it is honoured. In particular, this mechanism shall ensure that a Consumer cannot by-pass the Content Provider authorization even when the Consumer is aware of a content locator or identifier (e.g. URI) that has been used by that consumer before or by another Consumer (anti-deep linking). URL signing is a candidate mechanism to support this anti-deep linking requirement.

6.4.4   Confidentiality Requirements

[6.4.4.1]   The CDN interconnection solution shall provide content confidentiality protection within regulatory constraints.

6.4.5   Denial of Service Protection Requirements

[6.4.5.1]   The CDN interconnection solution shall have measures to detect Denial of Service (DoS) attacks posed upon the CDN interconnection solution. It should protect against Denial of Service (DoS) attacks to ensure fulfilment of the requirements of the Content Provider regarding timeliness and quality.

6.4.6   Digital rights management (DRM)

[6.4.6.1]   The CDN interconnection solution shall support transparency to the DRM solution used by the Content Provider.

[6.4.6.2]   The CDN interconnection solution should be used for distribution of DRM keys.

[6.4.6.3]   DRM solutions supported by the CDN interconnection solution should include the key management, the delivery, and encryption and decryption operations of keys and content, and the corresponding interfaces.

[6.4.6.4]   The CDN interconnection solution should have content files and - streams encrypted throughout all CDN stages: ingestion, storage, distribution and delivery.

NOTE 1:   The two above requirements do not directly impact the CDN, but they may impact the DRM solution used over the CDN.

[6.4.4.5]   The CDN interconnection solution should enable Content-Provider controlled-changing of the content encryption by the Upstream CDN and/or Downstream CDN.

NOTE 2:   There exist cryptographic systems that enable re-encryption of content without decrypting it. In such systems, the Content Provider would have to encrypt a piece of content only once, whereas each Consumer could receive a tailor-encrypted version of the content. As the Content Provider is in control of the keys, it can trust that the integrity and security of the content is maintained.

6.5   Retrieving content identification

[6.5.1]   The CDN interconnection solution shall be compatible with the Consumer retrieving the content identification from the Content Provider.

NOTE: The mechanism how the Consumer retrieves the content location is out of scope of the present document.

[6.5.2]   The CDN interconnection solution shall be able to support and resolve TV URI's for the identification of television channels, as specified in TS 184 009 [2].

6.6   Resolving content location

[6.6.1]   The CDN interconnection solution shall enable a Consumer to be redirected by the Content Provider to the Upstream CDN.

NOTE: Once the content is ingested into the CDN, there may be no need any more for this redirection. Typically the web site of a Content Provider has an object included that directly relates to the Upstream CDN.

[6.6.2]   The CDN interconnection solution shall enable a Consumer to be redirected by the Content Provider to the Downstream CDN.

[6.6.3]   The CDN interconnection solution shall allow an Upstream CDN Provider to select a Downstream CDN Provider to handle the request. When the selected CDN Provider is not the Delivering CDN, the CDN interconnection solution shall allow the selected CDN, in turn to select a Downstream CDN Provider, and so on until the selected CDN is the Delivering CDN.

[6.6.4]   The CDN interconnection solution shall not restrict the set of criteria that can be taken into account by the Upstream CDN Provider to select a Downstream CDN Provider. This shall include, and not be restricted to, the content item, the content type, the Consumer, the Consumer geo-location, time of day, tariffs of Downstream CDN, Downstream CDN performance, and administrative policy.

[6.6.5]   The CDN interconnection solution shall support CDN Provider loop prevention (e.g. to avoid a scenario where CDN Provider 1 selects CDN Provider 2 that selects CDN Provider 3 that selects CDN Provider 1).

[6.6.6]   The CDN interconnection solution shall enable a Consumer to be redirected by the Upstream CDN to the Delivering CDN Provider. This applies both in the absence of Transiting CDN Provider and in the presence of one or more CDN Transiting Provider(s).

[6.6.7]   The CDN interconnection solution shall support an optional mechanism to limit the number of transiting CDNs involved in the request redirection.

[6.6.8]   The CDN interconnection solution shall support an optional crank-back mechanism in case the Downstream CDN Provider selected by the Upstream CDN Provider cannot handle the redirection. This allows the Upstream CDN to select another Downstream CDN (or itself) to honour handle the request.

[6.6.9]   The CDN interconnection solution shall be compatible with the Upstream CDN Provider retrieving the content location from the Downstream CDN Provider.

6.7   Reporting

[6.7.1]   The CDN interconnection solution shall enable the Downstream CDN Provider to provide status report on identified content to the Upstream CDN Provider.

[6.7.2]   The CDN interconnection solution shall enable the Upstream CDN Provider to retrieve status reports on identified content from the Downstream CDN Provider.

NOTE 1:   Examples of status of identified content are "receiving", "preparing", "ready for delivery", "Ingesting", "unavailable", "deleted" and "unknown".

[6.7.3]   The CDN interconnection solution shall enable the Downstream CDN Provider to provide detailed transaction logs on identified content to the Upstream CDN Provider for deliveries performed on behalf of that Upstream CDN Provider.

[6.7.4]   The CDN interconnection solution shall enable the Upstream CDN Provider to retrieve detailed transaction logs on identified content from the Downstream CDN Provider for deliveries performed on behalf of that Upstream CDN Provider.

NOTE 2:   Examples of transaction logs information, for each delivery, include content identifier, start time, finish time, and delivery quality indicators (resolution, bandwidth, loss, etc.).

[6.7.5] The CDN interconnection solution should allow one or more control-plane interfaces between Upstream CDN and Downstream CDN for achieving real-time monitoring and control over on-going delivery.

NOTE 3: Examples of real-time control over on-going delivery may lead to, but not limited to, following capabilities.

- Real-time congestion awareness

- Dynamic bandwidth allocation

- Real-time QoS control

- Dynamic content adaptation

6.8 Topology and topology hiding

[6.8.1] The CDN interconnection solution shall enable the Upstream CDN Provider to push content to an identified CDN delivery node in the Downstream CDN.

[6.8.2] The CDN interconnection solution should enable the Downstream CDN Provider to provide the relevant content deployment capabilities to the Upstream CDN, such that the Upstream CDN can redirect a content delivery request from a Consumer directly to an identified CDN node.

[6.8.3] The CDN interconnection solution shall enable a Downstream CDN to hide its topology to the Upstream CDN and present itself as a single CDN node, or as a set of such, e.g. one per CDN interconnection interface.

Annex A (informative):
CDN Interconnection use cases

A.1 General

This annex provides a set of use cases to illustrate the application of CDN interconnection. The functional roles and CDN Provider relationships from clause 4.1 (Content Provider, Consumer, Ingesting CDN Provider, Delivering CDN Provider, Transiting CDN, etc.) are used where appropriate.

A.2 Consumer use cases

A.2.1 Popular global content

The soccer world cup is watched "live" by Consumers all over the world. Moreover, Consumers start browsing through the highlights of a match on a massive scale. CDN interconnection between CDN Providers world-wide makes sure that the global network will not suffer from large scale simultaneous delivery and changing traffic patterns and that all Consumers can see the streams and clips that they request to see, within the agreements between the CDN operator and network operator.

A.2.2 Popular remote content

Annually, the Spanish island of Mallorca is visited by many German tourists, who watch German TV channels and German videos on a large scale. CDN interconnection between a German CDN Provider and a local Spanish CDN provider can make sure that all tourists can see the streams and videos of their choice with suitable quality of experience.

A.2.3 Quality Improvements Derived from IETF draft [i.1]

Some existing CDN Service Providers make the decision to work with ISPs to deploy surrogates closer to the end users. Compared to alternatives such as adding capacity at major peering points, this method offers better experience to the end users. Some Content Providers are willing to pay a premium for such enhanced service rather than just using the CDN Service Provider to mitigate their server and network access costs. Improved experience may be provided by closer proximity to the end users. It could also involve network characteristics, such as provisioning or QoS, and specific delivery techniques such as encoding for constant Quality of Experience.

A.2.3.1 Network Service Provider CDN Service Provider Use Case

In an interconnection use case, CDN Service Provider-A is likely to offer an SLA to the Content Provider (CP) including performance or other quality metrics. If it cannot meet the SLA it will push content via the interconnection to a CDN Service Provider-B with CDN capabilities that are in a position to guaranty the SLA, and redirect users appropriately to CDN Service Provider-B. CDN Service Provider-A may not be able to, or may not wish to deploy its own CDN capabilities to meet the SLA requirements for only a subset of customers. The ability to offer stringent delivery quality SLAs is a differentiator against other CDN Service Providers and can be sold as a premium service. Although this use case has similarities to extending geographic reach, in this case it is expected that the CDN Service Provider does have a CDN deployed which could effectively serve content to the end-users, but wishes to increase quality of experience for specific CPs.

A.2.4   Offload use cases derived from IETF draft [i.1]

A.2.4.1   Overload handling and dimensioning

The support of prime-time traffic load may require over-dimensioning the CDN capacity. In addition unexpected spikes in content popularity may drive load beyond the expected peak. As prime time and peaks of content distribution may differ between two CDNs, a CDN may interconnect with another CDN to increase its effective peak capacity. Similarly, two CDNs may benefit from dimensioning savings by using the resources of each other during their peaks of activity.

The profile of activity peaks (time, duration, etc.) differ not only from one country to another but also according to the kind of CDNs. Therefore, CDN interconnect will be required since the additional capacity is likely to be provided by alternative technology. Offload also applies to planned situation where a CDN Service Provider needs CDN capacities in a particular region during a short period of time. For example, during a specific maintenance operation or for covering the distribution of a special event, such as an international sport competition.

A.2.4.2   Resilience

It is important for CDNs to be able to guarantee service continuity during partial failures (e.g. failure of a set of CDN components). In partial failure scenarios, a CDN Service Provider could redirect some requests toward another CDN. This downstream CDN would be able to serve the redirected requests or, depending on traffic management policies, to forward these requests to the appropriate server.

Resiliency may also be required against failure to ingest content from the CP. In these cases the content may be available from another CDN Service Provider.

A.2.5   Footprint Extension Use Cases Derived from IETF draft [i.1]

A.2.5.1   CDN Interconnection inside one CDN Service Provider

A large CDN service provider operates the CDNs of a set of subsidiaries from different countries, and these CDNs can rely on different CDN solutions. To provide a consistent service to his customers on its whole footprint, in certain circumstances, the CDN service provider needs to make its CDNs interoperate.

Note that currently, the distribution of some content is restricted. For instance, distribution rights for audiovisual content are often negotiated per country.

A.2.5.2   CDN Interconnection between CDN Service Providers

Several CDN service providers have a geographically limited footprint (e.g. a country), or do not serve all end-users in a geographic area. Interconnecting CDNs enables CDN Service Providers to provide their services beyond their own footprint by relying on other CDNs.

End-users in various countries access TV shows episodes. The Content Provider that distributes the TV show asks a French CDN Service Provider to deliver the serial to several countries. The French CDN Service Provider makes an agreement with an external CDN Service Provider that covers North Africa to provide a CDN service for France and North Africa.

This use case applies to other types of contents like automatic software updates (browser updates, operating system patches, or virus database update, etc.).

A.2.6   Popular segments

The following use cases are examples of segmented content, where some segments are much more popular than other segments.

A.2.6.1   Popular time segments

A new video clip becomes available. Many Consumers start watching the clip, but most stop watching after ten seconds as they find it not sufficiently interesting.

A guru recommends a section of a video clip through social media. Many of his followers start watching the recommended section, but they do not watch the rest of the video.

A.2.6.2   Popular video tiles

A major soccer match is distributed as tiled video. Most Consumers watch only the central tiles with the soccer players and the field. Only a happy few consumers with big high-resolution screens request the tiles of the surrounding area.

A.2.6.3   Scalable and multi-rate video

A movie is made available in a scalable video coded format (SVC). Many Consumers watch the movie on a mobile device, and they request only the low-resolution based layer. Consumers with higher-resolution screens and higher-bitrate connectivity also request the high-resolution enhancement layers.

A movie is made available in multiple bitrates. Consumers attached to a mobile network request only the low-bitrate version. Consumers with fixed higher-bitrate connectivity request the high-bitrate version with better quality.

A.3   Topology use cases

A.3.1   Primary and secondary CDN

In this use case, a Consumer contacts the primary CDN for the content. The primary CDN can decide to deliver the content directly to the Consumer, and act as Delivering CDN Provider. It can also redirect the request for content delivery to the secondary CDN that will take the functional role of Delivering CDN Provider. The primary CDN provider has its own criteria for this decision, for example be load/performance related or based on the geographical location of the Consumer. There can also be multiple secondary CDNs.

A.3.2   CDN Peering

With a bilateral agreement, two CDN providers can agree to use each other's CDNs for specified sets of Consumers. So when the content in the domain of CDN A is to be delivered to a Consumer in the domain of CDN B, the content request to CDN A is redirected to CDN B. And vice versa. This is typically used, but not limited, in case of access providers with CDNs that are contracted by a Content Provider to distribute and deliver content beyond their own domain. CDN peering would reduce the traffic between those access providers.

A.3.3   CDN Federation

In this use case, several (more than 2) CDN Providers agree to use each other CDNs for distributing content in the most optimal way. Consumer requests to a CDN will be redirected to the CDN in the federation that is best positioned to deliver the content to the Consumer. This makes it possible for the federated CDN providers to act as a global (or regional) CDN.

A.3.4   More than two CDN hierarchy

In this use case, the Consumer request is forwarded by the primary CDN (the Ingesting CDN) to a secondary CDN (a Transiting CDN), which decides that the content can be better delivered by a third CDN (the Delivering CDN) and thus redirects the request to this third CDN. Though there may be practical limitations to the number of CDNs involved in a given delivery act redirect (like end-user performance/response); these should not be limitations in the specifications.

NOTE 1:   This use case does not refer to possible internal forwarding processes within a CDN internally.

NOTE 2:   CDN federation would be an alternative to this use case by including the third CDN in the primary CDN decision-making process.

A.3.5   CDN to multicast

In this use case, the CDN that should deliver the content to the Consumer has capabilities to transfer the content to a multicast capable network. This only works for content that is distributed simultaneously to multiple users e.g. live streaming/linear content. This could result in an additional reporting model.

A.3.6   Segmented content

In this use case, the Upstream CDN Service Provider distributes segmented content (files and/or streams) to the Downstream CDN Service Provider. Because of the pricing model of the Downstream CDN Service Provider, the Upstream CDN Service Provider can only profitably have the most popular segments (see clause A.2.6) delivered by the Downstream Service Provider to Consumers. Moreover, the Upstream CDN Service Provider has sufficient transport and delivery capacity to deliver the less popular segments directly to Consumers requesting those, without needing to invoke the Downstream CDN Service Provider. Therefore, the Upstream CDN Service Provider distributes only some of the segments to the Downstream CDN Service Provider, but not all. The CDN interconnection solution assures the efficient and timely delivery of segments to the Consumers from both CDNs.

A.4   Other use cases

A.4.1   Delivery Format Adaptation

Before content can be delivered to a user, there might be the need to transform its delivery format prior to delivery.

One possible realisation is that the delivering CDN which is nearest to the UE performs such delivery format adaptation according to the UE's capabilities. Delivery format adaptation may include, but is not limited to, conversion to adaptive streaming, the transport format conversion, codec type conversion, content encapsulation conversion and content metadata conversion (e.g. content description, program information, etc.).

For example, content is delivered from Content Provider through CDN-A and CDN-B to the CDN-C in the form of a normal RTP stream. The delivering CDN, CDN-C, determines that a UE requires the content to be delivered using adaptive HTTP streaming, CDN-C now performs delivery format adaptation and transforms the RTP stream to an adaptive HTTP stream that can be delivered to the UE.
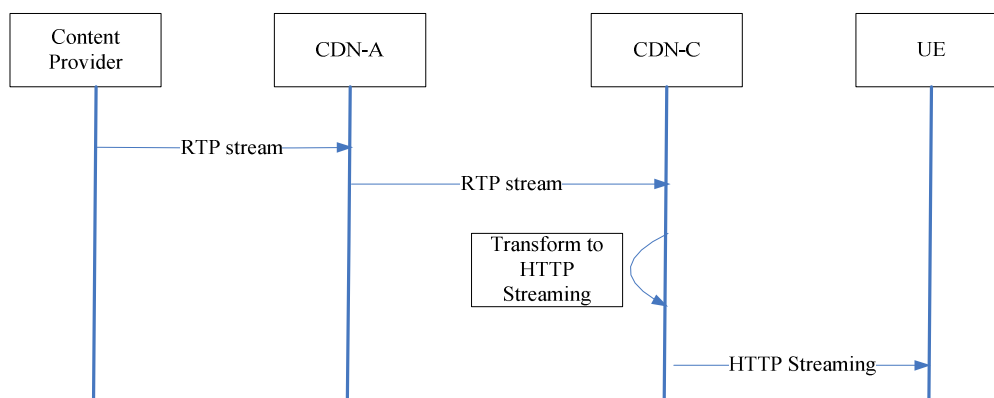
Figure A.4.1.1: Example of Delivery Format Adaptation

A.4.2   Support for HTTP Adaptive streaming

Future CDNs require better support for media streaming service. HTTP Adaptive streaming (HAS) is a promising solution for efficient and high-quality delivery of streaming services over the Internet, which supports re-use of existing infrastructure and technologies. HAS has received extensive attention, and different solutions have emerged from industry (e.g. Microsoft Smooth Streaming, Apple HTTP Live Streaming) as well as standardization bodies (e.g. MPEG-DASH [i.3]), and therefore HAS in a multi-CDN scenario is an important consideration.

NOTE: Activity is in progress which may lead to convergence of 3GP-DASH and OIPF HAS into the MPEG-DASH solution.

CDN-I architecture could support the deployment of HAS solution. The Content Provider distributes the content to the consumers through multiple CDNs providing ingesting, transiting and delivering services. In the case of HAS, the origin server hosts the media segments and the manifest file that includes the segments' URL in the CDN domain. The CDN caches the media segment and manifest, and interconnects with downstream CDNs.

The CDN interconnection could enable the following techniques (non-exhaustive list):

- URL rewriting: downstream CDN rewrites the URLs in the manifest file that are pointing to the media segments. Therefore the requests sent by the clients to get the media segments will follow the CDNI request routing process and be directly handled by the appropriate downstream CDN. The downstream CDN would have all information required to acquire the media segments from upstream CDN in case of cache miss in its network. This URL rewriting procedure could help reducing latency from client viewpoint, and network load (avoid handling all client requests for media segments in upstream CDN).

- Transcoding: It is not always possible for the downstream CDN to directly handle and distribute media segments from the upstream CDN. For example, when video codec/resolution/bitrate requested by the client cannot be directly fulfilled by the replica from uCDN. In this case, dCDN needs to transcode the content. The downstream CDN transcodes the content according to its agreement with upstream CDN and its own capability. It could generate media segments with new file format and new video parameters (bitrate, frame rate, resolution, etc.) The downstream CDN acquires necessary information such as capability, resources and policies through CDNI control and metadata interfaces. The transcoding operation could optimize the resources utilization for CDN and the quality for clients.

Annex B (informative):
Architectural approaches

B.1   Generic architecture for CDN interconnection

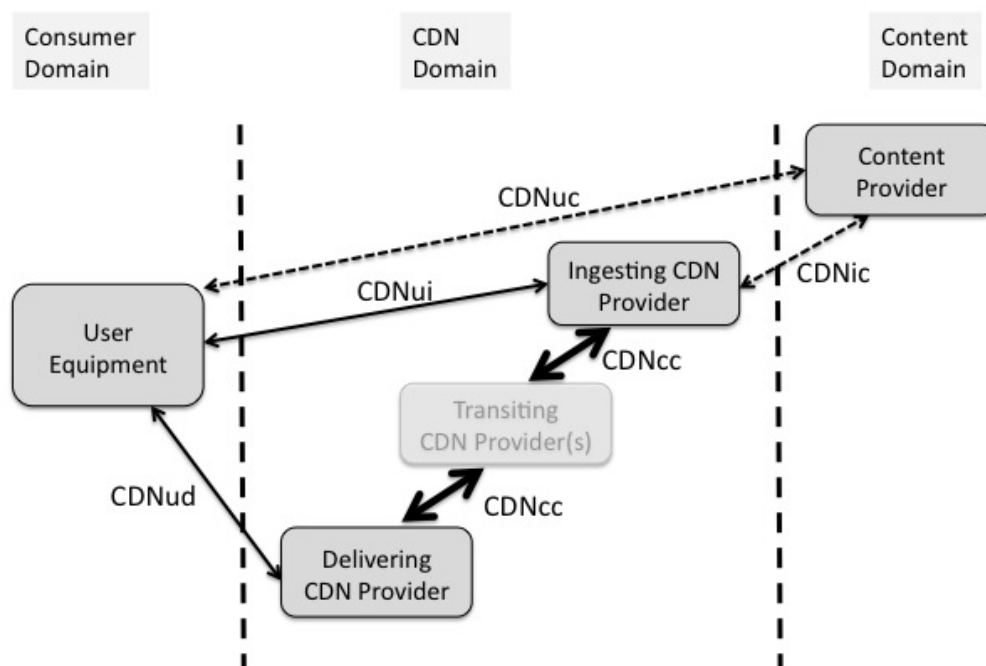Figure B.1.1 shows a generic architecture for CDN interconnection.

Figure B.1.1: Generic architecture for CDN interconnection

The Consumer, CDN Providers and Content Providers are connected via one or more IP network(s) (e.g. the Internet). Each CDN can have similar internal distribution interfaces. Content can be:

- on-demand;

- linear (typical live);

- streaming;

- progressive download.

DRM is regarded as a function of the content, so the architecture is indifferent for DRM. The internal working of the CDNs and QoS optimizations in the IP networks are out-of-scope.

The following architectural reference points could be identified. Each of these could be implemented by zero, one or more protocol interfaces. The focus of CDN interconnection is on the CDNcc reference point between any two CDN Providers participating in CDN interconnection.

- CDNui: Reference point between User Equipment and Ingesting CDN:

    - Content request

    - Connection test

    - Redirection to Delivering CDN

- CDNcc: Reference point between Upstream CDN Provider (Ingesting CDN or Transiting CDN Provider) and Downstream CDN Provider (Delivering CDN or Transiting CDN Provider):

  - Content distribution, push and/or pull.

  - Content deletion

  - System status

  - Content location

  - Content status reporting

  - Content transaction logs reporting

- CDNud: Reference point between User Equipment and Delivering CDN:

  - Content request

  - Content delivery

- CDNic: Reference point between Ingesting CDN and Content Provider system (out of scope):

  - Content acquisition

  - Content ingestion

  - System status

  - Content status reporting

  - Content usage reporting

- CDNuc: Reference point between User Equipment and Content Provider System (out of scope):

  - Metadata request (e.g. web page retrieval)

  - Metadata delivery (e.g. web page delivery)

  - Content request (in case the metadata did not provide the redirect)

  - Redirection to Ingesting CDN and/or Delivering CDN

B.2   Example procedure for a content request

Figure B.2.1 shows an example of a procedure for a content request in the case where there is no transiting CDN Provider and where distribution is performed on request from the Downstream CDN (i.e. Pull).
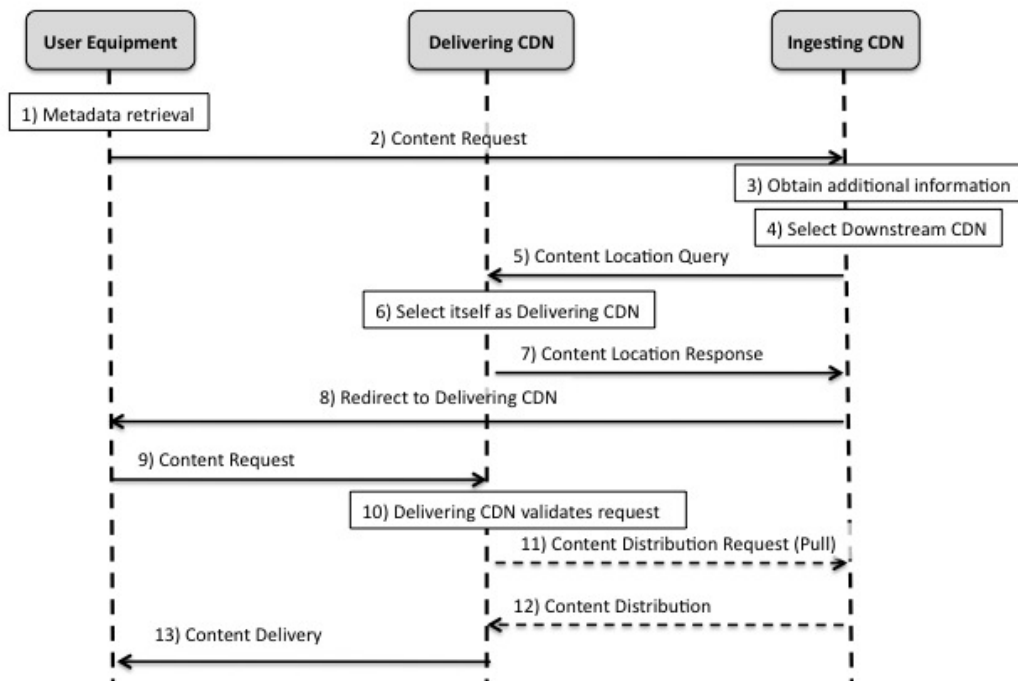
Figure B.2.1: Example procedure for content request

1) The user equipment retrieves metadata that enables it to send out a content request, e.g. from a website or electronic program guide provided by the Content Provider system or by the Ingesting CDN.

2) The user equipment sends a content request to the Ingesting CDN. The requested content is typically identified by a URI.

3) The Ingesting CDN has an option to get additional information for the user equipment and its access connection to the Ingesting CDN. Examples of such information are user equipment geo-location and broadband access provider. This information might be obtained through a query to a local database, a remote database (e.g. from a geo-location service provider).

NOTE: The Ingesting CDN may be able to deliver the content to the user equipment directly, but that is not relevant to this procedure example.

4) The Ingesting CDN Provider may have agreements with several Downstream CDN Providers. In accordance with its decision criteria and policy, the Ingesting CDN Provider selects the Downstream CDN Provider for this particular content delivery.

5) The Ingesting CDN Provider issues a query to the Downstream CDN Provider requesting a content location identifier (towards which the user is to be redirected).

6) In accordance with its decision criteria and policy, the Downstream CDN Provider selects itself as the Delivering CDN Provider.

7) The Delivering CDN Provider runs internal procedure to identify which cache is to be used to perform this particular delivery and returns the corresponding content location information (e.g. a URI) to the Upstream CDN (that is also the Ingesting CDN Provider in this case).

8) The user equipment is instructed to retrieve the content from the Delivering CDN Provider using the specific content location information provided to the Ingesting CDN Provider by the Delivering CDN Provider in step 7. HTTP redirect is one of the possible mechanisms to achieve this.

9) The user equipment sends a content request to the Delivering CDN Provider.

10) The Delivering CDN performs request authorization checks in accordance with the content access policy of the Content Provider. For example, this may not involve explicit checks (e.g. when content is to be made freely available) or may involve local validation (e.g. URL signing validation) or may involve validation/authorization from Content Provider (e.g. cache freshness validation).

11) If the content is already available in the Delivering CDN Provider (e.g. because it is stored content and has been pushed by the Upstream CDN Provider or has been pulled by the Delivering CDN Provider earlier, or because it is linear content already being distributed), the Delivering CDN directly jumps to step 12. Otherwise the content needs to be distributed to the Delivering CDN by its Upstream CDN (i.e. the Ingesting CDN in this scenario). In case of stored content, the Delivering CDN Provider issues a content distribution request to its Upstream CDN Provider as illustrated in figure B.2.1.

12) The Ingesting CDN Provider distributes the content to the Delivering CDN.

13) The Delivering CDN starts delivering the content to the user equipment (typically in parallel to receiving the rest of the content from its Upstream CDN).

B.3   Usage information

Usage equipment information is collected and distributed in the following way:

- The Delivering CDN collects usage information based on content delivery, including start time, finish time, gigabytes transferred, pause/stop/play stream, delivery speed, quality parameters.

- The Delivering CDN provides usage information to each of its Upstream CDN Provider (for the deliveries that had been delegated to it by that Upstream CDN Provider).

- Each CDN Provider receiving usage information from Downstream CDN Providers aggregates those. If the CDN Provider is a Transiting CDN Provider it provides usage information to each of its Upstream CDN Provider (for the deliveries that had been delegated to it by that Upstream CDN Provider).

- A Transiting CDN Provider and pass on usage information Ingesting CDN.

B.4   Access networks in the CDN architecture

Figure B.4.1 provides an alternative view on the CDN interconnection architecture, highlighting the positioning of access and transport networks. There is often a direct relationship between the Delivering CDN and the access network to which the user equipment is connected.
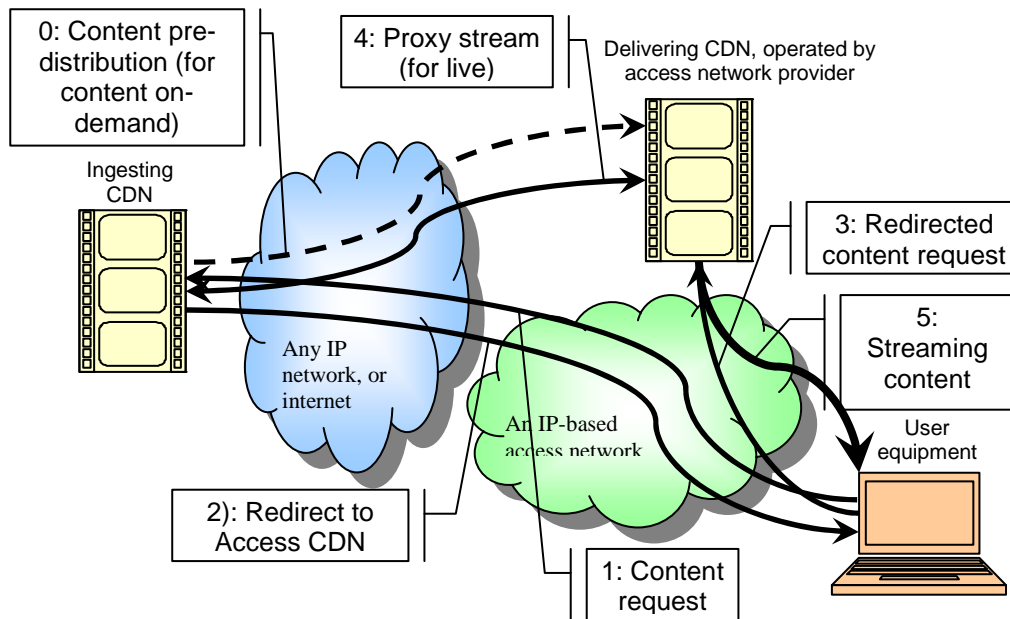
Figure B.4.1: Architecture view, highlighting access and transport networks

B.5   Procedure for content distribution

Figure B.5.1 shows a procedure for a content distribution in the case that Ingesting CDN distributes content to Delivering CDN (i.e. Push mode) actively. When a new content was released, the content provider may ingest the content to ingesting CDN instead of all of the delivering CDN. As agreement between Ingesting CDN (up streaming CDN) Provider and Delivering CDN (Down streaming CDN) Provider, the former could distribute the new content to delivering CDN according some policy. And then the content could be distributed inside Delivering CDN. If end user discovers this new content, the end user could request the content in the delivering CDN and of course the Delivering CDN could handle this request.
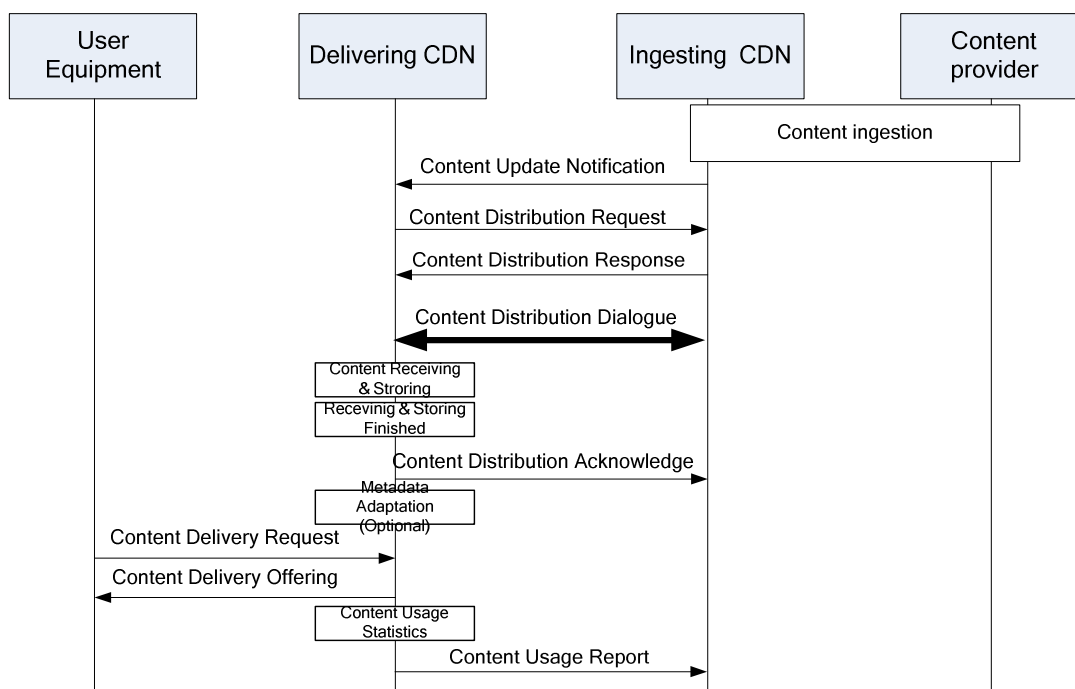

Figure B.5.1: Procedure for content distribution

Precondition: The Ingesting CDN Provider has agreements with Delivering CDN Providers. When a media new content was published or updated, the Ingesting CDN provider could distribute it to delivering CDN for user consuming.

1) The content provider ingests a new content to Ingesting CDN.

2) The Ingesting CDN issues a Notification message to Delivering CDN to notify the new media content published or updated, the metadata information could be carried in this Notification message.

3) The Delivering CDN send Content Distribution Request message to Ingesting CDN to request setup media content distribution dialogue.

4) The Ingesting CDN answer back Content Distribution Response message to Delivering CDN to confirm the setup of media content distribution dialogue.

5) The media distribution dialogue established and the media content distributed between Ingesting CDN and Delivering CDN (e.g. some schemes could be selected for the media distribution dialogue, such as FTP, HTTP, etc.).

6) The Delivering CDN receives distributed media content via media distribution dialogue scheme and stores the media content (such as with files) in its local storage unit.

7) The Delivering CDN feeds back Content Distribution Acknowledge message to Ingesting CDN, when the content distribution dialogue finished.

8) The Delivering CDN checks the metadata structure and transform it if the metadata from Ingesting CDN is different with its own metadata structure (Metadata Adaptation).

9) The User Equipment send Content Delivery Request message to Delivering CDN to request media content.

10) The Delivering CDN handles this request and response back media content with Content Delivery Offering message to User Equipment.

11) The delivering CDN record and make the content usage statistics, and report the statistics result to Ingesting CDN using Content Report message, when the media content was requested and consumed by end users.

B.6   Content delivery through CDN Interconnection

With the CDN interconnection, the content may be delivered from the Content Provider to the target consumer (UE) through multiple CDNs. As a simplest example, the content may be delivered from CP through multiple CDNs one by one towards the consumer(UE), see figure B.6.1 showing an example of content ingestion, distribution and delivery through CDN Interconnection. Meanwhile, one CDN may need to duplicate and distribute the content to its multiple downstream CDN or Ues, see figure B.6.2 showing an example of content distribution to multiple CDNs through CDN Interconnection. In this example, CDN-A requires CDN-B to deliver content to UE-x and requires the CDN-G to deliver content to both UE-y and UE-z.

For these two examples, the content distribution an delivery from the Content Provider to the Consumer includes multiple processes (e.g. the process between Content Provider and CDN-A is for the content ingestion; the process between CDN-A and CDN-B is for the content distribution; the process between CDN-C and Consumer is for the content delivery) and will be specified in later stage work.

Figure B.6.1: Content ingestion, distribution and delivery through CDN Interconnection
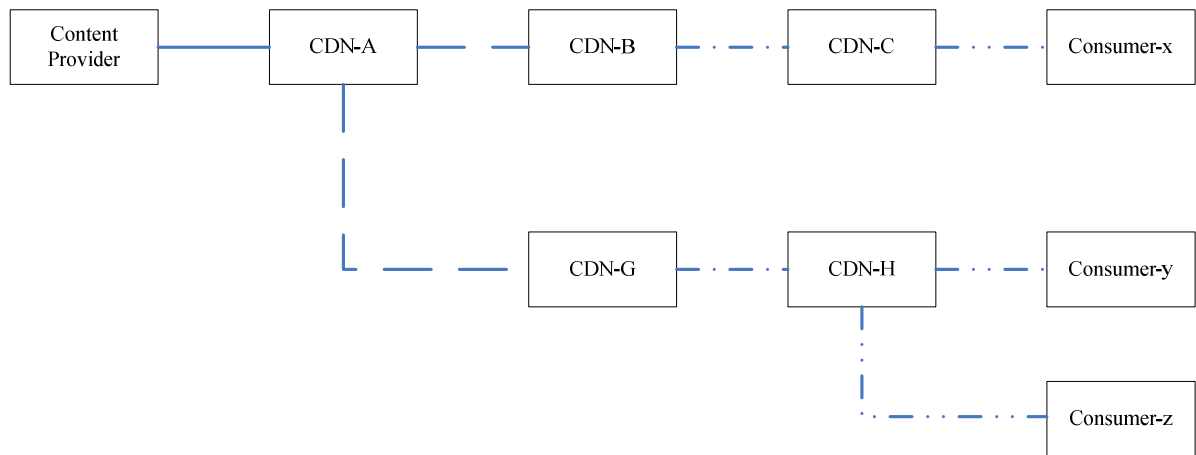
Figure B.6.2: Content distribution to multiple CDNs through CDN Interconnection

Annex C (informative):
A metaphor for the electronic content delivery ecosystem

C.1 General

This annex provides a metaphor for the electronic content delivery ecosystem to provide a better understanding of roles and relationships in this ecosystem. The metaphor of a newspaper distribution ecosystem was chosen, as that ecosystem is well understood and it has many aspects in common with content delivery. Of course, any metaphor should be used with care, as there will always be (subtle) differences.

Table C.1.1 gives an overview of roles and concepts from the newspaper distribution ecosystem and their equivalents from the content delivery ecosystem. Clauses C.2 and C.3 provide highly similar descriptions of the two ecosystems to highlight some of their equivalences, including an equivalence for CDN interconnection.

Table C.1.1: Equivalences between newspaper distribution and content delivery

Newspaper Distribution	Content Delivery equivalents
News (for newspapers)	Content (for electronic delivery)
Printing plates	Mastercopy (of the content)
Replica plates	Replica (of the mastercopy of the content)
Newspaper	Consumable (content)
Newspaper Company	Content Provider
Newspaper Reader	Content Consumer
Printer Company	CDN Service Provider
Postal Company	Network Service Provider
Newsstand Company	IPTV Service Provider

C.2 The newspaper-distribution ecosystem

The business of Newspaper Companies is to generate and/or collect news items and other articles, and bring those together into newspapers. The audience for the newspapers are Newspaper Readers. Different Newspaper Companies may have different business models, including subscription-based, advertising-based, combinations of those and other.

Getting the newspapers to the Newspaper Readers is essential to the Newspaper Company. Some Newspaper Companies may have their own printing presses, trucks to move the printed newspapers, outlets for Newspaper Readers to pick up the newspapers, and personnel to get newspapers delivered to mailboxes of Newspaper Readers. However, Newspaper Companies may also decide to outsource some or all of those newspaper-distribution activities to specialised companies.

- Printing Companies have one or more printing presses to print newspapers.

- Postal Companies have one or more trucks and personnel to move and deliver printed newspapers.

- Newsstand Companies have one or more newsstands where people can pick up newspapers.

In practice, players in the newspaper-distribution ecosystem may take multiple roles. Some companies may have printing presses, but some delivery trucks as well. Some companies may have newsstands, but delivery personnel as well. Also, some companies may specialize, e.g. to global or local delivery, high quality colour print or bulk black-and-white, specialized shops, etcetera, whereas other companies may generalize and cover as many aspects of newspaper (distribution) business as they can.

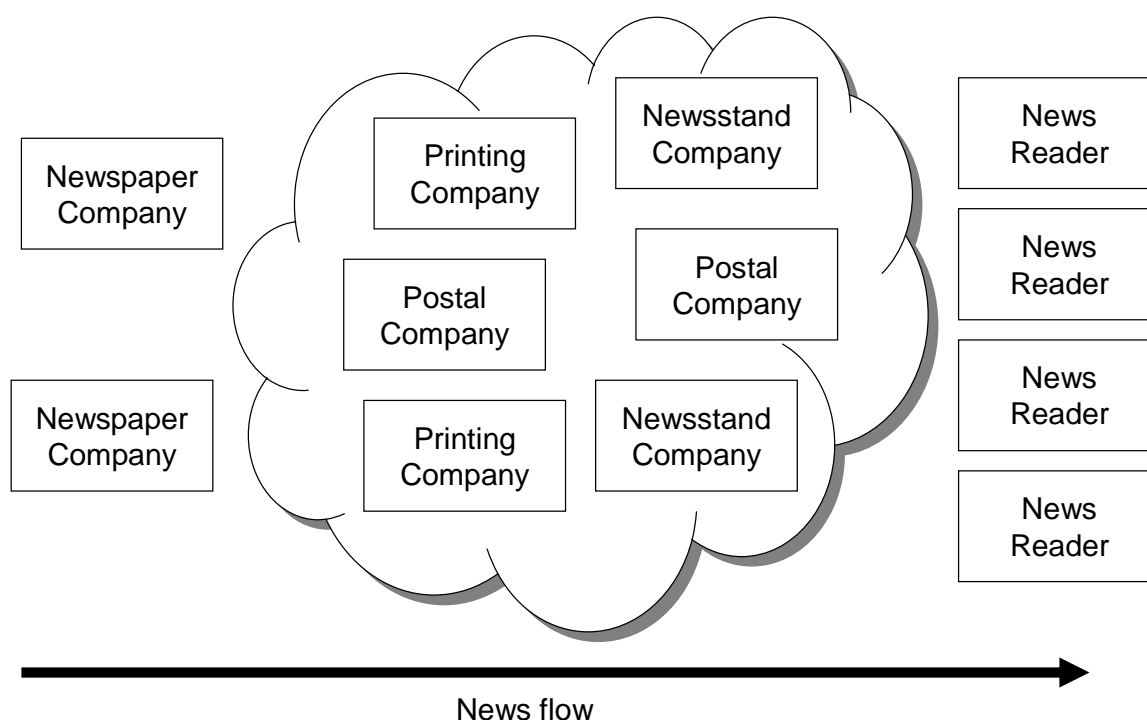Figure C.2.1 sketches a newspaper-distribution ecosystem.

News flow

Figure C.2.1: Sketch of a newspaper-distribution ecosystem

Ecosystem invisible to Newspaper Reader

The whole newspaper distribution ecosystem is opaque to the Newspaper Reader. The only thing that the Newspaper Reader has to know is that he can pick up newspapers from a newsstand or get them delivered to his mailbox. Some newspapers may be for free, others may be paid per print and it may also possible to subscribe (and unsubscribe) to newspapers.

Newspaper Company in control

As the Newspapers Company pays for the printing, distribution and delivery services of the other companies in the ecosystem, the Newspaper Company can set some requirements. Newspaper Companies may want to know how many newspapers are printed, the qualities of the printed newspapers, to where they are distributed, the timeliness of the printing and delivery, assurance that no illegal copies are printed or distributed, that old newspapers are destroyed, etcetera. Of course, the precise requirements of a Newspaper Company will vary depending on its particular business model.

News neutrality

Neutrality of newspaper-distribution is important to the Newspaper Company. No player in the ecosystem should modify articles, change styles and fonts, insert advertisements or change anything similar without explicit consent from the Newspaper Company. These types of requirements are typically agreed in Service-Level Agreements with the Newspaper Company.

Distribution neutrality

Neutrality of newspaper-distribution is also important to the Newspaper Readers. Players in the newspaper-distribution ecosystem should not misuse an acquired or natural monopoly on aspects of the delivery to unfairly discriminate other players. For example, a company that happens to have a local monopoly on postal services should not be allowed prohibitive pricing the delivery of newspapers composed and/or printed by other companies. This type of requirements are typically regulated by law and maintained by an independent regulator and/or competition authority.

Collaborating Printing Companies

Although Printing Companies are typically each other's competitors, there are also cases where Printing Companies may want to collaborate. Here are some examples.

- A Printing Company may have insufficient printing-press capacity to handle a special event or a specific large order. The Printing Company could commission the capacity of other Printing Companies as back-up for such occasions.

- A global Printing Company could commission a local Printing Companies to locally print newspaper in order to achieve more cost-efficient newspaper distribution in a specific region.

- Local Printing Companies could team up and have a joint venture to increase their distribution footprint, competing with global Printing Companies over large Newspaper Company account.

C.3   The content-delivery ecosystem

The business of Content Providers is to generate and/or aggregate digital content items, and bring those together into content (programs, TV channels, etc.). The audience for the consumable content are Content Consumers. Different Content Providers may have different business models, including subscription-based, advertising-based, combinations of those and other.

Getting the content as consumable content to the Content Consumers is essential to the Content Provider. Some Content Providers may have their own content delivery servers, a network to transport the content, web shops for Content Consumers to obtain the content, and solutions to get content delivered to the homes of Content Consumers. However, Content Providers may also decide to outsource some or all of those content -delivery activities to specialised companies.

- CDN Service Providers have one or more servers for streaming and downloading consumable content from.

- Network Service Providers have a network to transport mastercopies, replicas of the content and to deliver consumable content.

- IPTV Service Providers have services enabling people to consume the content: i.e. to watch TV channels and to obtain content on demand.

In practice, players in the content delivery ecosystem may take multiple roles. Some companies may have servers, but some network as well. Some companies may have web shops, but a subscription service as well. Also, some companies may specialize, e.g. to global or local delivery, guaranteed delivery or best-effort delivery, etcetera, whereas other companies may generalize and cover as many aspects of content (delivery) business as they can.

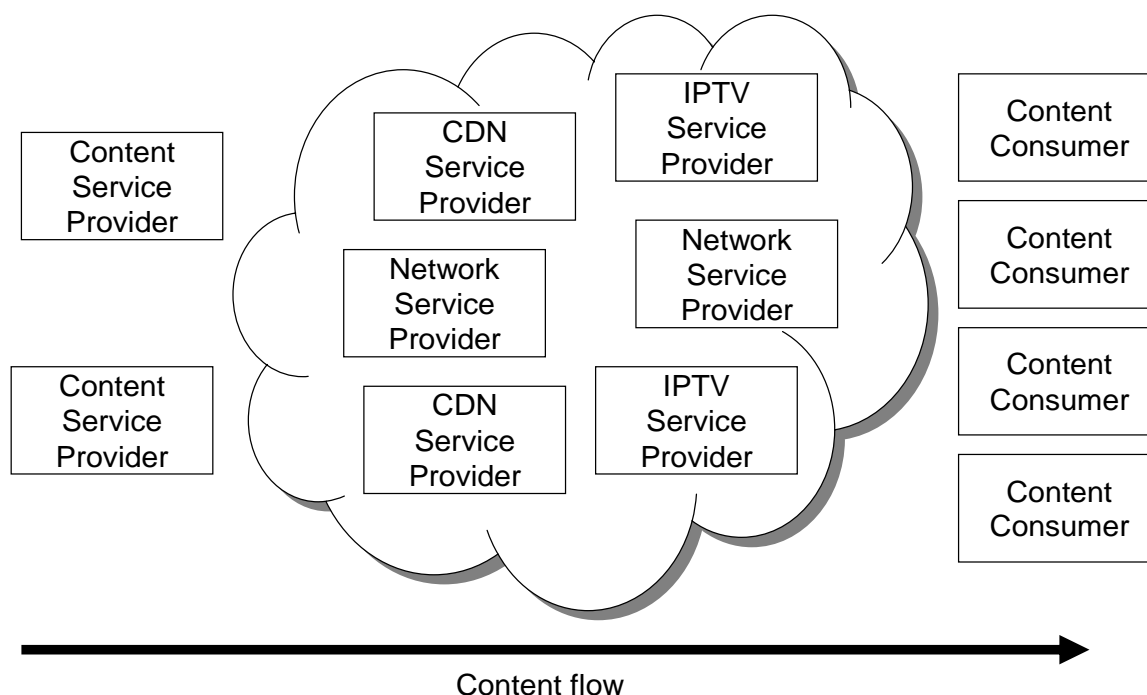Figure C.3.1 sketches a content-delivery ecosystem.

Figure C.3.1: Sketch of a content-delivery ecosystem

Ecosystem invisible to Content Consumer

The whole content delivery distribution ecosystem is opaque to the Content Consumer. The only thing that the Content Consumer has to know is that he can obtain consumable content from a web shop or get an IPTV service. Some consumable content may be for free, others may be paid per view and it may also possible to subscribe (and unsubscribe) to consumable content.

Content Provider in control

As the Content Provider pays for the delivery, transport and retail services of the other companies in the ecosystem, the Content Provider can set some requirements. Content Providers may want to know how many times the content was consumed, the quality of the delivery, to where they are distributed, the timeliness of the delivery, assurance that no illegal copies are made or distributed, that old mastercopies and replicas of the content are deleted, etcetera. Of course, the precise requirements of a Content Provider will vary depending on its particular business model.

Content neutrality

Neutrality of content delivery is important to the Content Provider. No player in the ecosystem should modify content, change encoding or resolution, insert advertisements or change anything similar without explicit consent from the Content Provider. These types of requirements are typically agreed in Service-Level Agreements with the Content Provider.

Network neutrality

Neutrality of content delivery is also important to the Content Consumers. Players in the content-delivery ecosystem should not misuse an acquired or natural monopoly on aspects of the delivery to unfairly discriminate other players. For example, a company that happens to have a local monopoly on network services should not be allowed prohibitive pricing the delivery of content generated and/or served by other companies. This type of requirements are typically regulated by law and maintained by an independent regulator and/or competition authority.

Collaborating CDN Service Providers → CDN Interconnection

Although CDN Service Providers are typically each other's competitors, there are also cases where CDN Service Providers may want to collaborate. Here are some examples:

- A CDN Service Provider may have insufficient server capacity to handle a special event or a specific large order. The CDN Service Provider could commission the capacity of other CDN Service Providers as back-up for such occasions.

- A global CDN Service Provider could commission a local CDN Service Providers to locally deliver content in order to achieve more cost-efficient content delivery in a specific region.

- Local CDN Service Providers could team up and have a joint venture to increase their delivery footprint, competing with global CDN Service Providers over large Content Provider accounts.

Annex D (informative):
Advanced use cases

D.1   General

This annex presents advanced use cases and concepts that are not further addressed in the present document.

D.2   Caching - CDN Interconnection

Some telecom operators and Internet Service Providers deploy caching servers, a.k.a. "transparent caching" servers, in their IP networks in order to cache content mainly distributed by CDNs over Internet, with as goal to relax and balance the load on their IP networks.

Today in most situations the two overlay networks - the Upstream CDN and the Downstream set of transparent caching servers - run independently from each other. There is no specific interconnection interface between the two overlay networks.

There could be some interest to set up interfaces between these overlay networks (of course on condition that their owners get the right business incentives for).

Here are two illustrations of the potential benefits (this is not an exhaustive list):

- Setting up an interface between the two overlay networks could be beneficial for providing the Upstream CDN (and beyond the Content Provider) with useful logging, monitoring and reporting data.

- Setting up an interface between the two overlay networks could be beneficial for allowing the Upstream CDN to request that a given content file be purged from, or invalidated in, any Downstream caching server.

The first difference with the "standard" CDN interconnection use case introduced in clauses A1, A2, A3 is about resolving content location (see clause 6.7). In this "caching-CDN" interconnection use case, the CDN Interconnection solution shall allow the Downstream set of caching servers to intercept and handle the Consumer request (i.e. without this request being first redirected by the Content Provider or the Upstream CDN).

NOTE 1: Once such specific interfaces are set up between the Upstream CDN and the Downstream set of transparent caching servers, the latter ones cannot be any more considered as fully transparent, at least from the viewpoint of the Upstream CDN. This should therefore call for a slight evolution of the terminology.

NOTE 2: Regulatory aspects may impact transparent caching feasibility.

D.3   Information-centric networking and CDN interconnection

D.3.1   Background

CDN interconnection has similar goals and use cases to Information-Centric Networking (ICN). This relation could affect the work of ETSI MCD on CDN interconnection, so an informative discussion is provided here. First, a very brief description of CDNs and ICN is given in order to set the background. Then, similarities and differences in terms of objectives, technical approach, deployment and business models are discussed. Finally, the possibility of interaction and coexistence of ICN and CDN in a future Internet is discussed. CDNs are real working systems, while ICN is still at the research stage. The reader should note that the analysis below is based on the state of ICN research and the assumption that ICN will eventually meet its design goals.

A CDN is a privately owned overlay network that aims to optimize delivery of content from Content Providers to Consumers. CDNs are usually independent of each other. Optimization is in terms of performance, availability and cost. CDNs operate by serving content to Consumers from managed caches - called surrogates - at the edge of the network. CDNs may also use reserved network resources. In this case, the CDN Provider collaborates with Network Operators on surrogate placement and network resource reservation. The deployment, extension and (part of) the operation of CDNs are centrally managed. To maintain transparency for Consumers, normal content locators (e.g. URLs) are used to access content. However, the CDN treats those locators as simple content identifiers when selecting a surrogate, in effect, decoupling the locator from the content location.

ICN shares many of the goals of CDNs. Optimization of delivery with ICN usually entails caching, QoS-aware routing and traffic differentiation, to various degrees. Unlike CDNs, ICN aims at operating natively at the network level (although operation as an overlay is also possible). A Network Operator deploys ICN-enabled elements (mainly routers) with minimal planning in terms of content demand. The reach of ICN grows without any central management as each Network Operator becomes ICN-enabled. For content access, ICN uses explicit content identifiers that are independent from the content location.

A CDN constitutes an administrative domain, whereas in ICN an administrative domain can be as granular as an ICN router. When viewed in terms of administrative domains, CDN interconnection resembles the interconnection of ICN elements/domains. The interconnection of ICN domains is itself an Information-Centric Network, as the interconnection of CDNs is still a CDN.

D.3.2   Comparison of ICN and CDNs

D.3.2.1   Objectives

A main objective of both CDNs and ICN is the effective delivery of content from Content Providers to Consumers. ICN also aims at accommodating end-users who can be both Consumers and Content Providers. The decoupling of content identifiers from the content location is an explicit goal in ICN, while in CDN this is a by-product.

D.3.2.2   Technical approach

The main elements of a CDN are a set of content servers and a request redirection system. The content servers are carefully placed to be close to the Consumers and can be populated prior to any requests based on foreseen demand. A Consumer requests content with a normal URL, which triggers a part of the redirection system that resides at the seeming location of the content. The redirection system selects a content server based on criteria aiming to optimize some aspect of the delivery task. The selected content server then delivers the requested content to the Consumer.

In ICN, any edge router with storage capabilities can act as a content server, which is populated based on actual demand. Alternatively, or in addition, QoS-aware routing and traffic differentiation techniques are used to establish a path from the content source to the Consumer. Content is requested with a dedicated identifier. This identifier can be used to route the request to the content source or to an intermediate content server, while constructing the path. Alternatively, the identifier can be used as an index in a directory system to retrieve content metadata. The metadata are then used to setup a path from the content source to the Consumer.

D.3.2.3   Deployment

A CDN is deployed as an overlay with all its elements independent from Network Operators and belonging to the same CDN Provider. The CDN Provider works closely with the Content Provider in order to ingest and place content. There's also close collaboration between the CDN Provider and the Network Operators for server placement and reservation of resources. Once the CDN is operational, any unforeseen change in Content Provider requirements, network conditions or Consumer demand will force the CDN Provider to re-design the deployment. To avoid this, CDNs are designed with over-provisioning and redundancy.

On the other hand, ICN is deployed as Network Operator infrastructure. Each Network Operator owns and independently manages the ICN elements in its domain. There's no "ICN Provider" to oversee the deployment of ICN. The system grows as each Network Operator becomes ICN-enabled. In order to use ICN, Content Providers need to provide content source servers and content metadata. ICN is designed with flexibility in mind, which permits handling of unforeseen events.

D.3.2.4   Business models

In a typical business case for CDNs, a CDN is deployed in a Network Operator domain and the Network Operator acts both as a CDN Provider and as a Content Provider. Network Operators use this model to offer content services, such as IPTV, to their customers and so to differentiate their business. In another model for CDNs, a CDN Provider agrees with several Network Operators to deploy content servers and reserve resources in their domain. The CDN Provider, e.g. Akamai, then sells content delivery services to interested Content Providers.

The ICN business model is very similar to that for connectivity services. A Network Operator deploys ICN in its domain and makes transit or peering agreements with other ICN-enabled Network Operators. The Network Operator then offers content delivery services to Content Providers. It is also possible for the Network Operators to offer content consumption premium services to its customers.

D.3.3   Interconnection of ICN and CDNs

In a future Internet where ICN is deployed by only some Network Operators, it would be difficult to meet end-to-end the ICN performance goals. This is because those domains that have not deployed ICN would create gaps in the Information-Centric Network. In such a case, CDNs can act as overlay bridges, because they might already have content close to the downstream ICN domain. In essence, CDN Providers would become Content Providers for ICN. However, the incentive for the CDN Provider is unclear, because such a move could undermine its own content delivery service. Borrowing from the motivation for the interconnection of CDNs, a CDN Provider who wants to extend its reach, instead of interfacing with a neighbouring CDN, could interface with an ICN-enabled Network Operator. This is of course a scenario that only market forces and time can validate.

History

Document history		
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