International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.2304

(03/2017)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Next Generation Networks – Enhancements to NGN

Network intelligence capability enhancement – Requirements and capabilities to support mobile content delivery optimization

Recommendation ITU-T Y.2304

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	**Y.2300–Y.2399**
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.2304

Network intelligence capability enhancement – Requirements and capabilities to support mobile content delivery optimization

Summary

Recommendation ITU-T Y.2304 identifies the technical requirements and the enhanced network intelligence capability enhancement (NICE) capabilities to support mobile content delivery optimization.

In order to support mobile content delivery optimization, the NICE capabilities need to be specifically enhanced as follows: the access and core transport capabilities are required to be enhanced to support cache in access and core network, the policy control and enforcement capabilities are required to be enhanced to support caching policy and content transcoding, the content and context detection and analysis capabilities are required to be enhanced to support network status collection and mobility information updates, and the open environment capabilities are required to be enhanced to support third-party mobile content delivery applications.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.2304	2017-03-29	13	11.1002/1000/13249

Keywords

Network intelligence capability enhancement, NICE, mobile content delivery optimization, MCDO.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.2304

Network intelligence capability enhancement – Requirements and capabilities to support mobile content delivery optimization

1 Scope

This Recommendation identifies the technical requirements and the enhanced NICE capabilities to support mobile content delivery optimization (MCDO). In this Recommendation, the enhanced version of NICE is termed as "network intelligence capability enhancement – mobile content delivery optimization" (NICE-MCDO).

This Recommendation provides an overview of why NICE features and capabilities need to be enhanced to support mobile content delivery, it also specifies the technical requirements of NICE-MCDO features and capabilities, and illustrates five use cases for NICE-MCDO.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.2019] Recommendation ITU-T Y.2019 (2010), *Content delivery functional architecture in NGN.*

[ITU-T Y.2301] Recommendation ITU-T Y.2301 (2013), *Network intelligence capability enhancement – Requirements and capabilities.*

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 application [b-ITU-T Y.101]: A structured set of capabilities which provide value-added functionality, supported by one or more services.

3.1.2 application provider [b-ITU-T Y.2012]: A general reference to a provider that offers applications to the customers making use of the services capabilities provided by the NGN.

3.1.3 charging [b-ITU-T Q.825]: The set of functions needed to determine the price assigned to the service utilization.

3.1.4 content [b-ITU-T H.780]: A combination of audio, still image, graphic, video, or data.

NOTE – A variety of formats are classified as "data" (e.g., text, encoded values, multimedia description language introduced by [b-ITU-T H.760]).

3.1.5 context [b-ITU-T Y.2002]: The information that can be used to characterize the environment of a user.

NOTE – Context information may include where the user is, what resources (devices, access points, noise level, bandwidth, etc.) are near the user, at what time the user is moving, interaction history between person and objects, etc. According to specific applications, context information can be updated.

3.1.6 context awareness [b-ITU-T Y.2201]: Context awareness is a capability to determine or influence a next action in telecommunication or process by referring to the status of relevant entities, which form a coherent environment as a context.

3.1.7 service [b-ITU-T Y.2091]: A set of functions and facilities offered to a user by a provider.

3.1.8 service provider [b-ITU-T M.1400]: A general reference to an operator that provides telecommunication services to customers and other users either on a tariff or contract basis. A service provider may or may not operate a network. A service provider may or may not be a customer of another service provider.

3.1.9 user [b-ITU-T Y.2201]: A user includes end user [b-ITU-T Y.2091], person, subscriber, system, equipment, terminal (e.g., FAX, PC), (functional) entity, process, application, provider, or corporate network.

3.1.10 network intelligence capability enhancement (NICE) [ITU-T Y.2301]: An enhancement for NGNs supporting some intelligence capabilities for the provisioning of services according to requirements of users and application providers. These intelligence capabilities (termed as "NICE capabilities") enable operators to assign and dynamically adjust specific network resources based on the requirements, as well as supporting interfaces for users and applications enabling on-demand resource and service provision.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 content delivery optimization: Mechanisms to decrease the delay between end user and application server and relieve the bandwidth tension to accelerate content delivery, which include at least content caching and content service.

3.2.2 mobile content delivery optimization: Mechanisms to decrease the delay between end user and application server and relieve the bandwidth tension to accelerate mobile content delivery, which includes at least content caching at both radio access network and core network, content service, and, if necessary, content optimization.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

API Application Programming Interface

CN Core Network

HTTP Hyper Text Transfer Protocol

MCDO Mobile Content Delivery Optimization

MIME Multipurpose Internet Mail Extensions

NGN Next Generation Network

NICE Network Intelligence Capability Enhancement

QoE Quality of Experience

QoS Quality of Service

RAN Radio Access Network

URI Uniform Resource Identifier

5 Conventions

In this Recommendation:

The keywords "is required to" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "is recommended" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords "can optionally" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

6 Introduction

Network intelligence capability enhancement (NICE) [ITU-T Y.2301] is an enhancement for next generation networks (NGNs) supporting some intelligence capabilities for the provisioning of services according to requirements of users and application providers. These intelligence capabilities enable operators to assign and dynamically adjust specific network resources based on the requirements, as well as supporting interfaces for users and applications enabling on-demand resource and service provision.

NICE offers intelligence to network, such intelligence improves user experience. Delay and bandwidth are two important factors that affect user experience. In order to decrease the delay and relieve the bandwidth tension, NICE provides the optional capabilities to support cache and media stream delivery functions in transport nodes [ITU-T Y.2301]. Such kind of capabilities optimize the content delivery by traffic localization. In this Recommendation, the term content delivery optimization for mechanisms refers to the decrease delay between end user and application server and the relieve bandwidth tension to accelerate content delivery. The content delivery optimization includes but is not limited to the cache capability described in [ITU-T Y.2301]

The content delivery in a mobile network is more complicated than in a fixed network due to the features brought by mobility. For example, the content delivery has to consider how to ensure appropriate quality of service (QoS) in a dynamic radio bandwidth and time-varying user location environment. The content delivery capabilities defined by NICE [ITU-T Y.2301] are required to be enhanced to support the features for mobile content delivery. The NICE capability enhancements for mobile content delivery are referred to as mobile content delivery optimization in this Recommendation.

NICE as described in [ITU-T Y.2301] enhances the capabilities of content delivery described in [ITU-T Y.2019], "Content delivery functional architecture in NGN", and this Recommendation enhances the NICE capabilities of [ITU-T Y.2301] for mobile content delivery. All the features and capabilities described in this Recommendation are aligned with, or extending, NICE as described in [ITU-T Y.2301].

7 Requirements of NICE to support mobile content delivery optimization

7.1 Enhancement of NICE features for mobile content delivery optimization

This Recommendation focuses on some specific enhancements to NICE. In particular, NICE-MCDO extends the following NICE features as defined in [ITU-T Y.2301]:

1) awareness features: additional requirements of content attributes and traffic characteristics awareness;

2) optimization features: additional requirements of dynamic QoS adjustment and mobility support;

3) openness features: additional requirements for mobile content delivery application programming interfaces (APIs) support.

NICE-MCDO also enhances the following features with some additional requirements:

1) charging features;

2) service control features.

7.2 Requirements of NICE-MCDO

7.2.1 Requirements of awareness

NICE-MCDO is required to support the enhancements of the awareness features that include the following aspects:

- content identification, including, but not limited to the following content attributes: content type, size, encoding, bitrates and application-specific parameters such as video resolution, frame rate;
- dynamic radio access network (RAN) awareness, such as, but not limited to the following access network attributes: access network type, radio access network status;
- traffic parameters awareness, including, but not limited to, the following traffic parameters: destination address and domain name information;
- mobility awareness, including, but not limited to, the users' serving base station information and users' handover events.

7.2.2 Requirements of optimization

NICE-MCDO is required to support the enhancements of the optimization features that include the following aspects:

- traffic scheduling with appropriate QoS parameters according to the content attributes;
- intelligent adjustment of bandwidth or QoS level according to the user terminal parameters and capabilities;
- intelligent content caching in the radio access network and the core network (CN);
- intelligent content transcoding according to the context attributes, including but not limited to, link quality, user profile and availability of resources;
- dynamic management of mapping between delivery nodes and their service areas (e.g., base station sets);
- dynamic delivery node selection according to the context attributes, including, but not limited to, user location, delivery node's workload and available bandwidth;
- delivery of content cached in the radio access network or in the core network;
- control of content session in order to support session switch among delivery nodes without session interruption;
- quality of experience (QoE) assurance during and after session switch.

7.2.3 Requirements of openness

NICE-MCDO is required to support the enhancements of the openness features that include the following aspects:

- Providing open APIs to support content adaptation to different user equipment types (cell phone, pad, and so on).

For example, a third-party provider optimizes the content delivery adapting it to all cell phones receiving pictures in low resolution, and all pads receiving pictures in high resolution.

- Providing open APIs to support content cached in access network and core network.

  For example, a third-party provider optimizes the content delivery via the most frequently requested content delivered by caches in access network, and other content delivered by caches in core network.

- Providing open APIs for authentication, authorization and launch of third-party content delivery applications.

  For example, the open environment provides a cloud computing platform which allows authorized third-party providers to run their applications on this platform to accelerate their dynamic content delivery by content localization.

7.2.4 Requirements of charging

NICE-MCDO is required to enhance the charging features that include the following aspects:

- charging policy management and enforcement;

  NOTE 1 – Traffic flows may have differential charging rates, e.g., traffic flows from a group of particular content providers may be free of charge while other traffic flows are charged at normal rates. NICE-MCDO is required to manage the charging policy accordingly.

- traffic data records generation according to the charging policy and the traffic parameters.

  NOTE 2 – For example, if a user traffic was scheduled to a cache deployed in the radio access network, it is the cache's responsibility to generate the traffic data records and interact with the core network for effective charging records generation.

7.2.5 Requirements of service control

NICE-MCDO is required to enhance the service control features that include the following aspects:

- support of adaptive content scheduling in order to provide authentication of the user and authorization of the content generated by the user. In particular, the user needs to be authenticated by the delivery nodes, e.g., according to the user's name, password and so on; the delivery nodes need to authorize the content (such as content volume, content transmission speed, etc.) based on the user's rights;

- generating of appropriate traffic and content scheduling policies and distribute the policies.

  NOTE – The traffic scheduling policy includes, but is not limited to, scheduling method (e.g., via an HTTP 302 location) and delivery node selection priorities. The content scheduling policy includes, but is not limited to, frequently requested content selection algorithm, caching expiration algorithm and content storage policy.

8 Capabilities of NICE to support mobile content delivery optimization

8.1 Overview of the enhanced capabilities of NICE

NICE-MCDO builds upon NICE capabilities described in [ITU-T Y.2301] and enhances NICE capabilities to support the content delivery optimization.

Figure 1 provides an overview of the NICE capabilities enhanced by NICE-MCDO.

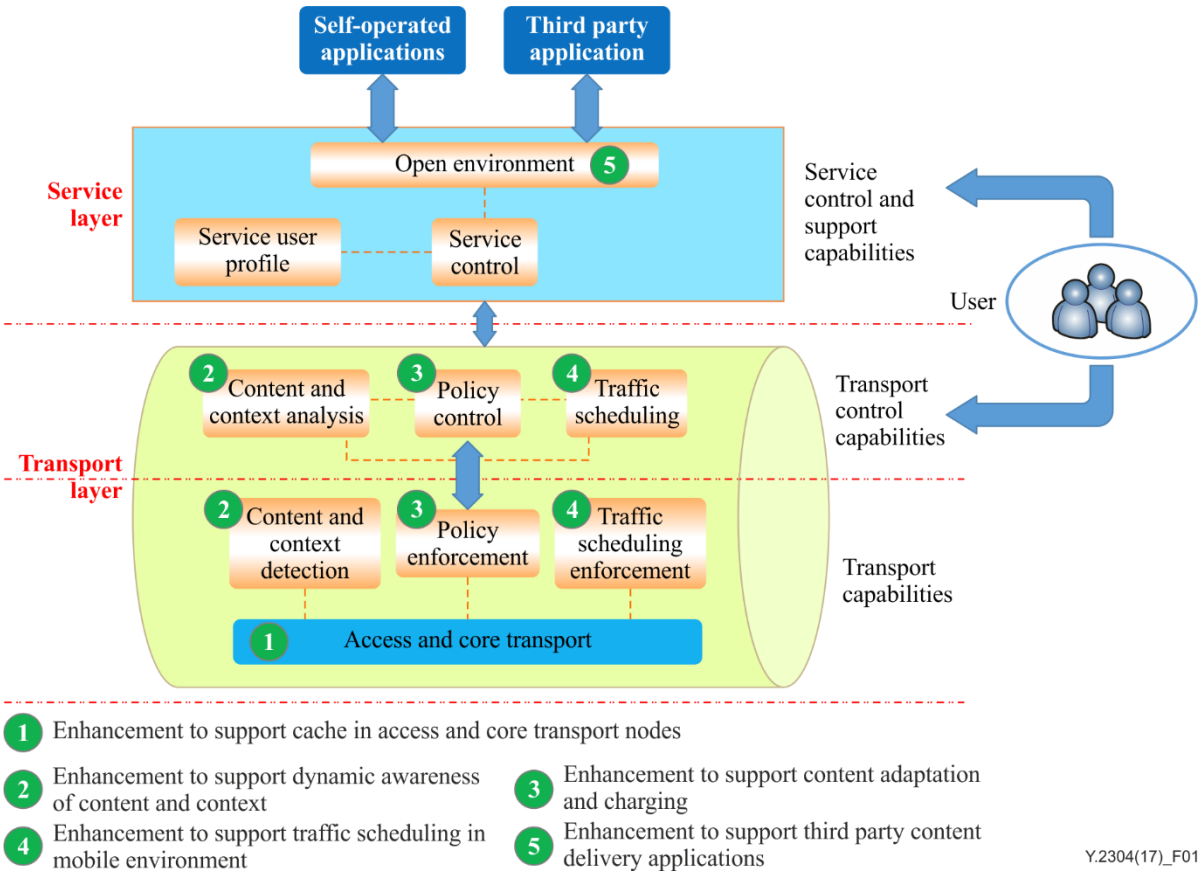


Figure 1 – Overview of the enhanced capabilities of NICE

The following describes the various enhancements highlighted by the numbers in Figure 1.

NICE-MCDO capabilities optimize the content delivery with caches deployed in core networks and radio access networks, termed as CN-cache and RAN-cache respectively. Both CN-cache and RAN-cache accelerate the content delivery by traffic localization.

NICE-MCDO enhances the content and context detection by deep inspection of application protocols, transport protocols and content data. Content and context analysis capabilities use the application-specific parameters captured by the content and context detection capabilities to derive appropriate content and context information.

Policy control capabilities generate enhanced content delivery policies and charging policies according to the content and context analysis results and distribute the policies to the policy enforcement capabilities.

Traffic scheduling capabilities use end user mobility information generated by content and context detection capabilities and control the traffic session between end user and delivery nodes.

Open environment capabilities provide APIs enabling third-party providers to launch their content delivery applications.

8.2 Relationship between requirements and capabilities

The relationships between requirements and capabilities of NICE-MCDO are as follows:

- content and context detection capabilities, and content and context analysis capabilities support the requirements of awareness;
- access and core transport capabilities, traffic scheduling and traffic scheduling enforcement capabilities support the requirements of optimization;

- open environment capabilities support the requirements of openness;
- policy control capabilities, and access and core transport capabilities support the requirements of charging;
- policy control capabilities and policy enforcement capabilities support the requirements of service control.

8.3 Enhanced capabilities of transport layer

8.3.1 Access and core transport capabilities

Access and core transport capabilities optimize the mobile content delivery by providing RAN-cache and CN-cache.

Access and core transport capabilities for NICE-MCDO are aligned with those of NICE [ITU-T Y.2301], with the following additional requirements:

- RAN-cache has the ability to handle transport tunnels applied in RAN to delivery content to clients;
- RAN-cache has the ability to keep the status of its content delivery session.

  For example, a RAN-cache keeps the offset of the last delivered packet and reports to the content scheduling function. When a client hand over occurs, i.e., a client moves out of the scope of the current RAN-cache, the content scheduling function schedules the traffic to the new delivery node and starts the communication from the packet following the handover point.
- RAN-cache support the generation of traffic data records for each of its content delivery sessions and report to the policy enforcement function.

8.3.2 Content and context detection capabilities

Content and context detection capabilities in NICE-MCDO collect transport information and application-specific information, which are used by the content and context analysis capabilities for further processing.

Content and context detection capabilities for NICE-MCDO are aligned with those of NICE [ITU-T Y.2301], with the following additional requirements:

- Detection of application protocol parameters.

  For example, the cache-control header in a hypertext transfer protocol (HTTP) response indicates if the content is allowed to be cached. The content and context detection capabilities can capture this header value.
- Detection of content meta-data according to the content type.

  For example, the content detection capabilities can capture the header objects of an mp4 video clip or headers of a JPEG image.
- Dynamic detection of the status of the access network the user is connected to, including but not limited to, the access network type, radio access network quality and link speed.
- Detection of each content delivery session's parameters, including but not limited to, traffic quintuple (source IP, destination IP, source port, destination port and protocol number) and uniform resource identifier (URI) information.
- Detection of user mobility information.

  For example, the context detection function keeps monitoring network signalling data and capturing users' hand over information.

8.3.3 Content and context analysis capabilities

Content and context analysis capabilities aggregate the information generated by the content and context detection capabilities and analyse the information.

Content and context analysis capabilities for NICE-MCDO are aligned with those of NICE [ITU-T Y.2301], with the following additional features:

- Analysis of content parameters, including but not limited to, image or video resolution, video frame rates, bit rate parameters and bandwidth/QoS parameters.
- Identification of cacheable content and generation of caching requests.

  For example, content and context analysis capabilities analyse content type (e.g., MIME), cache-control header of HTTP protocol and content size: if the current content is suitable for caching, content and context analysis capabilities request the policy enforcement capabilities to cache the current content.
- Analysis of user mobility events and generation of session switch requests.

  For example, a user moves out of the service scope of a RAN-cache, and context analysis capabilities generate a session switch request and send it to the traffic scheduling capabilities. This scenario is described in Appendix I.3.

8.3.4 Policy control capabilities

Policy control capabilities are aligned with the policy control requirements of NICE [ITU-T Y.2301], with the following additional requirements:

- Support of caching policy generation and distribution.

  For example, policy control capabilities can generate a caching policy which allows caching of cacheable content only if its size exceeds a specific threshold. Such kind of policies may improve the content delivery optimization performance and efficiency.
- Support of dynamic bandwidth or QoS adjustment according to the analysis results of the content and context analysis capabilities.
- Support of traffic charging policy generation and distribution.

  For example, policy control capabilities consider the traffic with a specific URI pattern as free of charge. The related policies are distributed to the policy enforcement capabilities.
- Support of content transcoding policy generation and distribution.

  For example, policy control capabilities find that the bit rate of the video content requested by a user is too high for the current radio access network status. A video transcoding policy (e.g., the desired transcoding output parameters) is generated and distributed to the policy enforcement capabilities.

8.3.5 Policy enforcement capabilities

Policy enforcement capabilities are aligned with the policy enforcement requirements of NICE [ITU-T Y.2301], with the following additional requirements:

- Support of enforcement of caching policies.
- Based on the caching policies generated by the policy control capabilities, the policy enforcement capabilities can filter the caching requests received from the content and context analysis capabilities and control the CN-cache or RAN-cache in order to cache the proper content.
- Support of traffic charging data generation according to the charging policies received from the policy control capabilities.
- Support of content transcoding according to the transcoding policies' parameters received from the policy control capabilities.

8.3.6 Traffic scheduling capabilities

Traffic scheduling capabilities are aligned with those of NICE [ITU-T Y.2301], with the following additional requirements:

- Management of the topology of the RAN-caches, including but not limited to, the lists of base stations via which user terminals can connect to the various RAN-caches.
- Management of traffic scheduling rules for mobility support.

8.3.7 Traffic scheduling enforcement capabilities

Traffic scheduling enforcement capabilities are aligned with those of NICE [ITU-T Y.2301], with the following additional requirements:

- Dynamic traffic scheduling according to the user context information (e.g., user location or serving base station information) and traffic scheduling rules received from the traffic scheduling capabilities.
- Management of content delivery session's status parameters and maintenance of content delivery session consistency for traffic scheduling.

  For example, traffic scheduling enforcement capabilities receive content delivery session's status report (e.g., the delivery progress in bytes) from the access and core transport capabilities. When the current content delivery session's traffic needs to be scheduled to another content delivery node (e.g., due to user location change), the traffic scheduling enforcement capabilities inform the new content delivery node about the session break point parameters.

8.4 Enhanced capabilities of service layer

8.4.1 Open environment capabilities

Open environment capabilities provide APIs for third-party providers to invoke awareness, optimization, charging and service control features of NICE-MCDO.

Open environment capabilities support the requirements of openness in NICE [ITU-T Y.2301], with the following additional requirements:

- APIs for content delivery optimization by adapting content to different user equipment types.
- Secure third-party application running environment which can allocate appropriate resources (e.g., computing resources, storage resources) to third-party content delivery applications and can control the lifecycle of these applications.
- APIs for transport layer openness via which third-party applications can invoke appropriate transport layer capabilities of NICE-MCDO (e.g., APIs for caching capabilities in access network and core network).
- APIs for authentication, authorization and launch of third-party content delivery applications. These APIs are used by authorized third-party application providers to pre-request the resources needed by the applications.

  NOTE – The resources needed by the third-party content delivery applications include, but are not limited to, computing resources, memory, storage and APIs for transport layer openness.

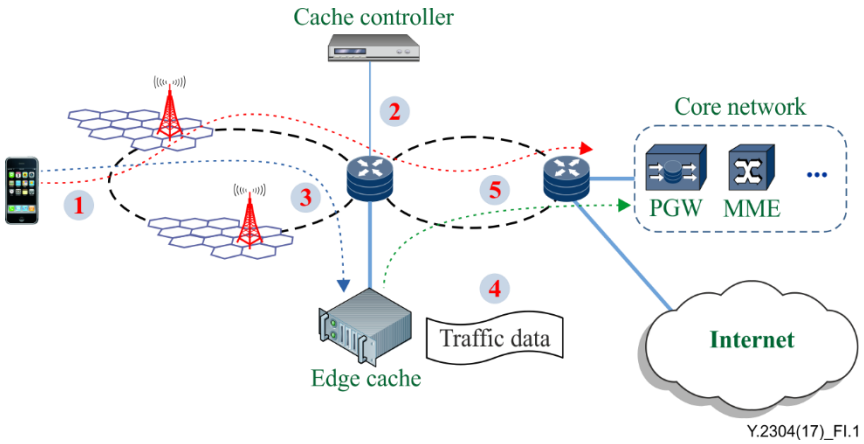
Appendix I

Use cases

(This appendix does not form an integral part of this Recommendation.)

I.1 Use case of content distribution and caching feature

The content may be cached at the edge of the network or at the core network. A caching control function captures the client request and schedules appropriate requests to the cache function. The cache function serves the client at the edge of network, generates traffic data and interfaces with the core network for traffic charging with pre-defined charging policy. This is illustrated in Figure I.1.

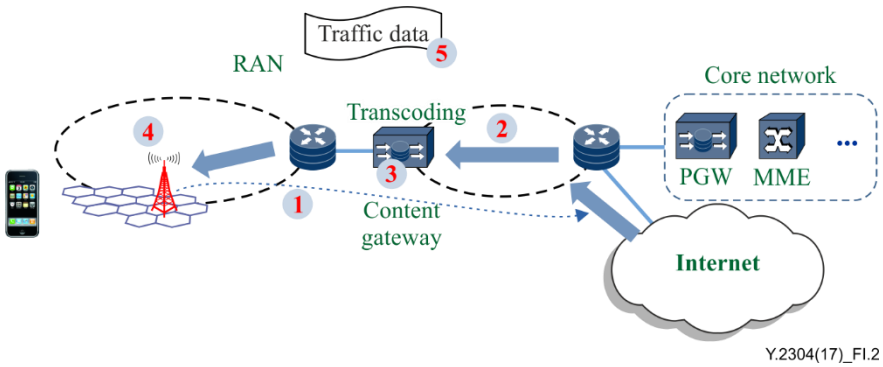


1 The client initiates a request towards the Internet.
2 The cache controller monitors the traffic and identifies that the requested content can be served by edge cache.
3 The cache controller schedules the client request to edge cache (e.g., by generating DNS answer or HTTP 302 location answer). The client requests to the edge cache the desired content. The edge cache replies to the client with the content.
4 The edge cache generates traffic data, which may contain traffic usage information and client profile information.
5 The edge cache sends the traffic data to the core network for traffic charging.

Figure I.1 – Illustration of content distribution and caching feature

I.2 Use case of RAN-aware content delivery optimization

The network status collecting and reporting function exposes accurate radio interface information (e.g., cell load, link quality) to the content optimization function, enabling dynamic content optimization, and thus improving QoE. The dynamic content optimization enhances video delivery through reduced stalling, reduced time-to-start and 'best' video quality. The content optimization is based on actual user traffic and network status, such as radio network resource usage. This is illustrated in Figure I.2.

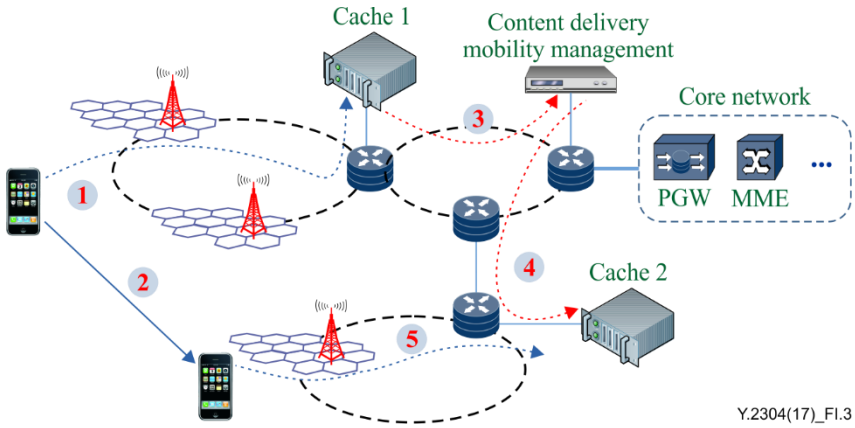


1 The client requests a video stream from the content provider located in the Internet.
2 The content provider replies to the client with video stream.
3 The transcoding function detects that the client radio network link speed is not enough for the current stream and starts the transcoding process, i.e., to transcode the video into a lower bit rate stream.
4 The transcoded stream is delivered to the client.
5 Similar to the use case described in clause I.1, the transcoding function generates the traffic data of the transcoded stream for charging.

Figure I.2 – Illustration of RAN-aware content delivery optimization

I.3 Use case of content delivery handover

The edge caches optimize the content delivery with RAN-aware features, but a single cache can serve a limited set of base stations. When a client who is consuming content moves from one cache serving area to another, multiple RAN-aware caches can detect the handover of the client and manage the session control between caches. This is illustrated in Figure I.3.

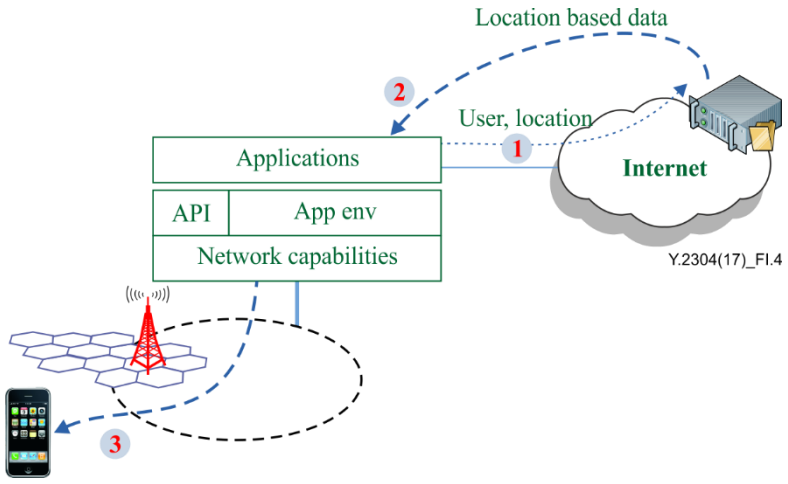


1 Cache 1 is delivering content to a client
2 The client moves towards a base station that is out of the serving area of the current cache.
3 The cache detects the handover events and reports the client status update to the central cache management function. The client status update message may contain user profile information and parameters of the current session.
4 The client enters the serving area of cache 2. Cache 2 obtains the session related information from the cache management function and re-initiates the session (typically, from the session breakpoint).
5 The client proceeds with the session from the new cache.

Figure I.3 – Illustration of content delivery handover

I.4 Use case of location based applications

The radio access network elements have the capabilities of measurement of client location. They can also provide a sandbox environment that allows running of authorized third-party applications on it. The application providers can use these network capabilities and provide location-specific applications or data to the clients. This is illustrated in Figure I.4.



1 The application provider has already deployed the application in the RAN. It detects the location of a client on a periodic basis and sends the related user profile and location information to the application logic located in the Internet.

2 The application logic located in the Internet checks the user profile and location information, generates location related application content and sends it back to the application logic in the RAN.

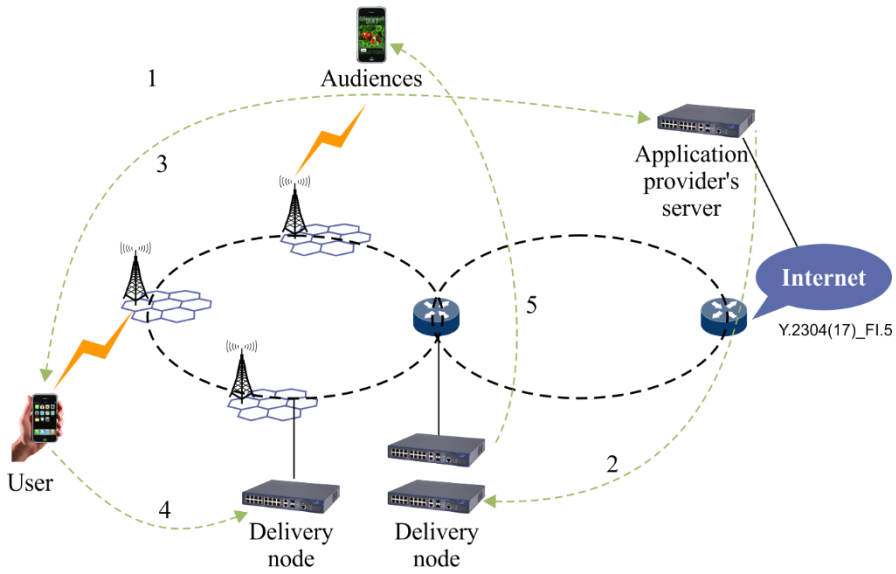
3 The application logic in the RAN pushes the content to the client.

Figure I.4 – Illustration of location based applications

I.5 Use case of resource authentication and authorization

Self-media broadcasting has recently gained popularity. Users use cell phone or pad to broadcast and need the content delivery system to deliver the content to the audience quickly [b-ITU-T F.747.8].

To reduce delay, the content produced by users is always directly uploaded to the appropriate delivery nodes but not to the application providers' servers. The delivery nodes authenticate the user (e.g., based on username, password, etc.) and then authorize his/her rights (such as content volume, transmission speed, etc.) to the content which is uploaded by the user himself/herself. The process is illustrated in Figure I.5.



1 The user initiates a broadcast request to the application provider's server. The application provider's server authenticates the user, e.g., based on username, password and so on.

2 When the user has passed the authentication phase, the application provider's server informs the user about the delivery node's IP address.

3 The application provider's server informs the delivery node about the user's rights (such as content volume, transmission speed, etc).

4 The user sends the content to the delivery node, the delivery node authenticates the user and then authorizes his/her rights.

5 The delivery node delivers the content to the audiences of the user.

Figure I.5 – Resource authentication and authorization process

Bibliography

[b-ITU-T F.747.8] Recommendation ITU-T F.747.8 (2015), *Requirements and reference architecture for audience-selectable media service framework in the IoT environment.*

[b-ITU-T H.760] Recommendation ITU-T H.760 (2009), *Overview of multimedia application frameworks for IPTV*.

[b-ITU-T H.780] Recommendation ITU-T H.780 (2012), *Digital signage: Service requirements and IPTV-based architecture*.

[b-ITU-T M.1400] Recommendation ITU-T M.1400 (2015), *Designations for interconnections among operators' networks*.

[b-ITU-T Q.825] Recommendation ITU-T Q.825 (1998), *Specification of TMN applications at the Q3 interface: call detail recording*.

[b-ITU-T Y.101] Recommendation ITU-T Y.101 (2000), *Global Information Infrastructure terminology: Terms and definitions*.

[b-ITU-T Y.2002] Recommendation ITU-T Y.2002 (2009), *Overview of ubiquitous networking and of its support in NGN*.

[b-ITU-T Y.2012] Recommendation ITU-T Y.2012 (2010), *Functional requirements and architecture of next generation networks*.

[b-ITU-T Y.2091] Recommendation ITU-T Y.2091 (2011), *Terms and definitions for next generation networks*.

[b-ITU-T Y.2201] Recommendation ITU-T Y.2201 (2009), *Requirements and capabilities for ITU-T NGN*.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	Tariff and accounting principles and international telecommunication/ICT economic and policy issues
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Environment and ICTs, climate change, e-waste, energy efficiency; construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling, and associated measurements and tests
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2017