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**Media Content Distribution (MCD);**
**MCD framework;**
**Part 9: Content Delivery Infrastructures (CDI)**

Reference
DTR/MCD-00008

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# Contents

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# Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Media Content Distribution (MCD).

The present document is part 9 of a multi-part deliverable. Full details of the entire series can be found in part 1 [i.1].

The present document is part of a series of Technical Reports that are providing a landscape of the subjects pertaining to Media and Content Distribution. The present document reviews Content Delivery Infrastructures.

# Introduction

The last decade has seen a flurry of standards compete for attention in the space of IPTV and mobileTV, in addition to an already large number of proprietary systems. This has resulted in confusion and a lack of agreed standards, leading to the domination of proprietary implementations. Because these implementations could work in isolation without adverse relationships with the IP networks, the damage was limited to the creation of non interoperable islands, with operators building their proprietary universe in a piecemeal fashion with very limited possible reuse, increasing costs.

The next steps are seeing how TV and video applications now connect to the internet at large. The internet is a different setting: it is shared by everyone and based on strongly established legacy standards, but it is also facing the challenge of delivery content on a scale that may be above its capabilities. The growth of the Web has been made possible by the internet commercial Content Delivery Networks, which has allowed large-scale delivery of Web content.

The role of the present document is to set the stage for creating Technical Specifications in the domain of Content Delivery Infrastructures standards.

# 1 Scope

The present document is part 9 of the set of documents described in TR 102 688-1 [i.1].

The present document describes the domain of Content Delivery Infrastructures and the existing solution elements. It also identifies the Use Cases and Requirements that should be satisfied by the resulting solution, perform a Gap Analysis of the state of the art with respect to the requirements and outlines elements of solution that could result in new specifications.

# 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.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

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## 2.1 Normative references

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

Not applicable.

## 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] ETSI TR 102 688-1: "Media Content Distribution (MCD); MCD framework; Part 1: Overview of interest areas".

[i.2] ETSI TR 102 688-2: "Media Content Distribution (MCD); MCD framework; Part 2: Views and needs of content providers".

[i.3] ETSI TS 182 019: "Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); Content Delivery Network (CDN) Architecture".

[i.4] IETF RFC 3466: "A Model for Content Internetworking (CDI)".

[i.5] ETSI TS 102 990: "Media Content Distribution (MCD); CDN Interconnection, use cases and requirements".

[i.6] Recommendation ITU-T Y.1910: "IPTV architecture document".

[i.7] ETSI TS 126 234 (V9.3.0): "Universal Mobile Telecommunications System (UMTS); LTE; Transparent end-to-end Packet-switched Streaming Service (PSS); Protocols and codecs (3GPP TS 26.234 version 9.3.0 Release 9)".

[i.8] Recommendation ITU-T Y.2019: "Content delivery functional architecture in NGN".

[i.9] ETSI TS 126 237: "Universal Mobile Telecommunications System (UMTS); LTE; IP Multimedia Subsystem (IMS) based Packet Switch Streaming (PSS) and Multimedia Broadcast/Multicast Service (MBMS) User Service; Protocols (3GPP TS 26.237)".

[i.10] ISO/IEC 23009-1: "Dynamic Adaptive Streaming over HTTP".

[i.11] ISO 14721:2003: "OAIS (Open Archival Information System) Reference model".

[i.12] ISO 20652:2006: "PAIMAS (Producer-Archive interface methodology abstract standard)".

[i.13] ETSI TS 126 247 (V10.0.0): "Universal Mobile Telecommunications System (UMTS); LTE; Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH) (3GPP TS 26.247 version 10.0.0 Release 10)".

[i.14] IETF RFC 3568: "Known Content Network (CN) Request-Routing Mechanisms".

[i.15] IETF RFC 3570: "Content Internetworking (CDI) Scenarios".

[i.16] IETF RFC 3143: "Known HTTP Proxy/Caching Problems".

[i.17] Draft-pantos-http-live-streaming-01.

NOTE: Available at http://tools.ietf.org/html/draft-pantos-http-live-streaming-01.

[i.18] Draft-pantos-http-live-streaming-06.

NOTE: Available at http://tools.ietf.org/html/draft-pantos-http-live-streaming-06.

[i.19] ATIS-0800007: "IPTV High Level Architecture".

[i.20] IETF draft-bertrand-cdni-experiments.

NOTE: Available at http://tools.ietf.org/html/draft-bertrand-cdni-experiments-02 .

[i.21] IETF draft-bertrand-cdni-use-cases.

NOTE: Available at http://tools.ietf.org/html/draft-ietf-cdni-use-cases-08.

[i.22] IETF draft-davie-cdni-framework.

NOTE: Available at http://tools.ietf.org/html/draft-davie-cdni-framework-01 .

[i.23] IETF draft-deventer-cdni-content-terminology.

NOTE: Available at http://tools.ietf.org/html/draft-deventer-cdni-content-terminology-00 .

[i.24] IETF draft-ietf-cdni-problem-statement.

NOTE: Available at http://tools.ietf.org/html/draft-ietf-cdni-problem-statement-08 .

[i.25] IETF draft-jenkins-cdni-names.

NOTE: Available at http://tools.ietf.org/html/draft-jenkins-cdni-names-00.

[i.26] IETF draft-jenkins-cdni-problem-statement.

NOTE: Available at http://tools.ietf.org/html/draft-ietf-cdni-problem-statement-03.

[i.27] IETF draft-lefaucheur-cdni-requirements.

NOTE: Available at http://tools.ietf.org/html/draft-lefaucheur-cdni-requirements-02 .

[i.28] IETF draft-ma-cdni-publisher-use-cases.

NOTE: Available at http://tools.ietf.org/html/draft-ma-cdni-publisher-use-cases-00.

[i.29] IETF draft-peterson-cdni-strawman.

NOTE: Available at http://tools.ietf.org/html/draft-peterson-cdni-strawman-00.

[i.30] IETF draft-stiemerling-cdni-routing-cons.

NOTE: Available at http://tools.ietf.org/html/draft-stiemerling-cdni-routing-cons-00.

[i.31] IETF draft-thompson-cdni-atis-scenarios.

NOTE: Available at http://tools.ietf.org/html/draft-thompson-cdni-atis-scenarios-00.

[i.32] IETF draft-watson-cdni-use-cases.

NOTE: Available at http://tools.ietf.org/html/draft-watson-cdni-use-cases-00.

[i.33] IETF draft-xiaoyan-cdni-requestrouting.

NOTE: Available at http://tools.ietf.org/html/draft-xiaoyan-cdni-requestrouting-01.

[i.34] IETF draft-zhou-cdni-use-case.

NOTE: Available at http://tools.ietf.org/html/draft-zhou-cdni-use-case-01.

[i.35] IETF Distribution Requirements for Content Internetworking.

NOTE: Available at http://tools.ietf.org/html/draft-amini-cdi-distribution-reqs-02 .

[i.36] IETF Security Threat for Content Internetworking.

NOTE: Available at http://tools.ietf.org/html/draft-ietf-cdi-threat-00.

[i.37] CableLabs MD-SP-ADI1.1-I04-060505: "CableLabs® Asset Distribution Interface Specification Version 1.1".

[i.38] OIPF Volume 1 - Overview, release 2.

NOTE: Available at http://www.oipf.tv/specifications.

[i.39] OIPF Services and functions for Release 2.

NOTE: Available at http://www.oipf.tv/specifications.

# 3 Definitions and abbreviations

## 3.1 Definitions

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

**adaptive streaming:** process that adjusts the quality of a video based on changing network conditions to ensure the best possible viewer experience

**Content Delivery Infrastructures (CDI):** system of equipments and networks which role is to ensure efficient delivery of Content to clients

NOTE: Content Delivery Networks are typical examples.

**Content Delivery Network (CDN):** system of computers containing copies of data, placed at various points in a network so as to maximize bandwidth for access to the data from clients throughout the network

NOTE: Also known as Content Distribution Network (CDN).

**content delivery:** describes the delivery of Content Items over a delivery medium such as broadcasting or the Internet

**content distribution:** act of moving content between CDNs

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

**content item:** piece of media "content" such as audio or video or computer software

**content preparation:** act of preparing content and metadata before its ingestion into a CDN

**progressive download:** type of streaming in which the audio or video file begins to play after a certain minimum amount of data has been transferred, rather than requiring the entire file to be downloaded before playback starts

**web cache:** caching of web documents (e.g. HTML pages, images, video, etc.) to reduce bandwidth usage, server load and perceived lag

NOTE: A web cache stores copies of documents passing through it; subsequent requests may be satisfied from the cache if certain conditions are met.

**web proxy:** in computer networks, server (a computer system or an application program) that acts as an intermediary for requests from clients seeking resources from other servers

## 3.2 Abbreviations

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

| | |
|---|---|
| ADI | CableLabs Asset Distribution Interface |
| BCAST | Broadcast Services (OMA) |
| CCF | Cluster Controller Function |
| CD&LCF | Content Distribution & Location Control Functions |
| CD&SF | Content Delivery & Storage Functions |
| CDI | Content Delivery Infrastructure |
| CDN | Content Delivery Network |
| CDNCF | Content Delivery Network Control Function |
| CDN-I | Content Delivery Network Interconnection |
| CN | Content Network |
| CORBA | Common Object Request Broker Architecture |
| DASH | Dynamic Adaptive Streaming over HTTP |
| DCD | Dynamic Content Delivery (OMA) |
| DTG | Digital TV Group |
| FFS | For Further Study |
| FTP | File Transfer Protocol |
| GSI | Global Standards Initiative |
| HTTP | Hyper Text Transfer Protocol |
| HTTPS | Hypertext Transfer Protocol Secure |
| IIF | Interoperability Forum |
| IMS | IP Multimedia Subsystem |
| IP | Internet Protocol |
| IPTV | Internet Protocol television |
| ITF | IPTV Terminal Function |
| MCD | Media Content Delivery |
| MPEG | The Moving Picture Experts Group |
| NGN | Next Generation Network |
| OAIS | Open Archival Information System |
| OIPF | Open IPTV Forum |
| OMA | Open Mobile Alliance |
| PAIMAS | Producer-Archive Interface Methodology Abstract Standard |
| PIM | Personal Information Manager |
| RTMP | Real Time Messaging Protocol |
| RTP | Real-Time Protocol |
| RTSP | Real-Time Streaming Protocol |
| SDP | Service Delivery Platform |
| SIP | Session Initiation Protocol |
| STB | Set Top Box |
| TV | TeleVision |
| UDP | User Datagram Protocol |
| UE | User equipment |
| URI | Uniform Ressource Identifier |
| VOD | Video On Demand |

# 4 Role of Content Delivery Infrastructures

The role of Content Delivery Infrastructure is to efficiently, scalably and with adequate performance and timeliness distribute content items to final customers.

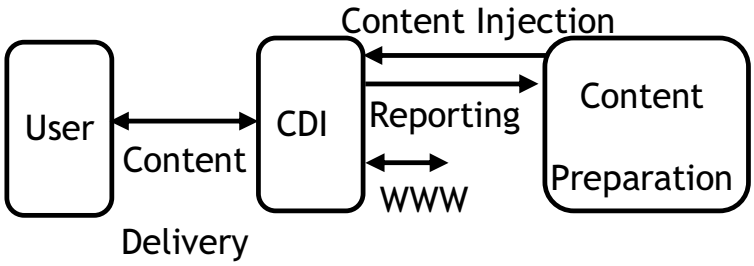


**Figure 1: CDN in context**

CDIs interact with two main entities: Content Provision on the upstream and Clients (users) on the downstream.

CDIs get their content from an upstream source: the Content Provision. The Content Provision typically injects content into the CDI and extracts or receives reports on content consumption.

The role of the CDI is to respond to user requests for given pieces of content. The "Content Delivery" relationship is constrained by what protocols clients implement.

Alternatively, the CDI can retrieve content from the internet on behalf of the client, thus behaving like a Web Proxy.

# 5 Use cases and Requirements

This clause gathers use case and requirements from earlier MCD documents (notably [i.2]) and adds more elements that were derived from a more precise understanding of the content delivery landscape.

## 5.1 Requirements from Content Providers

The following requirements are being abstracted from the "Needs of content Providers" document [i.3]:

- R1: Support of Content access through a Content Portal
- R2: Support for protected content delivery, support for different Content Protection Mechanisms
- R3: Support for content delivery reporting mechanisms (optionally qualified by destination, time, etc.)
- R4: Support for file-based and stream-based content delivery
- R5: Support for Progressive Download and Adaptive Streaming
- R6: Support of a mechanism to remove content items from the CDI
- R7: Support for joint delivery of Metadata and Content
- R8: Support for control of delivery based on geographic location criteria
- R9: Support for Push and Pull models of content provision
- R10: Content Format neutrality, including content encapsulation and content protection
- R11: Support for Multicast Delivery

## 5.2 Specific Use Cases

The content Delivery Infrastructure should satisfy the following use cases:

User

- **UC1:** Operator content Live Streaming: an operator offers content for live streaming, the user retrieves the content from the CDI as it is being played
- **UC2:** Internet content Live Streaming: an item of content is offered by an internet content provider, the user retrieves the content from the CDI as it is being played
- **UC3:** Operator content downloading: an operator offers content download, the user retrieves the content from the CDI for later consumption
- **UC4:** Internet content downloading: an item of content is offered by an internet content provider, the user retrieves the content from the CDI for later consumption
- **UC5:** Interconnection of CDNs for wide distribution
- **UC6:** Interoperable Content Injection
- **UC7:** Mobile streaming: an operator offers content for live streaming, the mobile user retrieves the content from the CDI as it is being played, through the mobile network

CDN Interconnection Use Cases should be looked up in annex A of [i.5].

## 5.3 Specific Requirements

The following requirements should be satisfied by the Content Delivery Infrastructure:

Network:

- RN01: Should work on basic IP networks
- RN02: Should be portable on different network infrastructures (ITU-T or ETSI NGN, 3GPP, IETF, etc.)
- RN03: Should not require deep integration with a specific underlying infrastructure
- RN04: Should not unnecessarily prescribe CDN implementation
- RN05: Should support delivery to mobile terminals as well as fixed terminals
- RN06: Should optionally support specific delivery modes for mobile terminals
- RN07: Should optionally support QoS for delivery of content to the user
- RN08: Should not expose QoS in the user interface
- RN09: Should reuse existing protocols to the maximum possible extent
- RN10: Should be reusable for different applications

User-related:

- RU1: Should support basic delivery protocols: HTTP and optionally RTSP/RTP
- RU2: Should support progressive download and Adaptive Streaming delivery modes where applicable
- RU3: Should support trick modes for Content Delivery
- RU4: Should support geographic proximity Content Delivery
- RU5: Should support mechanisms for request routing (i.e. allowing requests to be transferred to different entities to improve the operation efficiency)

Content:

- RC1: Should support CDI operator content
- RC2: Should support content accessed over the wwweb (through http) as an option
- RC3: Should be agnostic to content format:
  - Accommodate different codecs
  - Accommodate different content protection mechanisms
  - Reduce need for processing metadata

Content Injection:

- CI1: Should allow Injection of Content Items in file format
- CI2: Should allow injection of Content in Stream Format
- CI3: Should provide clear indication of injection status
- CI4: Should provide the information necessary to access the content (e.g. URI)
- CI5: Should enable reporting of Content Access statistics for a given Content Item

CDN Interconnection:

- RI1: Should support interconnection of Identical or Heterogeneous CDNs:
  - Should support CDN federation use cases
  - Should support CDN resource sharing use cases

# 6 Taxonomy of CDNs

There are different types of Content Delivery networks, that can be differentiated on their main purpose, where and how they obtain content items, how they are controlled and deliver the content. Some criteria are the following:

- Origin of the content (Internet, Internally stored content, Third party, etc.)
- Destination and protocol of the content (IPTV STB with specific protocols, HTTP browser, etc.)
- Other criteria

The categories described here are non-exclusive and can be combined to form a more elaborate form of CDN.

| | | Content Origin | |
|---|---|---|---|
| | | Internet | Stored |
| Content Destination | IPTV STB | IPTV cache | IPTV CDN |
| | Generic HTTP client | Proxy cache | HTTP CDN |

**Figure 2**

## 6.1 Traditional Internet CDN

The category for Traditional Internet CDNs encompass the common Internet commercial WWW content hosting solutions.

Functionally, they receive HTTP requests directly from users and serve those requests from a conglomerate of geographically distributed servers.

The Input interface is not specified, though it can be composed of different interfaces based on standard protocols (HTTP and HTTPS, FTP, etc.). Sometimes protocols are supported for specific purposes (Adobe® RTMP, etc.).

The reporting interface is even less specified and can range from tailored HTTP+HTML to raw logs or text files obtained in a variety of ways.

## 6.2 Operator VOD CDNs

Operator VOD CDNs are specialized for the delivery of stored content items and serve those requests from a conglomerate of geographically distributed servers within an operator network.

In many cases, VOD CDNs are integrated within an IPTV system and are controlled by system-specific protocols (SIP, RTSP, etc.)

## 6.3 Caches

Caches (often designated in web architectures as proxy-caches because the cache impersonates servers) are mediators between the internet and users, storing popular content items to provide better response times and lighten the load on the connection towards the internet.

# 7 State of the art

This clause goes through the main standards and proprietary solution elements related to Content Delivery.

## 7.1 Existing and upcoming CDN Architecture Standards

### 7.1.1 ITU-T IPTV GSI, SG13 and SG16

Starting with the IPTV Focus Group, ITU-T has developed a "Content Delivery Functions" Functional Block which role is essentially an IPTV-targeted CDN (largely for the support of operator-hosted VOD) that was integrated in its IPTV architecture document [i.6]. More recently this CDN was precised in a specific recommendation on CDN functional architecture [i.8].

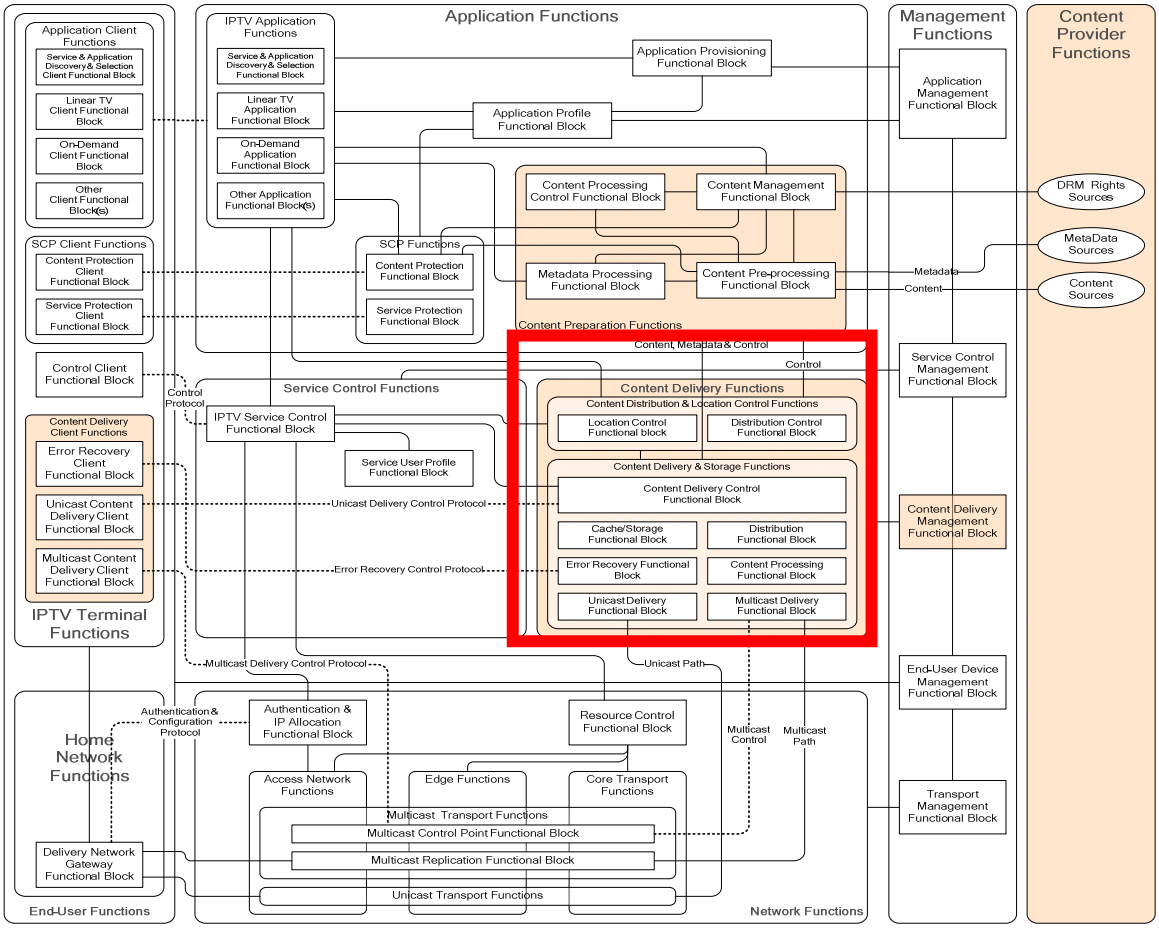


**Figure 3: Recommendation ITU-T Y.1910 [i.6] Overall Architecture**

The CDN functional block is depicted with several sub-components and internal interfaces.

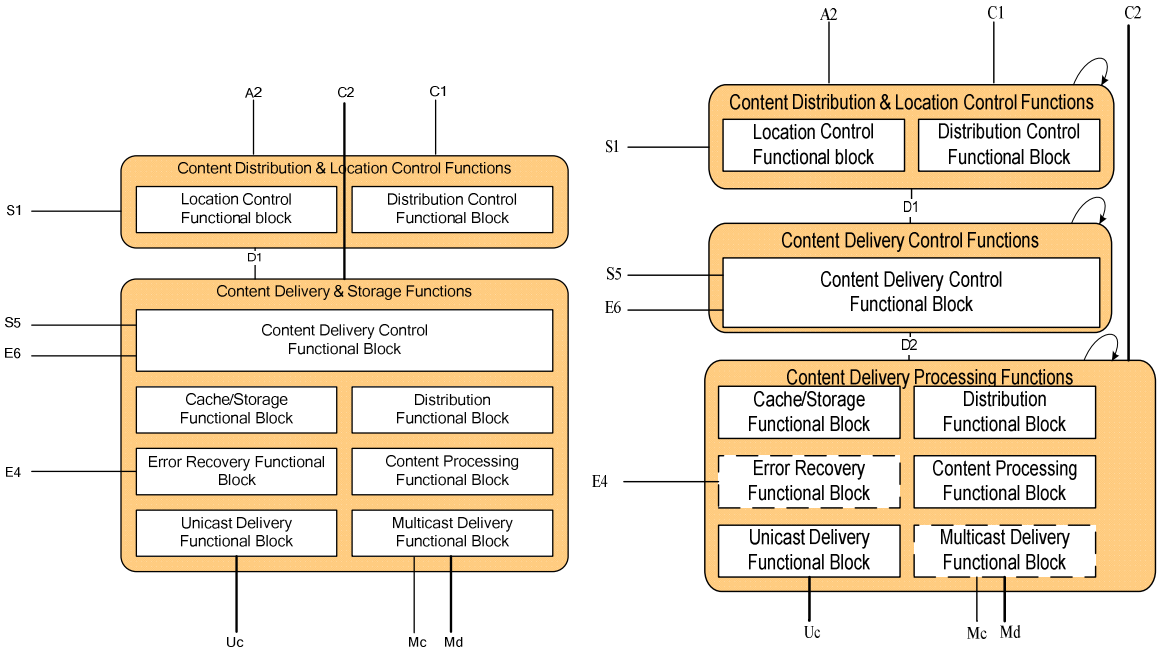


**Figure 4: Recommendation ITU-T Y.2019 [i.8] detailed Content Distribution Architecture**

The above figures depict the architecture as in Recommendation ITU-T Y.1910 [i.6] (figure 3) and as in Recommendation ITU-T Y.2019 [i.8] (figure 4). It should be noted that Recommendation ITU-T Y.2019 [i.8] does not redefine or change the external interfaces defined in Recommendation ITU-T Y.1910 [i.6] but adds internal components and interfaces.

The external interfaces to the CDN components are:

- Service Control:
  - S1 (S1' is identical to S1) used to forward the service signalling messages, e.g. service requests, content resource requests, between the ITF/IPTV application functions and the CD&LCF. For the IMS variant, S1 is defined as SIP. For other variants, the protocol is not specified in Recommendation ITU-T Y.1910 [i.6] (FFS).
  - E4 used to exchange messages for requesting and delivering error recovery information. Protocol not specified in Recommendation ITU-T Y.1910 [i.6] (FFS).
  - E6 used to exchange content control messages, e.g. video recording commands. Defined as RTSP in Recommendation ITU-T Y.1910 [i.6].
- Input (Ingestion):
  - A2 used by the IPTV applications functional block to request service parameters from CD&LCF. Protocol not specified in Recommendation ITU-T Y.1910 [i.6] (FFS).
  - C1 used to facilitate content preparation functions to configure policies such as content distribution rules, selection criteria, etc. in the CD&LCF. Protocol not specified in Recommendation ITU-T Y.1910 [i.6] (FFS).
  - C2 used to transfer content from content preparation functions to CD&SF. Protocol not specified in Recommendation ITU-T Y.1910 [i.6] (FFS).
- Transport:
  - Uc (also called Ud in Recommendation ITU-T Y.1910 [i.6]) used by the CD&SF to deliver content streams in unicast mode. Defined as RTP over UDP in Recommendation ITU-T Y.1910 [i.6].
  - Mc used to pass information to allow for the dynamic computation, establishment and maintenance of multicast trees. Defined as PIM in Recommendation ITU-T Y.1910 [i.6].
  - Md used by the CD&SF to deliver content streams in multicast mode. Defined as RTP over UDP in Recommendation ITU-T Y.1910 [i.6].

#### 7.1.1.1 Assessment

Many of the external interfaces appear to be in line with the CDI requirements (notably the Transport interfaces Uc/Ud MC/Md, possibly C2), however some introduce coupling that might be contrary to several requirements:

- S1 is based on IMS in one of the variants, which introduces coupling with an IMS subsystem which may contradicts the requirement on network architecture neutrality.
- E4 introduces a dependency on external error recovery mechanisms.
- A2 and C1 introduce coupling between the content preparation and CDN functions. The internal structure appears to constrain the implementation in contradiction with requirement RN04.

There is no explicit consideration of the requirement to interconnect CDNs between different operators, though there is provision of hierarchical relationships between CDN components. This appears to prevent CDN interconnection of CDN components not compliant with Recommendation ITU-T Y.2019 [i.8].

However it may be possible to specify a subset of Y.1910 that would be appropriate for the purpose of CDI, if it is complemented with a heterogeneous CDN interconnection addition. That subset should concentrate on the external interfaces while omitting the specification of internal mechanisms and reference points. Because most of the specification in Recommendation ITU-T Y.2019 [i.8] relates to internal coordination mechanisms and protocols, there is little that can be considered appropriate for CDI whose purpose is mainly external interfaces to the CDI.

### 7.1.2 ETSI TISPAN

ETSI TISPAN started considering Content Delivery Networks as addition to its Release 3 IPTV specification. Starting first as an IPTV-oriented CDN for VOD in the IMS IPTV, it has grown in every direction to cover IMS-IPTV and dedicated IPTV, but also Internet-service and even CDN interconnection. The goal was provide single CDN for both TISPAN NGN based IPTV architecture as alternative and from scalability reason to media functions (media delivery and media control).

TS 182 019 [i.3] (Content Delivery Network (CDN) architecture - Interconnection with TISPAN IPTV architectures) describe architectural principles of a CDN as shown in figure 5.

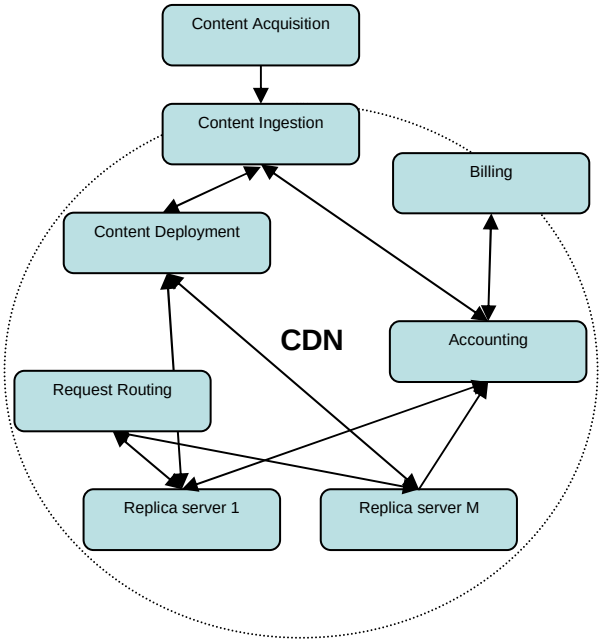


**Figure 5: Architectural components of a CDN**

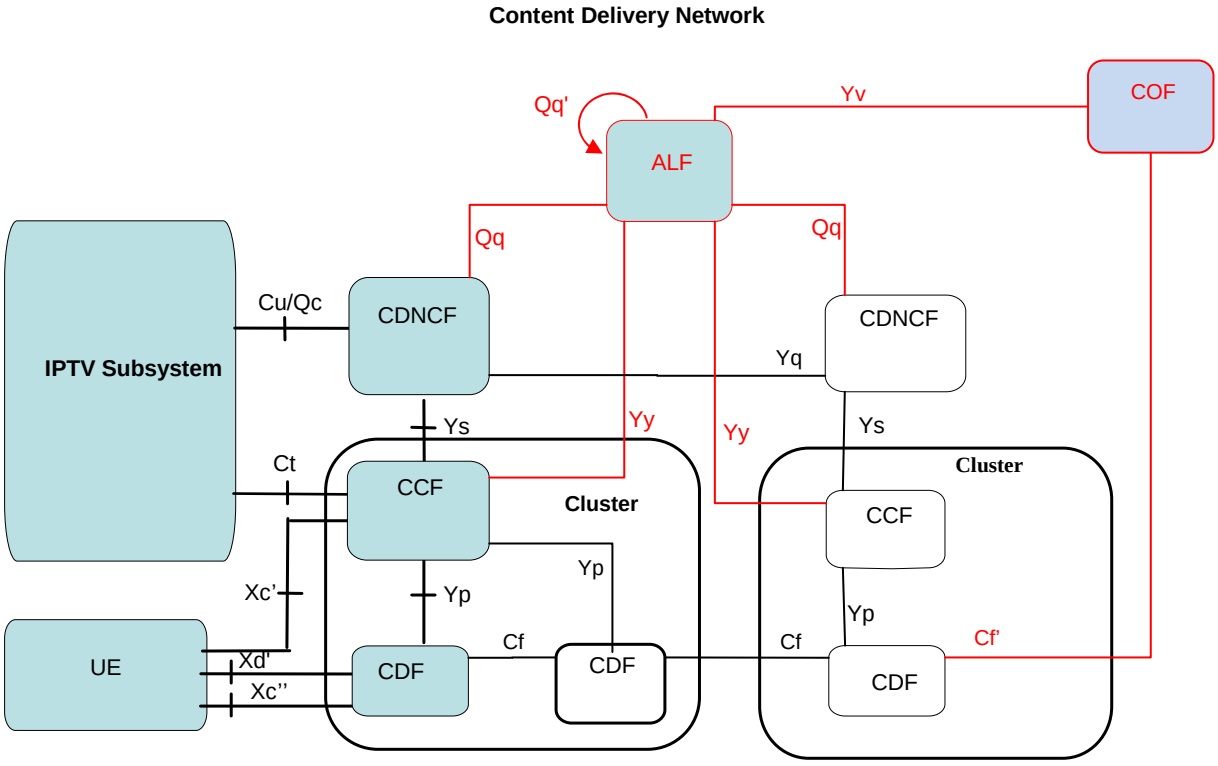


**Figure 6: Overall view of the TISPAN CDN architecture**

Figures 5 and 6 show in order: the CDN architecture and its relationship to the IPTV subsystem and UEs, the different CDN functional entities.

TISPAN CDN architecture describe a number of external Interfaces that are specified in [i.3]:

- Interfaces to IPTV service platforms (Cu Qc Ct):
  - Service control related interface, in charge of initiating the delivery the requested content to the UE (Cu, identical to Y2 in IMS-based IPTV, identical to Sa in Integrated IPTV)
  - Management related interface, in charge of administration and provisioning tasks
    - Allows the IPTV subsystem to query the CDNCF for the CCF to be contacted for a content (Qc)
    - Carries IPTV service control signalling originating from the IPTV subsystem to CCF (Ct, identical to Y2 in IMS-based IPTV, identical to Sa in Integrated IPTV)
- Interfaces to UE:
  - Content control related interface (Xc' and Xc'', functionally equivalent to RTSP)
  - Media delivery interface(Xd'): Delivery information is sent to the UE, after which delivery is initiated and completed by the UE
- Interface towards content distribution systems:
  - Service control related interface
  - Media delivery interface

#### 7.1.2.1 Assessment

Many of the external interfaces appear to be in line with the CDI requirements, however some introduce coupling that might be contrary to several requirements:

- Y2 ties to the IMS subsystem
- In effect each outside component needs to be aware of the existence of multiple internal CDN components, possibly requiring specific connection setup operations:
  - Integrated IPTV subsystem needs to know about the CDNCF (for Qc) and CCF (for Ct)
  - UE needs to know about CCF (for XC') and Cf (for Xc" otherwise identical to Xc' and Xd')

The internal structure appears to constrain the implementation in contradiction with requirement RN04, but this simply means that the TISPAN CDN can be considered a specific implementation architecture for the CDI, at least for the subpart that not controlled with IMS.

There is an explicit provision for CDN interconnection between TISPAN CDNs. This could prevent interconnection of CDNs which internal architecture and implementation is significantly different from TISPAN's. Should TISPAN also support an heterogeneous CDN interconnection interface, then this concern would become moot.

At this point, there are no content ingestion interfaces specified, though it is mentioned in figure 1.

It appears possible to specify a subset of TISPAN WI2076 CDN that would be appropriate for the purpose of CDI, if it is complemented with a heterogeneous CDN interconnection addition. That subset would concentrate on the external interfaces while omitting the specification of internal mechanisms and reference points. The exposure of different internal components to the outside interfaces should be hidden to address requirement RN04.

### 7.1.3 ATIS IIF

ATIS IIF has worked on an architecture that was close to that of Recommendation ITU-T Y.1910 [i.6] and inherited a similar Content Delivery Functional Block which is described in ATIS-0800007 [i.19], IPTV High Level Architecture. The specification with the best level of detail is the Content On Demand Working Text [i.6].

As with the ITU-T specifications, ATIS also retain an IMS-based and a non-IMS-based variant. The main diagram differs from ITU-T's by putting client functions on the right-hand side.

External Interfaces to the Content Delivery Component:

- End User Functions:
  - E6, used to exchange content control signalling information (e.g. session setup and teardown in the redirect case, play, pause, fast forward, rewind, download) between the ITF and the CD&SF
- Service Control Functions:
  - S1, used by the CoD Service Control Function to locate an instance of the CD&SF capable of delivering the requested content to the ITF
  - S5, used to exchange session management information between the CoD Service Control Function and the CD&SF
- Application Functions:
  - C1, used by the Content Origin Function to notify the CD&LCF of relevant information associated with an asset
  - C2, used by the Content Receiving Function to retrieve content from the Content Origin Function
  - C4, used to request security information for the purposes of session-based encryption of the content, if applicable

- Transport Functions:
  - Ud, used by the CD&SF to deliver content streams in unicast mode

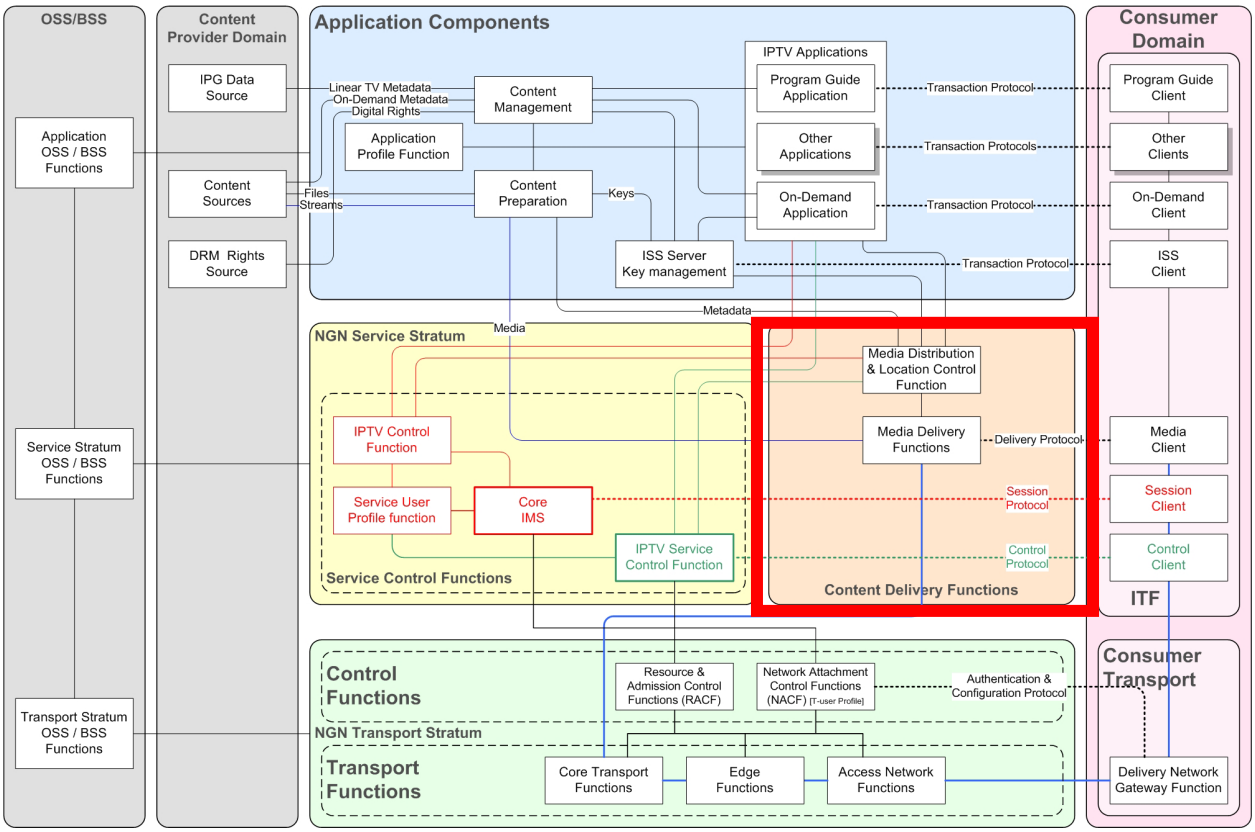


**Figure 7: ATIS IIF Overall Architecture**

### 7.1.3.1 Assessment

Many of the external interfaces appear to be in line with the CDI requirements, however some introduce coupling that might be contrary to several requirements:

- C4 exposes content encryption functions, in contraction with the CDI requirement on content format neutrality.
- S1 exposes content location functions.

The internal structure appears to constrain the implementation in contradiction with requirement RN04.

Overall the CDN appears to have been thought as tightly integrated within an IPTV system, which makes implementation more constrained and limits the applicability to more architecture-neutral systems.

There is no explicit provision for CDN interconnection.

At this point, there are no content ingestion interfaces specified, though it is mentioned in the overall diagram.

However it may be possible to specify a subset of this CDN that would be appropriate for the purpose of CDI, if it is complemented with a heterogeneous CDN interconnection addition. That subset should concentrate on the external interfaces while omitting the specification of internal mechanisms and reference points. The exposure of different components to the outside interfaces should be hidden.

### 7.1.4 Open IPTV Forum

The OpenIPTVForum has introduced a Content Delivery Component for provision of VOD in the Enhanced Managed Profile based on IMS.

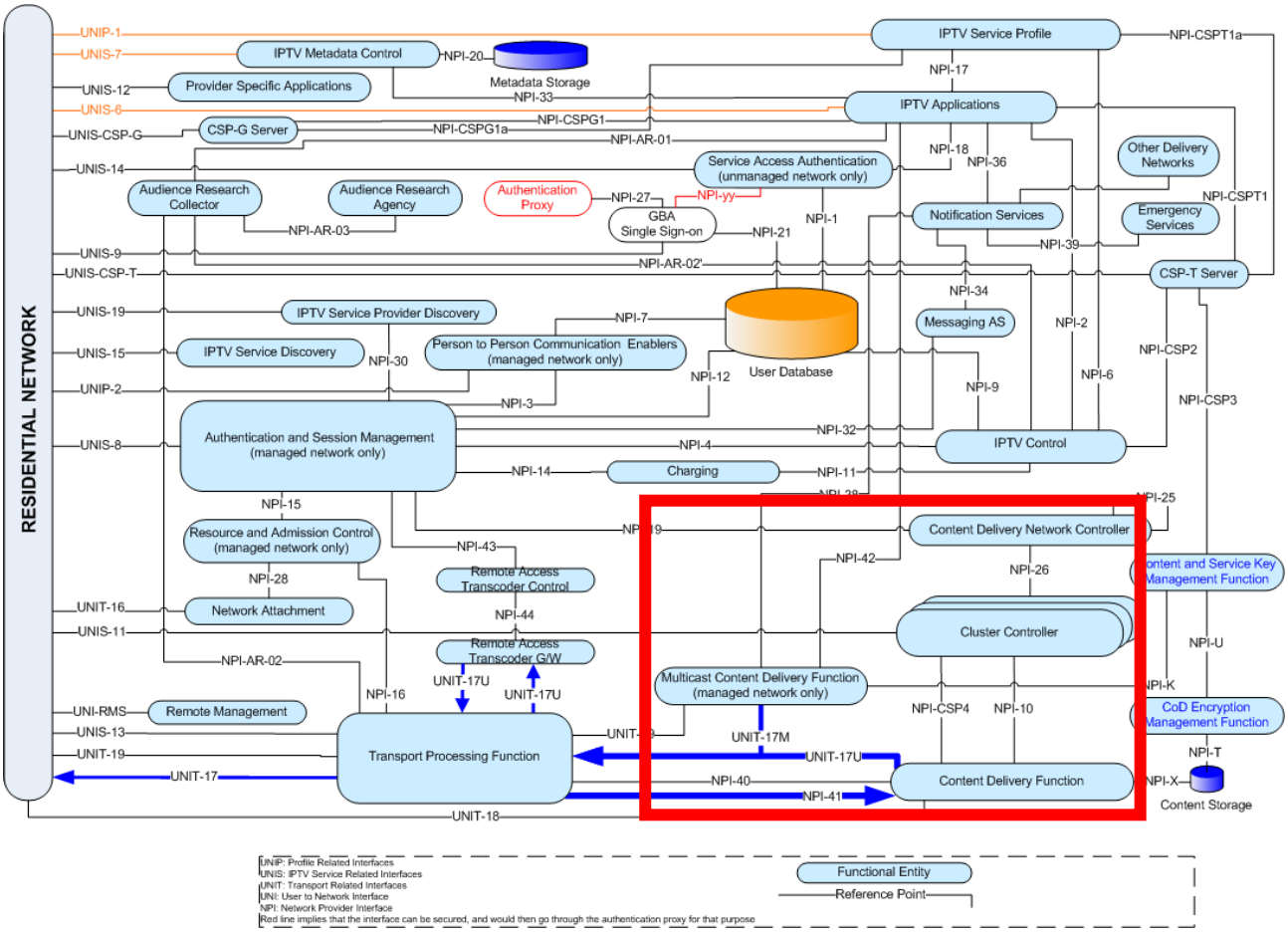


**Figure 8: Overall OIPF Architecture**

#### 7.1.4.1 Assessment

The CDN in the OpenIPTVForum is closely linked with the "Authentication and Session Management" Component (which refers to the IMS) and appears meant to serve only the Extended Managed Profile for the provision of operator VOD services. This is compounded by the fact that Control interfaces are based on SIP.

This means that the OIPF specifications OIPF Volume 1 - Overview, release 2 [i.38] and OIPF Services and functions for Release 2 [i.39] might not be able to support clients implementing simple internet-based interfaces (as included in the OIPF Open Internet Profile, or even the Baseline Managed Profile), which is in contradiction with the requirements and objectives of CDI.

### 7.1.5 DVB

DVB has produced commercial requirements for Internet-TV Content Delivery and is still in the decision process how to proceed with potential technical work.

#### 7.1.5.1 Assessment

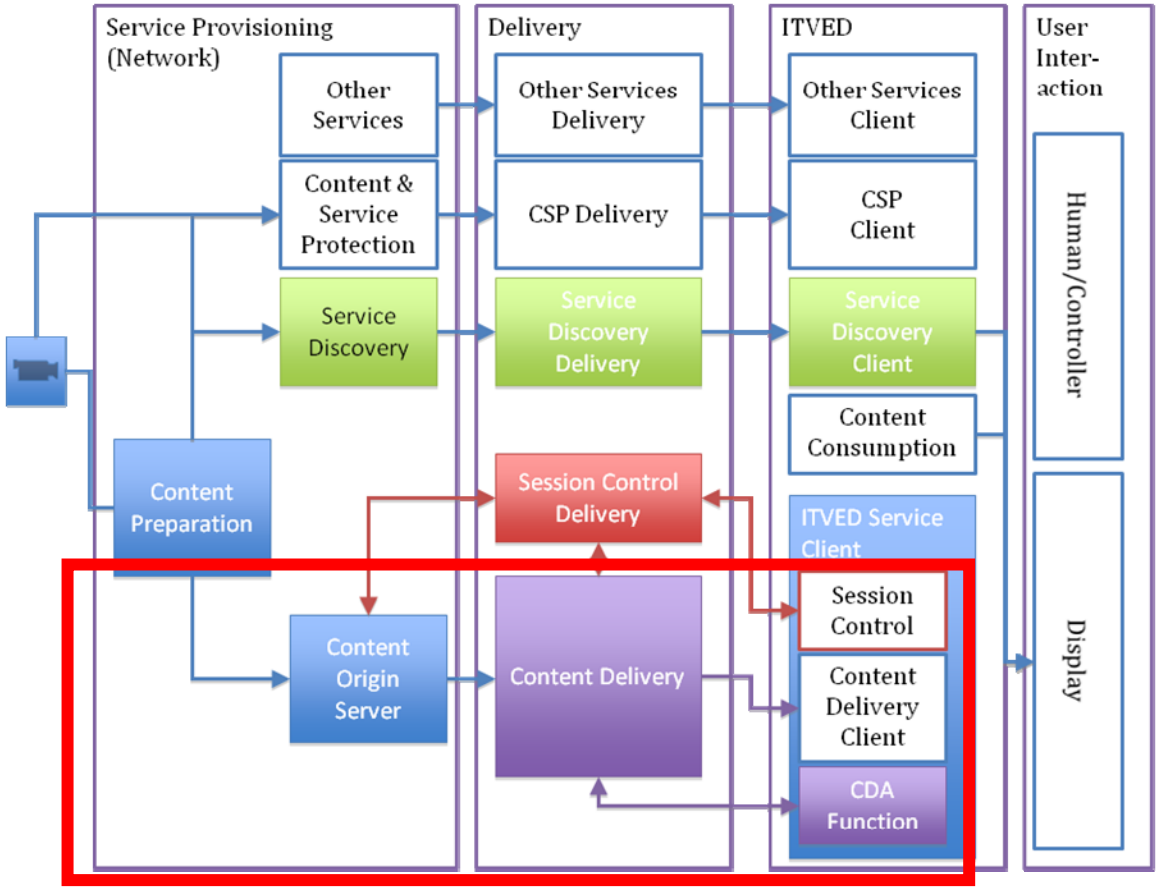


**Figure 9: DVB and Content Delivery**

### 7.1.6 3GPP

3GPP has a specification called Packet Switched Streaming whose purpose is to stream content to terminals. PSS can be used either standalone or in combination with IMS in the 3GPP architecture [i.7] and [i.9].

The PSS server performs control and streaming delivery functions on a Unicast access type. The PSS client, located in the UE, performs service selection and initiation, receives and present the content to the user.

The PSS client interfaces to the PSS server transparently through the Packet Switch Network. The PSS client can discover the PSS services via multiple means like e.g. browsing. The session description protocol is SDP. The session control protocol is RTSP (Gi). The transport protocol is RTP.

In the IMS variant, the PSS server is accompanied by a PSS adapter which performs the translation from SIP requests to equivalent RTSP requests on the PSS Server.

#### 7.1.6.1 Assessment

Though the purpose of the PSS is a rudimentary for CDNs, there is no apparent contradiction with the CDI architecture. The PSS UE to Server interface appears to fulfil a subset of the requirements of the equivalent CDI interface.

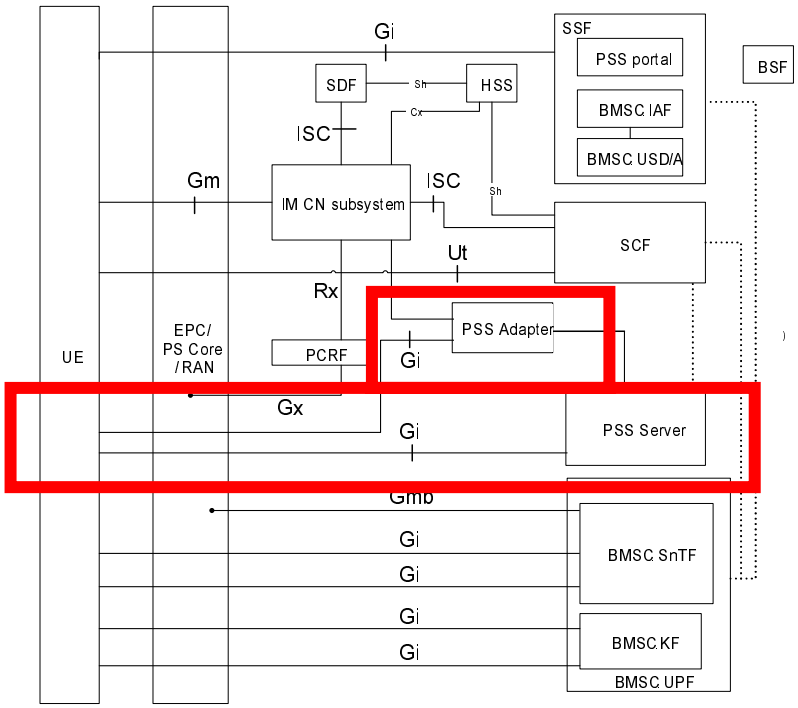


**Figure 10: 3GPP PSS Architecture**

## 7.1.7 IETF CDNi

Since april 2011, IETF has started working on Content Delivery Network Interconnection and created a working group during the summer, with significant interest from both the multimedia and networking community.

There is a significant number of drafts in progress:

- draft-bertrand-cdni-experiments [i.20]
- draft-bertrand-cdni-use-cases [i.21]
- draft-davie-cdni-framework [i.22]
- draft-deventer-cdni-content-terminology [i.23]
- draft-ietf-cdni-problem-statement [i.24]
- draft-jenkins-cdni-names [i.25]
- draft-jenkins-cdni-problem-statement [i.26]
- draft-lefaucheur-cdni-requirements [i.27]
- draft-ma-cdni-publisher-use-cases [i.28]
- draft-peterson-cdni-strawman [i.29]
- draft-stiemerling-cdni-routing-cons [i.30]
- draft-thompson-cdni-atis-scenarios [i.31]
- draft-watson-cdni-use-cases [i.32]
- draft-xiaoyan-cdni-requestrouting [i.33]
- draft-zhou-cdni-use-case [i.34]

#### 7.1.7.1 Assessment

As per its normal modus operandi, IETF will be working on a protocol to interconnect Content Delivery Networks. It will likely not specify a complete architecture that would be more complex than the CDN elements participating in the interconnection.

The uses cases are well in line with the CDI requirements and are close to those of the CDN-I work item. It will be very important to follow, contribute and reuse as much as possible this effort from the IETF.

### 7.1.8 OMA

Content distribution systems in OMA comprise OMA BCAST (Broadcast Services), OMA DCD (Dynamic Content Delivery) and OMA Push enablers, with binding to underlying delivery protocols as illustrated in figures 11 and 12.

Figure 11 illustrates the content delivery framework provided by OMA DCD, which enables contextually adaptive delivery of discrete content, as defined by metadata associated with individual service channels and content items.

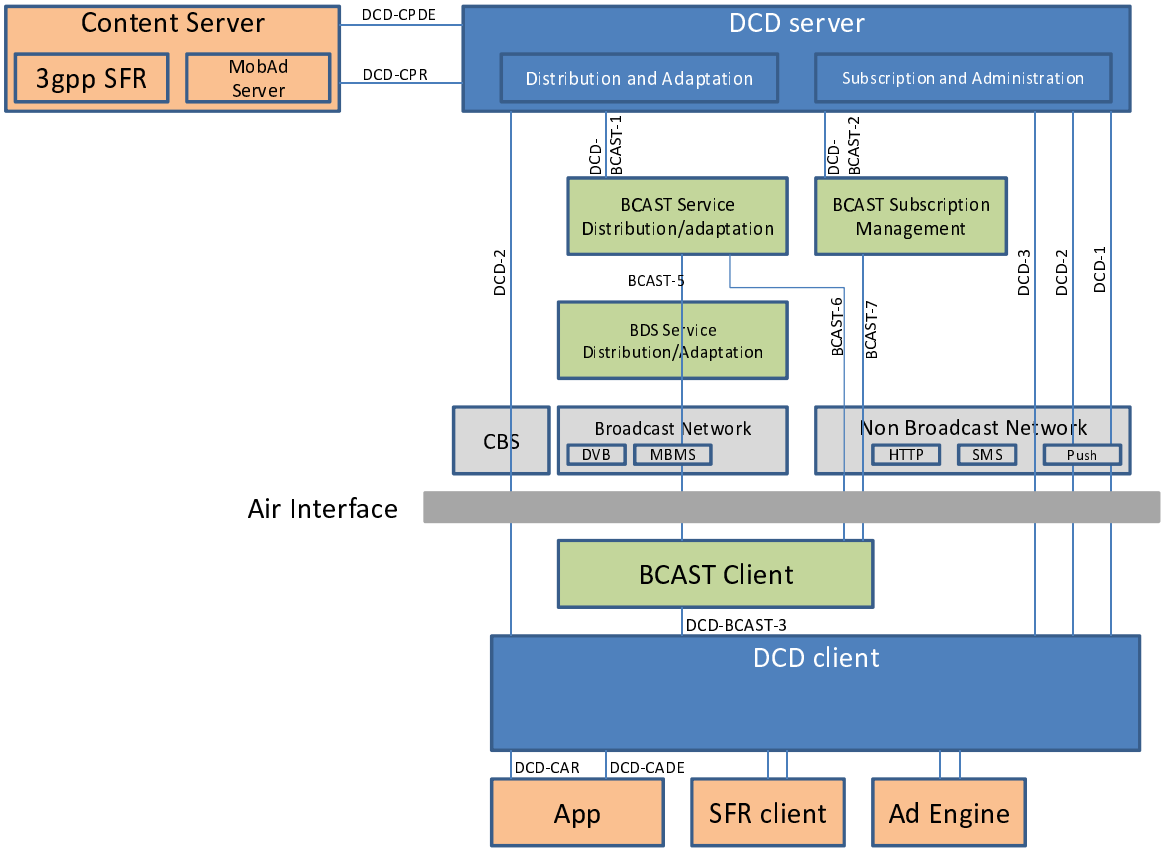


**Figure 11: OMA DCD and OMA BCAST**

Figure 12 illustrates the content delivery framework provided by OMA Push, which enables server-initiated, contextually adaptive delivery of discrete content across a variety of bearers and protocols.

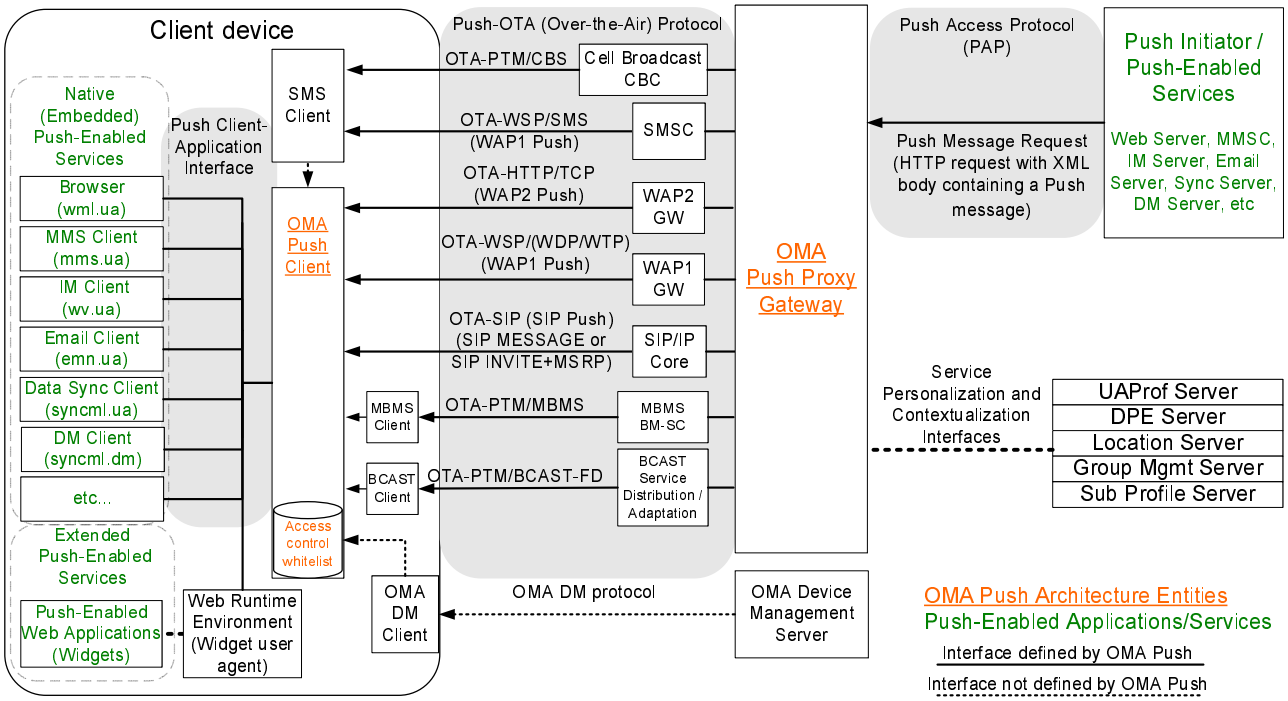


**Figure 12: OMA Push**

## 7.2 Existing and upcoming Content Delivery Protocols

### 7.2.1 HTTP

HTTP proxy caches:

- Known HTTP Proxy/Caching Problems RFC 3143 [i.16]
- Internet Web Replication and Caching Taxonomy RFC 3466 [i.4]

### 7.2.2 OIPF Adaptive Streaming

After starting an effort for Adaptive Streaming specification, OIPF has decided to follow 3GPP and to submit their requirements and extensions to 3GPP. The growing popularity of ISO MPEG DASH has led to submit modification requests to ISO MPEG, which could lead to DASH endorsement by OIPF at a later stage.

### 7.2.3 3GPP HTTP Adaptive Streaming

After an initial head start, 3GPP SA4 has decided to work with ISO MPEG to make their specification a subset of the ISO specification.

3GPP SA4 has published an adaptive streaming specification as part of its release 9 [i.7]. The latest release of the specification for release 10 has been approved in summer 2011 and available as TS 126 247 [i.13]. Significant effort has been made to align the specification with MPEG DASH.

### 7.2.4 MPEG DASH

MPEG has nearly completed its specification on Dynamic Adaptive Streaming over HTTP [i.10]. DASH (Dynamic Adaptive Streaming for HTTP) which has been published.

DASH specifies only the format of what is transmitted on the network between a client and an associated server. It is able to accommodate several content protection schemes.

### 7.2.5 ATIS Adaptive Streaming

After initial consideration of original work, ATIS IIF has decided to follow ISO MPEG DASH.

### 7.2.6 DVB Adaptive Streaming

DVB has produced commercial requirements for Internet-TV Content Delivery which are including Adaptive Streaming and is still in the decision process how to proceed with potential technical work.

### 7.2.7 DTG Adaptive Streaming

After initial consideration of 3GPP HAS, DTG has endorsed ISO MPEG DASH.

### 7.2.8 IETF HTTP Live Streaming

In 2009 Apple contributed an Adaptive Streaming draft (draft-pantos-http-live-streaming-01 [i.17]), which has now been refined (draft-pantos-http-live-streaming-06 [i.18]).

The specifications [i.17] and [i.18] enjoy a fair level of deployment in the market (notably due to its implementation in Apple Iphones. However there is not much progress in IETF and it is not clear it is progressing towards RFC status.

### 7.2.9 IETF and Content Delivery

In 2002, the IETF has set up the Content Distribution Internetworking (CDI) WG chartered with creating a standard for CDN interconnection.

There were three published (informational) RFCs in 2003:

- A Model for Content Internetworking (CDI) (RFC 3466 [i.4])
- Known Content Network (CN) Request-Routing Mechanisms (RFC 3568 [i.14])
- Content Internetworking (CDI) Scenarios (RFC 3570 [i.15])

The group died in 2003 with 2 drafts in progress (long expired):

- Distribution Requirements for Content Internetworking [i.35]
- Security Threat for Content Internetworking [i.36]

The CDI group died notably because of the demise of several companies that pushed the effort in the dotcom bubble burst and not from suddenly dying interest. Those existing specifications and drafts are now considered obsolete with respect to the state of the CDN landscape.

In 2011, IETF restarted work on CDN interconnection with a more focused approached geared at interconnecting CDNs to support basic use cases. The WG should be formed during the summer of 2011. There are already a number of IETF drafts dealing with different aspects of the CDNi problem space.

The scope of the CDNi working group appears close in intent to the MCD CDN interconnection work item and should be taken into account to achieve a better requirement coverage.

## 7.3 Existing and upcoming Content Injection related protocols

Content injection is the action of introducing content items into the Contend Delivery Infrastructure. As the work on "Needs of Content Providers" demonstrated, this entails pushing content and the associated metadata into the CDI. A specific use was also mentioned to input continuous media (broadcast stream) rather than a single item.

A significant part of this domain entails the determination of injection success status and distribution statistics recovery.

The encoding of the metadata should allow to store the necessary information at CDI stage.

A number of base protocols are appropriate for pushing data files (FTP/SFTP, HTTP, WebDAV, etc.) and are routinely used by CDN providers in combination with Web-based interfaces.

### 7.3.1 CableLabs Asset Distribution Interface (ADI)

Cablelabs has defined a content injection interface for their cable distribution systems, but this interface has been reused in a number of non-cable contexts with relative success (CableLabs MD-SP-ADI1.1-I04-060505 [i.37]).

The specification includes a content model, corresponding metadata specification and content transfer methods (ftp, http, file, etc.). The associated messaging protocol (based on CORBA) ensures proper completion status transmission.

### 7.3.2 ISO Archival Interfaces

ISO has defined interfaces for document archival that were later reused for content injection:

- ISO 14721:2003 - OAIS (Open Archival Information System) Reference model [i.11]
- ISO 20652:2006 - PAIMAS (Producer-Archive interface methodology abstract standard) [i.12]

Used by Europeana (http://www.europeana.eu/)

## 7.4 Existing CDN Proprietary Solutions

The different commercial CDN present on the market have defined proprietary interfaces to their CDNs, which are disclosed to their customers but are otherwise not public.

The user terminal interface is usually limited to plain HTTP. In addition, some CDNs supports early adaptive streaming interfaces (Adobe® Flash® streaming, Microsoft® Silverlight®). It is likely that adaptive streaming standards will be deployed shortly.

The content injection interface varies with the provider, though FTP and Web-based interfaces abound.

There is no exposed public CDN interconnection interface.

# 8 Gap Analysis

The analysis of the aforementioned state of the art solutions reveals that there is a lot of commonality between the different approaches. However there are reasons to believe that interoperability across them will be difficult. While there is a relatively small set of protocols to be supported, several solutions appears to bring specific elements that tie it with a larger architectural component.

This appears to be the consequence from the early birth of these CDNs as integral components of broader IPTV subsystems (as exemplified by ITU-T, ATIS IIF, ETSI TISPAN). In many cases, it is difficult to envision the deployment of these CDNs without the ensemble they were conceived with, though it is often possible to interconnect the internal CDN part with a generalized external CDN (which is the case for ETSI TISPAN).

In addition, many of the solutions take the approach of specifying in detail the internal workings of the CDN. The benefits that can be expected from this approach are to ensure substitutability of internal components (an approach that has been widely supported by such organizations as 3GPP, ETSI TISPAN, ITU-T and ATIS IIF).

However, if such a substitutability requirement is not explicitly stated, the CDI requirement to leave implementation latitude takes precedence. It allows to ensure that the CDN architecture and function adopts the most efficient implementation.

Nevertheless there seems to be potential to unify many of the traits of the aforementioned specifications by concentrating on the common points:

- User Equipment Interfaces, which need to be largely common to all, especially in the open internet.
- Content Ingestion Interfaces, which have little reason to differ sharply.

The CDN interworking interface presents a different issue because it is not considered in its entirety, when it is at all. ITU-T and ATIS IIF do not mention it explicitly. ETSI TISPAN addresses interconnection between TISPAN CDNs. If there are non TISPAN CDNs in existence (which is not only likely but already a reality), the need to comply with large tracts of the TISPAN CDN architecture and protocols whatever their internal architecture is today.

| | CDN user interface | CDN Interconnection | CDN Injection |
|---|---|---|---|
| ITU-T | X | Internal | |
| ETSI TISPAN | X | Internal | |
| ATIS IIF | X | internal | ADI |
| IETF CDNi | | X | |
| ISO MPEG | X | | |

**Figure 13: Standards interface mapping**

# 9 CDN Architectures and Interfaces

In MCD Work Item 2 (TR 102 688-2 [i.2]), the collection of requirements among content providers had identified the following potential architectural elements.

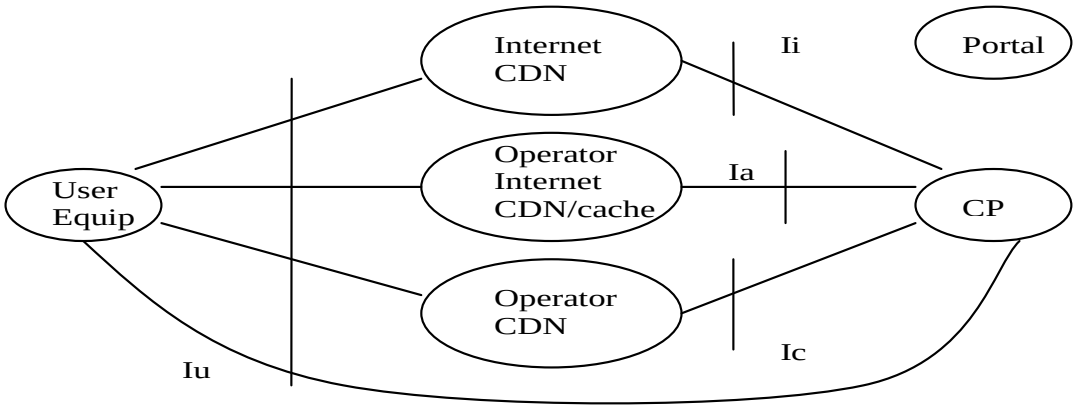


**Figure 14: Components and interfaces**

It was envisioned that 4 specific interfaces might be required: Iu, for the user equipment to CDN interface, Ic for the Operator CDN to Content Provider interface, Ia for the Operator Internet cache/CDN to Content Provider interface and Ii for the internet CDN to Content Provider interface.

Further consideration and work on additional requirements allowed to measure the similarity of the roles and of the different interfaces, allowing to propose a new delineation of functionality and roles.

**Standardization scope**

Some standards call for a complete system specification of a CDN to ensure full interoperability between all components. This requirement has not been retained for CDI, while specific requirements on a small number of external interfaces were outlined. This results in an approach where the resulting work will attempt to specify the bare minimum to fulfil the desired functions. This allows for higher implementation flexibility and permits the exploration of different internal design choices that might prove necessary or useful depending on the targeted use cases or deployment scenario.

**Separation of roles**

To allow for maximal decoupling between the different functions, several large sub-blocks are defined, of which the CDN itself is only one:

- Content Preparation
- Content Delivery (CDN)
- Content Publication (out of CDI scope)

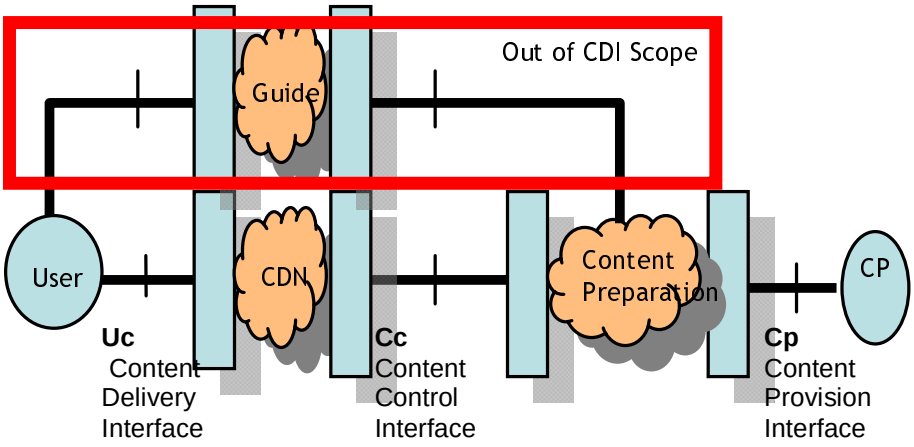


**Figure 15: Functional CDI Blocks**

In this diagram, each Functional Block is composed of one or several exposed components (the rectangular boxes) and an opaque component (the clouds). This is to outline that the implementation of these opaque parts is out of scope of the CDI work item, which is solely concerned with the exposed components in the Content Delivery Chain and their interfaces.

These functional Blocks host several interfaces:

- The Content Provision Interface (Cp), lying between the content provider and the Content Preparation Block
- The Content Control Interface (Cc), lying between Content Preparation and the CDN itself
- The Content Delivery Interface (Uc), lying between the User and the CDN

Additional interfaces may be defined around the Content Publication Block, but the latter is out of the scope of the present document.

## 9.1 Content Delivery

Content Delivery is the interface between the CDN and User Equipment. This interface is heavily constrained by the base of terminals already deployed, along with the common practises of the CDN industry.

This interface really consists in two phases: content request resolution and content delivery proper. Content Request resolution starts from the user request for a given piece of content. Resolution is the process to turn this (abstract) content reference (typically an URI) into a workable (concrete) content reference (usually an URI). Many delivery protocols facilitate multi-step transparent resolution processes with "redirect" functionality, allowing sophisticated and late-binding resolution strategies.

## 9.2 Content Control (Cc)

Content Injection is the interface by which the CDN is being filled in "push mode", usually by the Content Preparation system.

NOTE: Should investigate if there is a need for a "pull mode" interface.

## 9.3 Content Provision (Cp)

Content Provision is the interface Content Providers use to push content into a Content Preparation system.

NOTE: Should investigate if there is a need for a "pull mode" interface.

## 9.4 CDN Interconnection (Ci)

This interface supports the interconnection between two CDNs.

NOTE: CDN Interconnection is the subject of MCD WI13.

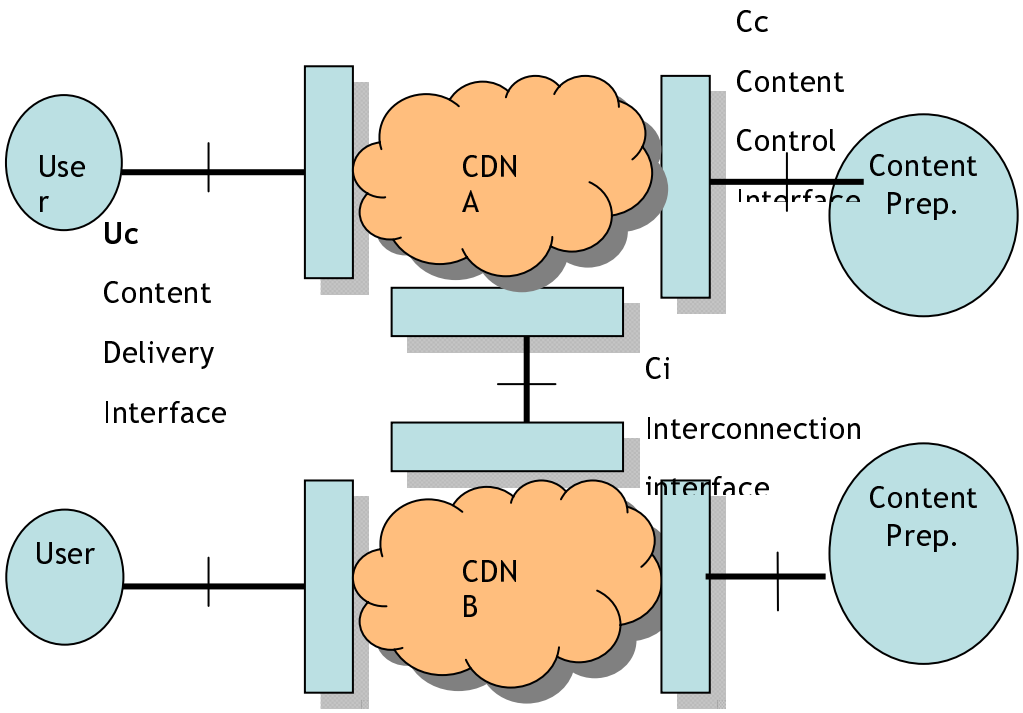


**Figure 16: CDN Interconnection**

Again, in this diagram the implementation of the opaque components is out of scope of CDI. Evidently, the interconnection interfaces may constrain the implementation, but they constitute the only relevant part for the CDI work.

# 10 Conclusions and Recommendations

Content Delivery is a very active domain where a flurry of standards and solutions are present with many others actively developed. There is a high risk for ETSI to overlap with one of those initiatives if great care is not taken to concentrate on original requirements and specific areas.

Content Delivery Protocols are a booming area and there is a significant chance that several Adaptive Streaming protocols will emerge. It is unlikely that ETSI can provide value in this space, except possibly by endorsing one of the protocols defined by another organization. The market is likely to resist embracing several contradicting solutions and a small number of preferred solution could naturally emerge.

Content Delivery Architectures are also present in numbers, but most are linked to an IPTV solution, there is no clear neutral CDN appropriate for general content delivery within the internet. There is little work on the domain of content injection interfaces, though CableLabs's solution appears to get significant traction within the content community.

Overall, there appears to be room for work on the following areas:

- Overall architecture of Content Delivery Infrastructures.
- Content Delivery Interface, between the CDI and the user, essentially to precise what client devices should support.

- Content Injection Interface, to harmonize different push interfaces (ADI, etc.) and put them in a consistent picture, with harmonized metadata.
- CDN Interconnection Interface, to enable the connection of heterogeneous CDNs.

It is recommended that ETSI works on these elements to achieve a consistent system for CDIs and prepares Technical Specifications.

Finally, there should be room within ETSI to produce a specification that would bring:

- A simplified CDN high-level architecture similar to that of MCD and close to the very high-level architecture of TS 182 019 [i.3]. That could take the form of a CDN as a specific opaque entity with selected external interfaces, providing dedicated functionalities (adaptive streaming, trick play, etc.).
- A specification of the UE interfaces appropriate for generic devices (a combination of HTTP, RTSP/RTP and MPEG DASH Adaptive Streaming with appropriate content formats).
- A specification for a Heterogenous CDN interconnection interface.
- A specification for a Content Ingestion Interface reusing existing elements (metadata, some elements from ADI).

This specification could take the shape of a subset, superset or profile of the NTECH CDN interface so as to reuse a maximum of the work already performed.

A number of requirements have been identified as key and should be particularly taken into account in future work:

- Genericity: ability to support content distribution of any content to any device.
- Should be able to take advantage of QoS mechanisms when available.
- Should be content-protection agnostic, support different content protection mechanisms.
- Should enable flexible business models and scenarios (different combination of actors and roles for content provision, operators, content providers, brokers, distributors, etc.).
- CDN external interfaces should remain independent of internal implementation mechanisms, allowing evolution of the latter without impacting the former.
- Should provide capability to offer consumption information to content provider side (e.g. for charging purposes or statistics).

# Annex A: Bibliography

Digital Video Broadcasting (DVB): "Internet TV Content Delivery Study Mission Report, DVB BlueBook A145 (12/09)".

NOTE: See DVB BlueBook A145.

ATIS IPTV Interoperability Forum IIF-WT-063 IPTV CONTENT ON DEMAND SERVICE.

# History

| Document history | | |
|---|---|---|
| V1.1.1 | July 2013 | Publication |
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