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Information technology — Future Network — Problem statement and requirements —

Part 6: Media transport

Technologies de l'information — Réseaux du futur — Énoncé du problème et exigences —

Partie 6: Transport des médias

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Foreword

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The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

In exceptional circumstances, when the joint technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide to publish a Technical Report. A Technical Report is entirely informative in nature and shall be subject to review every five years in the same manner as an International Standard.

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ISO/IEC TR 29181-6 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 6, *Telecommunications and information exchange between systems*.

ISO/IEC TR 29181 consists of the following parts, under the general title *Information technology — Future Network — Problem statement and requirements*:

— *Part 1: Overall aspects*

— *Part 3: Switching and routing*

— *Part 4: Mobility*

— *Part 6: Media transport*

— *Part 7: Service composition*

The following parts are under preparation:

— *Part 2: Naming and addressing*

— *Part 5: Security*

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Introduction

ISO/IEC TR 29181-1 describes the definition, general concept, problems and requirements for the Future Network (FN). The other parts of ISO/IEC TR 29181 provide details of various components of the technology.

This part of ISO/IEC TR 29181 identifies problem of the media transport in the IP-based networks and examines the requirements for the transport of media data over the Future Network.

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Information technology — Future Network — Problem statement and requirements —

Part 6: Media transport

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1 Scope

This part of ISO/IEC TR 29181 describes the problem statement and requirements for the Future Network in the perspective of Media Transport. This part of ISO/IEC TR 29181 specifies:

a) detailed description of the media transport requirements in the Future Network;

b) identification and definition of services, basic and media services, which will fit the requirements for communications over heterogeneous environments supporting various user preferences, for any kind of media content, either time-dependent or time-independent;

c) requirements and functionalities of Media Aware Network Elements, which are intended to be nodes in the network to provide seamless media experiences to users.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC TR 29181-1, *Information technology — Future Network — Problem statement and requirements — Part 1: Overall aspects*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC TR 29181-1 and the following apply.

3.1
data
sequence of octets which is conveyed across the network as a single unit

[SOURCE: ISO/IEC TR 29181-3, 3.1]

3.2
media
sequence of bits in a defined format which encodes physical entities such as images, sounds, and text.

3.3
time-independent media
media where the semantic of the content does not depend upon a presentation according to the time domain

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EXAMPLE 1 text

EXAMPLE 2 still image

3.4
time-dependent media
media where there exists a temporal relation amongst the media units

EXAMPLE 1 audio

EXAMPLE 2 video

3.5
content
media media that is carried in the payload of datagrams sent over the network

3.6
static content
time-independent media that is carried in the payload of datagrams sent over the network

3.7
streamed content
time-dependent media that is carried in the payload of datagrams sent over the network but does not have requirements for latency

EXAMPLE 1 MP3 files

EXAMPLE 2 Video-on-Demand

3.8
live content
time-dependent media that is carried in the payload of datagrams sent over the network and has requirements for latency.

EXAMPLE 1 telephone conversation

EXAMPLE 2 video conference

3.9
encapsulation
additional octets or other symbols associated with a data unit which serve to delimit it or to identify aspects of the service it should receive

[SOURCE: ISO/IEC TR 29181-3, 2.15]

3.10
container
encapsulation structure containing a payload, either data units or content, and the header composed by two parts, what refers to the payload and to the underlying network

NOTE Container has attributes as header fields, which some are related to particular services, and others are general and specific for a sort of communication.

3.11
context
set of data or information that completely describes a particular communication environment at a particular point in time

[SOURCE: ISO 16484-5:2007 (Identifier: CDB-00119069-001)]

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3.12
context-awareness
ability of a network to be aware of the context and react accordingly in order to adapt either itself or the data conveyed over

3.13
modular paradigm
paradigm where complex functions are composed by well-known and deterministic basic functions

NOTE In network realm, protocols are breaking down into its fundamental (also called atomic) functions, such as sequencing, cyclic redundant coding, addressing, and so on, which combined results into complex functions (or protocols).

3.14
MANE (Media Aware Network Element)
content and context aware network element capable of processing media content passing through to accommodate a given content or service according to the context

NOTE This element may handle all attributes of containers taking into account the content type and properties, networking properties and status, and other environmental and conditional properties that may have effect in routing of the contents and services.

3.15
quality of service (QoS)
set of qualities related to the collective behaviour of one or more objects

[SOURCE: ITU-T Rec. X.902 | ISO/IEC 10746-2]

NOTE QoS is usually defined regarding to three parameters: bandwidth, delay and error. In conversational communications, bandwidth consumption is related to the chosen technology (although the lower one is desired), the delay has to be bounded to assure conversational interactivity among participants, and should be provided a high error resilience to assure a good data delivery in front of any change on the network.

3.16
quality of experience (QoE)
set of subjective and/or objective qualities related to user perception about consumed media content

NOTE QoE is usually referred to how the user perceives the consumed content. QoE is more related to subjective quality estimation rather than objective measurements, although they can be related by different mapping schemes.

3.17
connection-oriented
communication between peer protocol entities by means of a connection or association established by an underlying layer

[SOURCE: ISO/IEC 11582:2002 (Identifier: CDB-00009275-001)]

3.18
connectionless
communication between peer protocol entities by means of an unacknowledged, unidirectional transport mechanism provided by an underlying layer

[SOURCE: ISO/IEC 11582:2002 (Identifier: CDB-00009276-001)]

3.19
layer coding (LC)
coding technique in which the video stream is split into several hierarchical layers consisting of base layer and one or more enhancement layers

3.20
multiple description coding (MDC)
coding technique in which a single media stream is fragmented into multiple substreams which can be delivered over the network in different paths

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4 Symbols (and abbreviated terms)

3D	Three Dimensional
AIMD	Additive Increase / Multiplicative Decrease
CABCC	Content-Aware Based Congestion Control
CLD	Cross-layer design
CLO	Cross-layer Optimization
FEC	Forward Error Correction
HD	High Definition
HTTP	Hypertext Transfer Protocol
LC	Layered Coding
MDC	Multimedia Description Coding
MEDIEVAL	MultimEDia transport for mobIlE Video AppLications
MMT	MPEG Media Transport
MPEG	Moving Picture Experts Group
MPEG-TS	MPEG-Transport Stream
OSI	Open Systems Interconnection
P2P	Peer to Peer
RTCP	Real-Time Control Protocol
RTP	Real-Time Protocol
SMART	Smart Multimedia Routing and Transport
SMS	Short Messages Services
STREP	Small or medium-scale focused research project
SVC	Scalable Video Coding
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol/Internet Protocol
UDP	User Datagram Protocoll
UHD	Ultra-High definition
VoIP	Voice over IP
WWW	World Wide Web

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5 Overview

5.1 Networks evolving to support of media

During the last few decades, the various research communities have carried out large research activities in networking and grid e-Infrastructures, which have concluded with the needs of new types of networks and distributed computing models of communication. In the mid-80s, the research activity was focused on the Networking Layer (the lower layers of the stack) in order to improve overall quality of the end-to-end transmission. In the mid-90s, the telecom boom has arrived and started advertising that networks were ready for the end user. The trend of collaborative environments appeared, where networks were used only as a transport tool, and it was necessary to work on distributed solutions. The Supercomputing or more recently the P2P (peer-to-peer) were, and still are, the research lines for searching these solutions, in the layer called GRID or distributed computing.

Today, the research is focused on the two emerging layers. The first layer is the Scientific Data Layer, where all the data to be processed and transported will be collected. Scientific Data Layer deploys data repositories for the scientific community and future generations of scientist supporting. The data repositories are implemented in a coordinated way to be used as digital libraries, archives, data storage, access to information and the necessary pooling of resources [6]. The second layer is a new Multimedia Layer, specifically focused on the convergence of advanced graphics, media and live videoconferencing, which enables any kind of multimedia data exchange between users on a computer network. Multimedia Layer can communicate directly with the Scientific Layer, GRID Layer, or Network Layer. It is dependent on the multimedia application and/or the type of network which it runs on.

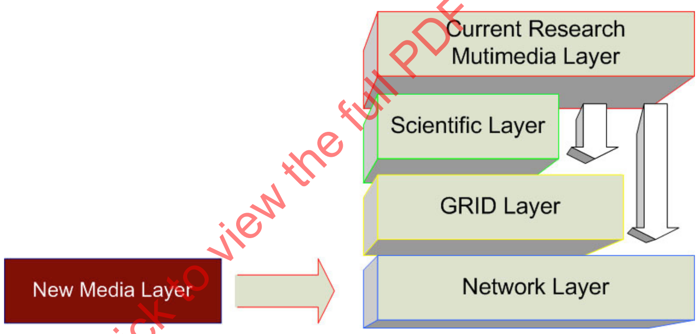

Figure 1 — Layers of research activity

Current multimedia research activities have focused on how to adapt the diverse characteristics of media to the running network architecture by defining middle layer that provides particular features for this sort of traffic. RTP/RTCP, RTP for uncompressed video, MPEG-TS, and so on, are well-known examples of these mid layers designed for this reason, to adapt the media content to the TCP/IP network. New middle layers are in continuous evolution to adapt themselves basically to users and underlying network requirements. All these middle layers are designed to adapt the media data to the Internet, over the classical stack of communications designed in the 70s to transmit computer data from end-to-end user.

The middle layers or protocols are presented in the Figure 2. Starting from the left side is the the OSI model, the TCP/IP stack, and the protocols adopted for the media transport.

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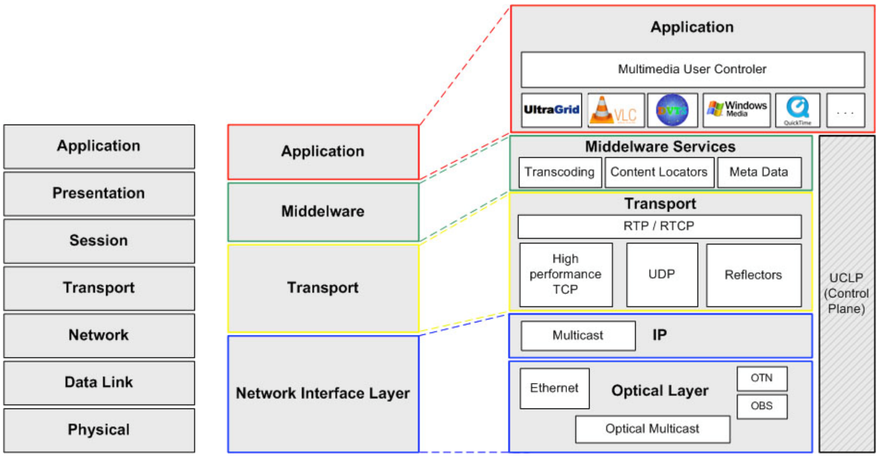

Figure 2 — Current middle layers or protocols used for media

5.2 User demand for media-based services

Few years ago, after the revolution of the WWW and the spreading of the Internet to the end user, the highest percentage of the traffic in the backbone was based on raw data or time-independent content. Nowadays, this trend has changed towards the exchange of time-dependent media content, either streamed or live, between users themselves or between content providers and users. This change to the traffic types has affected the current Internet framework, where intelligence is in the edges not in the core of the network, communication model changed from the server client model to the P2P model, as well as to the types of contents transmitted. In fact, Internet is already a media network based on P2P media traffic and time-dependent content applications such as VoD (Video on Demand), videostreaming, and broadcasting. It is in this Internet where a little part of users generates the major part of the global IP traffic. In this regard, in 2009, media content, from P2P and video services, represented the 80 % and 90 % of the global Internet traffic, respectively. Due to the convergence of television, video, graphics, and audio, it is expected that video traffic will continuously increase as with the increasing demand of media content such as HD, 3D, face-to-face video conferencing, video gaming, etc.

Content Delivery Network is an example reflecting this demand, because network operators are starting to set-up customized infrastructures, composed by clusters of VoD servers and high capacity network resources, to enable a network to feed and deliver streamed and live media content to end users in a faster and more reliable way. The CDN is an associated hybrid-networking infrastructure that requires an enormous amount of effort in realization and fine-tuning to enable high quality media stream to be delivered along the network.

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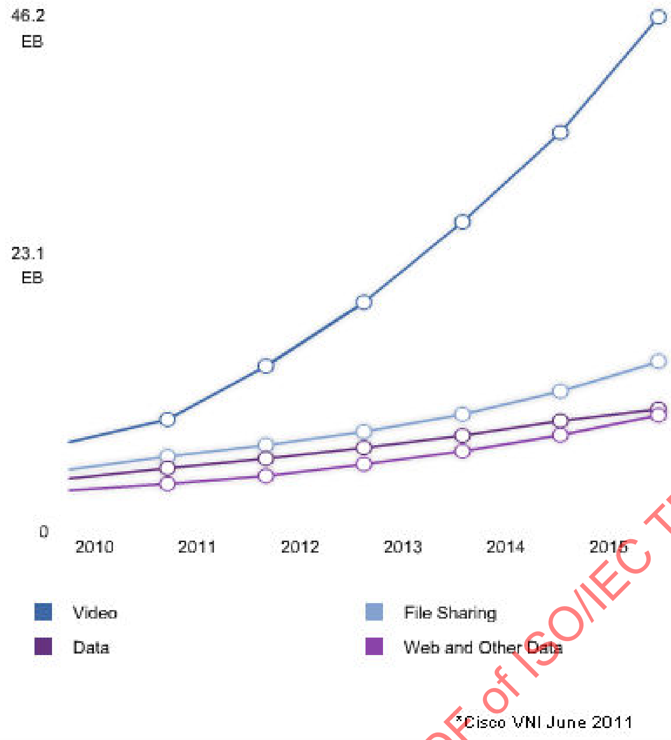

Figure 3 — IP network forecast according to CISCO Visual Networking Index [4]

It must be remembered that current network started as a computer networking revolution, and now the Internet is evolving as a user driven network, based on various types of audio-visual media content. So, the change in our traditional paradigm of an information and communication network which relies on computers and telecommunications is clearly moving towards a new media network which shares all kind of cultural knowledge, science, technology, arts, and games.

Users are becoming into active players in the media-based networks. An evidence of this is the growth of the contents generated by the users. Their interest in media contents is growing amazingly, and it is expected to continuously increase in the near future. That means the people are the new driving forces in the design of the Future Network and will introduce new requirements and demand for new services, applications, and functionalities.

So, the Future Network must start based on this reality, where users are continuously consuming various types of media (music, TV series, etc.), both time-dependent and time-independent, and beginning to offer self-generated videos to the network. People at home will start creating high quality contents, where the user can interact with the contents and, even, generate and modify it in a collaborative manner. The problem is that the current Internet is not ready for this convergence between the real media world and networks and future demands.

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6 General concept of FN media transport

The media transport in the Future Network is based on the premises of simplicity and flexibility (evolvable) and is focused on high quality multimedia communications.

This document introduces general concept of the Future Network based on the actual mechanisms and protocols used to manipulate the multimedia data. To face this challenge, service-oriented architectures offer a flexible approach, which enables to define services and compose multiple services in run-time or design-time, to fit the requirements for particular media communications over heterogeneous context, for any kind of media content, either time-dependent or time-independent. Future Network will go further than the application layer and go down to the communication protocols themselves, choosing in a dynamic fashion any kind of basic services (e.g.: acknowledgement, sequence number, flow identification, congestion windows, etc.) and media services (e.g.: content adaptation, scalability, transcoding, etc.) that are needed in a particular communication, according to the parties capabilities and the media transport requirements. Thus, this document describes a general concept of the media transport, as the media service composer element, forming a common container with just the metadata needed, to compose and dynamically adapt specific media services for a given communication for every sort of contents.

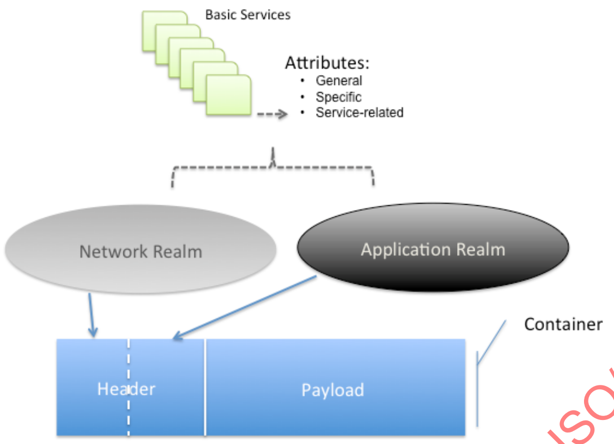

Figure 4 — Container

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6.1 Support of connection-oriented and connection-less model

The model is designed as a service-oriented approach for a flow-oriented context-aware network working mainly in a connection-oriented mode, although connection-less is allowed for particular sort of services, where communications are composed in situ (using reusable components) according to the needs and requirements of the consumed service.

The media transport in the future network should be able to work in connection-oriented and connection-less fashion in datagram transmission, depending on the working environment. In Internet, most data are conveyed by using TCP with its strict flow and congestion control. Even media applications using UDP transport protocol relay either on RTP/RTCP, as transport / control protocols, or with a particular control scheme at application level. So, Future Network is designed to work with both modes, mainly as a connection-oriented but also as a connectionless mode accordingly to the communication characteristics. The connectionless mode does not regard upon the on-line status of the peer on the other side, such as short messages services (SMS and tweets). Broadcasting services may be set as connection-oriented communications following a multicast pattern across the network, or connection-less in simplex communications such as traditional radio / TV.

6.2 Classification of basic services and composite service

Services are classified into basic (atomic), and composite services. Basic (atomic) services have individual functions commonly used in networking protocols, e.g. acknowledgments, sequence numbers, flow control, etc. These are well-defined and self-contained functions, used to deliver data in a self-adaptable, self-configurable, and context-aware manner. Concretely, media services are those atomic can operate with multimedia mechanisms (such as transcoding, VBCC, protection, etc.) that belong to the content realm which may be executed by the same peer or by different peer to perform task in order to provide a higher level media service. Composite services are the result of combining basic services. Each composite service or application implies consuming different basic services or other composite services which may have possible dependences between them. Service can involve one or more nodes, depending on the complexity of the service. As a result, a container for each particular communication is generated.

Most error resilience techniques applied on real-time communications are FEC (Forward Error Correction), which adds redundant information increasing the data rate. The application of interleaving mechanisms

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increases the probability of recovering lost multimedia data in the presence of bursty losses across the network. These techniques can be applied according the data conveyed as a modular services in an atomic architecture.

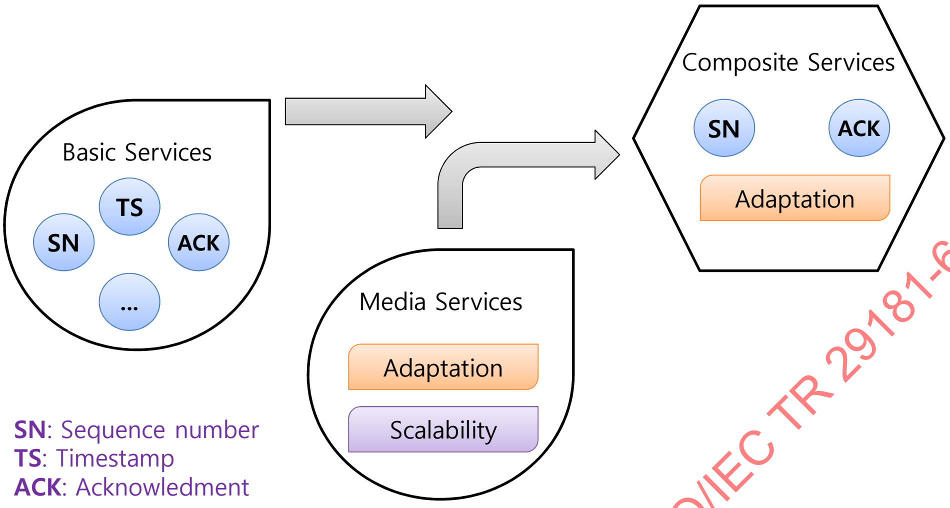

Figure 5 — Basic services and composite services

In order to obtain the desired behaviour, functionality and QoS constrains, communications are established concatenating atomic services into a workflow for consuming a certain composite services. They are allocated amongst the involved nodes, as required by conditions of temporal context and service requirements. In this way, all functions are used only when and where they are required, so that there is no functional overlapping or usage of counterproductive functions. Thus, atomic services can be executed in a per-hop, per-section (between two non-adjacent nodes), per-AS (between Autonomous Systems) and/or end-to-end basis (section ranging the entire route). Nodes on the network are intended to be Media Aware Network Elements, which react either by commands from the control plane or directly over the content or the bit-stream according to some rules depending on the content itself (i.e., Scalable Video Content or Multiple Description Video Coding).

6.3 Deployment of MANE (Media Aware Network Element) in the network

MANE (Media Aware Network Element) is a content and context aware network element capable of processing media contents to accommodate a given contents or services according to the context. This element may handle all attributes of containers taking into account the content type and properties, networking properties and status, and other environmental and conditional properties that may have effect in routing of the contents and services. It is an edge elements of any network, included Autonomous System (AS), operated by a single manager, which perform tasks regarding to the media content such as content adaptation, scalability decision-making, backward signalling, media mobility, content based congestion control, etc. These tasks can be performed inside a network, such as in a LAN, or amongst Autonomous Systems inside the core network.

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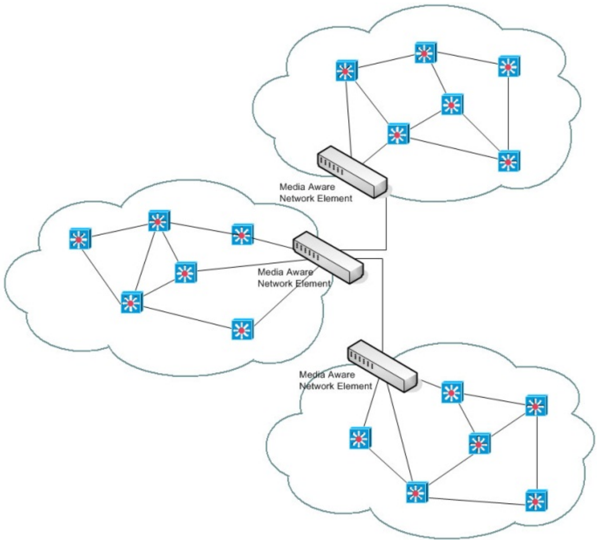

Figure 6 — MANEs in the interconnect networks

The capabilities of MANE include caching, adaptation, synchronization, and media aware routing in the network. MANE also needs to deal with heterogeneous network, user capabilities and preference that may change in time. The multiple MANEs interacts to provide the most adequate various media delivery accordingly to the recognized contexts. MANEs may configure media-specific routing information to provide media delivery. However, the routing information are configured by the FN service composition.

6.4 Content delivery networking

Content delivery networking is an approach that allows user to focus on the required data instead of having to search for the physical location where data is to be retrieved from. Some of the features of the content delivery networking include content caching, content searching, content routing, content delivery, and content retrieval. In media transport aspect, future network should be aware of contents and content receiver to support optimized content delivery. The FN should be able to provide efficient content routing and content delivery. For content routing, FN should configure efficient path to deliver contents. A mechanism is needed to merge and synchronize multiple incoming contents over the network. For content delivery, FN should delivers contents to the receiver by by unicast or multicast using channels managed by content aware router. Future network should deal with other issues related to content networking such as performance, resilience, security, and privacy.

7 Problem statement

This clause lists problems of media transport in the current network.

7.1 Protocol overhead and useless information

Current network architecture design is based on a hierarchical layered model like OSI or TCP/IP stacks. In these models, networking functions and protocols are grouped in layers, according to a common objective and scope. Thus, each layer performs different networking tasks, restricting inter-layer communication to immediately adjacent layers. In theory, each layer is in charge of a group of functions, but in practice functions overlap at different layers, adding protocol overhead and blurring the layered structure of the protocol stacks.

To send an RTP packet it is needed 20 bytes of the IPv4 header, 8 bytes of UDP, and 20 bytes more of RTP. So, 48 bytes is needed for headers assuming that there is no additional information (optional fields). For IPv6 (40 bytes) the RTP headers add up to 68 bytes, and a TCP/IPv6 acknowledgement packet is 60 bytes, though it only carries about 4 bytes of useful information. It must be remembered that TCP/IP network was designed

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to work over any sort of network, and for any sort of application. The main operation of TCP/IP is to transfer data from end to end, by two different ways, connection oriented (TCP) or connectionless (UDP).

As example of useless fields on the current stack, when MPEG-TS (well self-structured media format with several information used to “transport” media stream) is sent over the network, a lot of headers and additional information about the MPEG stream are added. Some fields are already present in the RTP header, increasing the amount of duplicated information, resulting in a waste of time and resources. This is an important hint that these protocols need a hard redesign or be replaced. Historically, new features have been added by means of inserting extra information in higher layers, instead of squeezing the capacities and features of the existing ones.

7.2 Limitation of Layered Coding

Layered Coding (LC) is based on the idea of splitting a video stream into several hierarchical layers consisting of a base layer, with minimal features, and enhancement layers. The more layers received the more quality achieved, as a receiver-driven adaptation system. The main drawbacks of this coding are basically two folded: (1) real implementations of LC, such as wavelet-based solutions (DWT, e.g.: JPEG2000 and Dirac Pro) and SVC (Scalable Video Coding), require enormous computational complexity and entail high delay, and (2) its weakness in terms of reliability in error prone environments.

7.3 No media-awareness

Current common congestion controls are focused on adapting the data rate at bit level according to the network available resources, instead of on adapting the content (semantic approach). For example, windows-based congestion control is based on a transmission window, such as TCP that limits the amount of data to be transmitted usually following the AIMD (Additive Increase / Multiplicative Decrease) algorithm according to the network status. Other congestion control approaches closer to the multimedia world, such as rate-based, media-aware rate control and receiver-based mechanism, act over the sending data rate in a smoother way than the strict data based congestion controls. However, these methods also treat the video flow as a bit stream adapted to the network conditions.

Future network should be focused on the experience of the user, enabling a control according to the media content conveyed instead of the network status. As aforementioned, a bit-stream oriented congestion control is used for time-independent media where a reliable and fast communication is pursued. On the other hand, for time-dependent media solutions based on content adaptation are basically done over semantic content parameters, instead of over the bit stream. Both strategies act over the output data rate, increasing or decreasing the amount of bits issued according to the network congestion, but taking care of different parts of the bit-stream. As an example, if the content is a video stream (time-dependent media), according to the variable conditions of the network and taking into account the nature of the data conveyed, the output data rate adaptation is directly related to the adaptation in real time of the video source parameters, such as either the resolution, the frame rate or the codec, instead of directly decreasing the data rate.

7.4 No information exchange between protocol stacks (layered network stack)

The Internet does not have any collaboration between different layers. The OSI reference model has designed layers as separate entities and abstract them by assigning specific roles and requirements to each layers. Currently, Internet is used in variety of devices including wireless and cellular devices and in variety of application including real-time multimedia videoconferences, VoIP, and various other types of multimedia streaming services. These trends has caused the network to face new problems which includes, adaptability to dynamic changes of the network and traffic conditions, increase in number of connectivity, high effective capacity utilization, low processing overhead within the network and end-systems. However, these new requirements are difficult to handle by the IP-based network.

7.5 Support for new types of media

In the near future, the upcoming media types will be 3D contents, UHD (Ultra-High Definition), hologram. New media types will need the support of high transmission rates, efficiency, and flexibility that is difficult to be supported by the current network and current media systems. Currently 3D contents as well as 3D devices are

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delivered to the market places which are growing to interactive 3D contents such as 3D gaming. The UHD enables applications and services such as telemedicine and super high-vision cinema, and super high-vision theater. UHD contents needs high transmission rate which may cause problem when delivered in the current unicast-based transport mechanisms. Different approach such as multipath-based transport mechanism is needed to support such high quality contents [19].

7.6 Merging of current solutions in supporting media transport

Many research in the past for enhancing media transport was dedicated to defining efficient caching architecture, techniques of media adaptation, and multicast service support, separately. An independent approach for finding optimal solution for media transport solves only one specific problem [16]. In providing FN media transport, solutions to the three approaches should be merged and dealt with altogether to find most efficient solution in supporting media transport. Efficient caching architecture should be applied to MANE, efficient media adaptation should be applied to MANE and end-devices, and FN should provide efficient multicast services.

7.7 Contents are left to the end-system

Internet was designed to support host-to-host applications such as telnet and ftp in which the networking target is the address of the host. However, Internet is used more and more in applications where the target is the contents rather than the host. This trend has motivated content-oriented networking studies (e.g. DONA, CCNx). These technologies did not change the functionality of Internet. Instead they have adapted the use of a special server which is a host that acts as a network element to provide content based networking. However, the Future Network should be aware of the content and its characteristics to provided efficient content delivery.

8 Requirements for media transport in Future Network

8.1 General requirements

REQ.FN-MT-101 FN media transport framework should support any types of media contents including current and future types of media ranging from very low to very high data rates and requiring different level of QoS/QoE, and various types of communications such point-to-point, point-to-multipoint, and multipoint-to-multipoint.

NOTE Various types of content will appear in the future. Some example would be Ultra HD content, 3D contents, etc. These types of contents require high data rates in the network and meticulous processing capability in the media devices.

REQ.FN-MT-102 FN media transport framework should support wide range of devices able to consume / generate media content (i.e.: smartphones and smart TVs) and provide suitable media transport service.

NOTE The media devices include media producing device, media consuming device, media storage device, MANE, or any media type of devices that is participating in the media transport.

REQ.FN-MT-103 FN media transport framework should support identification of media content, media devices, and user preferences.

NOTE 1 The consuming device requests for a particular media contents to the media-based networks. The information of the actual sender(s) or media contents processing procedures is irrelevant to the consuming device. The consuming device should be able to identify the media contents.

NOTE 2 In certain occasion, the consuming device may needs to identify the servicing media devices to get the desired service. However, the identification of the media devices does not have to be based on the physical location.

REQ.FN-MT-104 FN media transport framework should support suitable delivery, in terms of delay (tight) and / or reliability (losses), of data and content (time-independent media objects and time dependent media objects).

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NOTE 1 The time-independent media object is a type of content that does not depend upon a presentation according to the time-domain. Such example would be text, image, etc.

NOTE 2 The time-dependent media object is a type of content that has temporal relation amongst the media unit. Such example would be multimedia video stream, continuous media.

REQ.FN-MT-105 FN media transport framework should be able to exchange information with other modules by incorporating QoS/QoE related information from different module (i.e., network module, application module, etc.).

NOTE Inter-module information exchange provides dynamic feedback of the QoS/QoE information across different modules to provide adaptive setting of service control.

REQ.FN-MT-106 FN media transport framework should support content adaptation through techniques such as layered coding (LC) and multiple description coding (MDC), among others.

NOTE 1 LC is a coding feature that is used in SVC, in which the video stream is split into several hierarchical layers consisting of base layer and one or more enhancement layers.

NOTE 2 MDC is a coding technique that fragments a single media stream in multiple substreams which can be delivered over the network in different paths.

REQ.FN-MT-107 FN media transport framework should be able to generate either in run-time or design-time an adaptive and tailored container for each communication according to both content and network requirements.

NOTE Replication of functions along the network stack is a feature of current internet that has to be wiped out in the FN. Just use what it is really needed in one communication. Nevertheless, as FN is being set-up, just a bunch of well-predefined containers shall be probably used all the time becoming the de facto containers.

REQ.FN-MT-108 FN media transport framework should be able to adapt the dynamic characteristic of media according to both content and network requirements, as well as user preferences and choices.

NOTE Specific features such as synchronization between different streams (i.e., audio and video), timing between sender and receiver, data type identification are functions performed by entities in certain communications. Thus, depending on the kind of communication, some specific features should be needed. For example, online communication, jitter, and delay are crucial, but for offline data integrity becomes more important than others.

REQ.FN-MT-109 FN media transport framework should support security at media level to ensure privacy and trustiness.

REQ.FN-MT-110 FN media transport framework should consider heterogeneous devices as nodes of the network which will be able to initiate, handle and finalize tailored media content transmissions.

NOTE MANEs, core network equipment and terminal devices should have, apart of specific capabilities, common functionalities to handle the media flowing from, to and through them.

REQ.FN-MT-111 FN media transport framework shall be based on the principles of simplicity, flexibility, scalability, and able to evolve over time.

REQ.FN-MT-112 FN media transport framework should consider media transport in the DTN (Disruption-Tolerant or Delay-Tolerant networkings).

NOTE 1 DTN is a network architecture that may lack continuous network connectivity. Use of local buffer is one method to overcome the media transport over DTN.

NOTE 2 In future network mobile devices should be connected all the time to the network, but not always this situation shall be possible. Ad-hoc networks, outside coverage range, disruptive connections, smart cities using sensor spread around, enable a scenario where communications can be temporaly unavailable.

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8.2 Requirements related to functionality of MANE

REQ.FN-MT-201 FN MANE should support dynamic adaptation and configuration (i.e., combining, separating, adding, orchestration or removing) of media objects.

REQ.FN-MT-202 FN MANE should support content adaptation to a wide range of device capabilities or device resource limitations to underlying network characteristics, specific attachments and user personalization.

NOTE Scalability and adaptation enables the contents to adapt to particular contexts. Content adaptation is to modify contents based on the given input to generate an adapted output contents according to a particular context, such as the capabilities of the device used by the other party in a videoconference call. Adaptation can be performed in the spatial, temporal, quality domain, as well as simply modifying the codec applied in the case of audiovisual content.

REQ.FN-MT-203 FN MANE should support be context-aware of the network environment, of the related device/system, of the characteristics of media contents and of the preference of the user.

NOTE The some of the contexts that the media transport:

- Any digital devices with various capabilities will be sending and receiving media contents The device can be attached to various types of network which can be wired or wireless.
- The status of the network that the device is connected to can be varied.
- The device can have various screen resolutions. The device may be still in a single place or moving across different networks as with the movement of the user.
- The contents delivered may be time-dependent or time-independent requiring various types of QoS/QoE.

REQ.FN-MT-204 FN MANE should support tailoring of container metadata according to application-related attributes and network-related attributes.

REQ.FN-MT-205 FN MANE should support exchange of metadata information among MANEs along networks, enabling flexible interconnection at media level.

NOTE Current media delivery frameworks, such as multicast or CDN, are not deployed globally (end-to-end) or between different networks because of lack of interconnection among them. MANEs have to enable interconnection at media level and facilitate network communication.

REQ.FN-MT-206 FN MANE shouldt have capabilities to cache/store media contents and enable delivery of them from the cache/storage that is located near to the end user.

NOTE Keeping in mind that all devices belong to the FN, and content flows from point to point/s, caching solutions enable better QoE and QoS for content delivery, increasing rebustness, lowering delay and drifts, saving network resources, among others.

REQ.FN-MT-207 FN MANE should support interaction with non-MANE network equipment through common interfaces and/or metadata inside containers.

NOTE Non-MANE network equipment does not have to know what kind of traffic is conveying, but can act according some policies before certain metadatas. For example, maybe MANE can inform the router be careful in delivery i-frame, but normal router would not be able differentiate i-frame, however, MANE can inform the router to not to discard frame with certain format.

REQ.FN-MT-208 FN MANE should support a signalling plane or protocol to enable aforementioned features for both MANE and non-MANE devices (included terminals).

8.3 Requirements related to media delivery and network

REQ.FN-MT-301 FN media transport framework should be resilient to delay, jitter, and losses.

NOTE In the current Internet, some functions are implemented in multiple layers. In order to avoid implementation of same functions in multiple layers, discussion is needed to clearly specify which layer should handle the specified functions.

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Actually, the idea in Part 6 evokes to a network architecture where the protocol stack is tailored for each communication, therefore duplication, in terms of features, will be avoided. It is also the idea behind the universal container.

REQ.FN-MT-302 FN media transport framework should support differentiation at content level in order to enable a prioritized delivery based on the media.

NOTE: FN should provide method for the media transport to specify the priority based on the media contents. Prioritization could be absolute (such as IntServ) or relative (such as DiffServ).

REQ.FN-MT-303 FN media transport framework should support the seamless use of heterogeneous network environment.

REQ.FN-MT-304 FN media transport framework should support multipath delivery.

NOTE Content handling techniques, such as MDC and future media compositions or orchestrations, enable delivery of multiple streams over the network from different paths.

REQ.FN-MT-305 FN media transport framework should support content-aware based congestion control (CABCC).

NOTE Current congestion controls, such as the TCP's, are intrinsically related to the underlying network performance instead of to the content transmitted, yielding many times in a lack of sense at media level.

REQ.FN-MT-306 FN media transport framework should support mobility of users along different network and attachments.

NOTE FN should be able to provide seamless communication regardless the network, attachment or device.

REQ.FN-MT-308 FN media transport framework should be able to find the best path to enable the best QoE for users.

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Annex A
(informative)

Use cases for media transport

A.1 HD Multiparty videoconference

Multiparty videoconferencing involves several participants with devices of wide variety of capabilities connected to heterogeneous networks. One possible solution to support multiple parties with different capabilities (different context) is enabling scalability to be adapted to the video in the heterogeneous environment, by means of, for example, a Polyphase Downsampling Multiple Description Coding technique that is applied on the video content to generate several lower resolution balanced subsets from the original video source, which will be issued over the network into self-contained separated flows. Thus, with this solution a wide range of devices can be covered with the same video source, in such a way that the more subsets delivered the more fidelity is achieved.

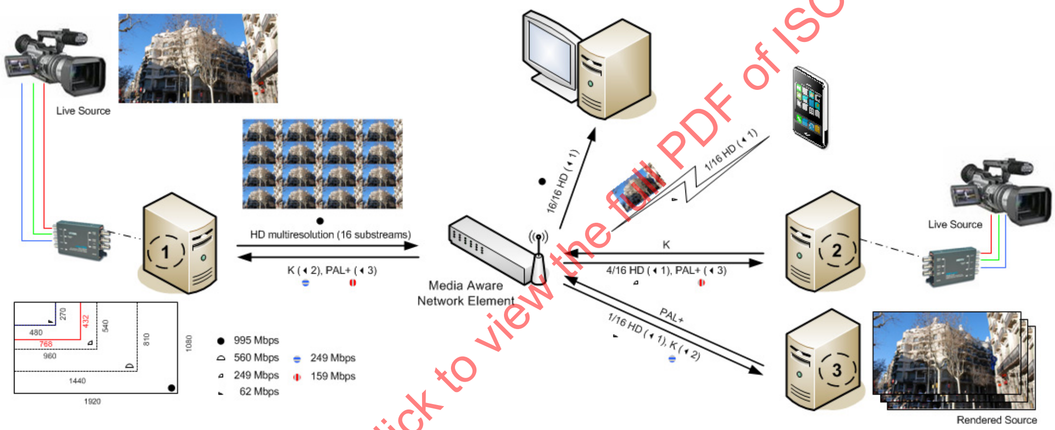

Figure A.1 — Multiparty HD scenario

A.1.1 Current Solution

Currently, such scenario is composed by two planes, a control plane and a data plane. Data plane works over a RTP/UDP/IP stack with extra signalling to control the synchronization, or an extension to the RTP header to differentiate and synchronize the multi-streaming generated for this technique. In the current solution, the sender of the live source will need to be aware of the receiving devices and delivers appropriate stream to the pertaining device. Thus, sender may need to setup more than one session in order to provide appropriate stream to each receivers.

A.1.2 Future Network Solution

Future Network will be a content aware network able to provide a composite service to fit the specific requirements for a given communication. MANE (Media Aware Network Element) will need to be aware of the participating parties and their characteristics in terms of capability of the device, status of the interconnected network, and preference of the users. The MANE manipulates the video to be adjusted to the receiving device.

In implementing this use case in the FN, a control plane is needed to establish, negotiate, monitor, and tear-down the communication among the involved parties. A data plane to transport the data is required. During the negotiation phase, current multimedia signalling application protocols determine the capabilities of the parties participating in the call, entailing which kind of media will be issued over the network infrastructure.

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Future Network should go down to the communication protocols, choosing in a dynamic fashion the basic services (i.e., acknowledgement, sequence number, flow identification, congestion windows, etc.) that are needed in a particular communication, accordingly to the capabilities of the participating parties and the characteristics of media to be transmitted. Taking into account of the existing communication environment and traffic status as a reference, the basic services that could be negotiated amongst the parties can be: sequencing, sub-stream synchronization, content handling, timestamping or global time referencing QoS labelling, FCS of all data, content based congestion control, and back reporting with media statistics. These services entail related attributes as part of the header fields of the container. Besides, there will be general attributes such as media type (content to which a particular composite service is provided), parties identification, and data length. The general attributes are attributes that has no relation to the communications network used. And specific attributes are associated to the type of transmission network such as line number, data pointer (with regard to the content information conveyed, current offset), and media unit reference (current M-bit to signal the end of a media unit of the media object, in this case a frame). This will result in a group of attributes which conforms to the header of the total container to support each basic service. Using this methodology, it is possible to avoid use of replicated functions and is possible to use only those functions that are needed to support a particular communication in a flexible way.

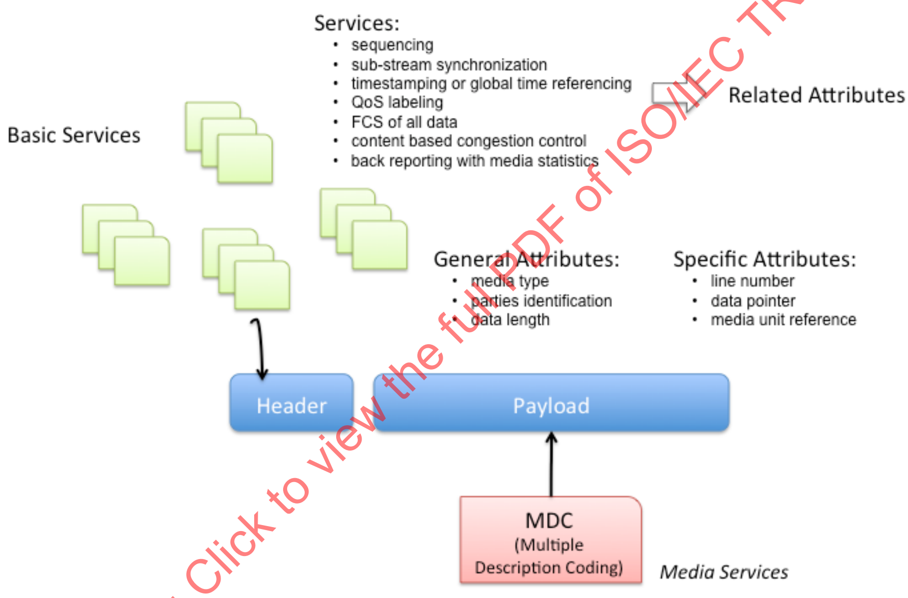

Figure A.2 — Service for multistreaming communication

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A.2 Web browsing

Multimedia contents consume the largest part of the current traffic carried in the network, mainly because of p2p applications of file sharing, live streaming and lately the Video on Demand application. In this scenario, the second majority traffic on the network is reserved to web browsing, an asynchronous reliable service of data transfer between two nodes in the network following a client/server model. Actually, this is the kind of service for which the current TCP/IP network was primarily designed, to provide a reliable (using TCP) or fast (UDP) communication between peers working over non-reliable physical networks.

A.2.1 Current Solution

Currently, web browsers uses HTTP/TCP/IP which performs a strict data control in order to assure the complete data transfer between the server and the client without errors (integrity). This reliable communication is achieved by means of a connection-oriented protocol at the transport level, the TCP, which performs also a strict control, in terms of flow and congestion.

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A.2.2 Future Network Solution

Future Network will be a content aware network, by means of the control plane, which in the negotiation and establishment process shall specify the type of media contents (time-dependent or time-independent). Hence, in this scenario the basic services will be those that identify the peers and assure an asynchronous reliable data transfer. Basic service shall be: sequencing, content handling, QoS labelling, FCS of all data, content based congestion control, and acknowledgement. General attributes shall be media type (content to which a particular composite service is provided), parties identification, and data length. Specific attributes, regardless of the basic services and general attributes shall be the currently used HTTP attributes.

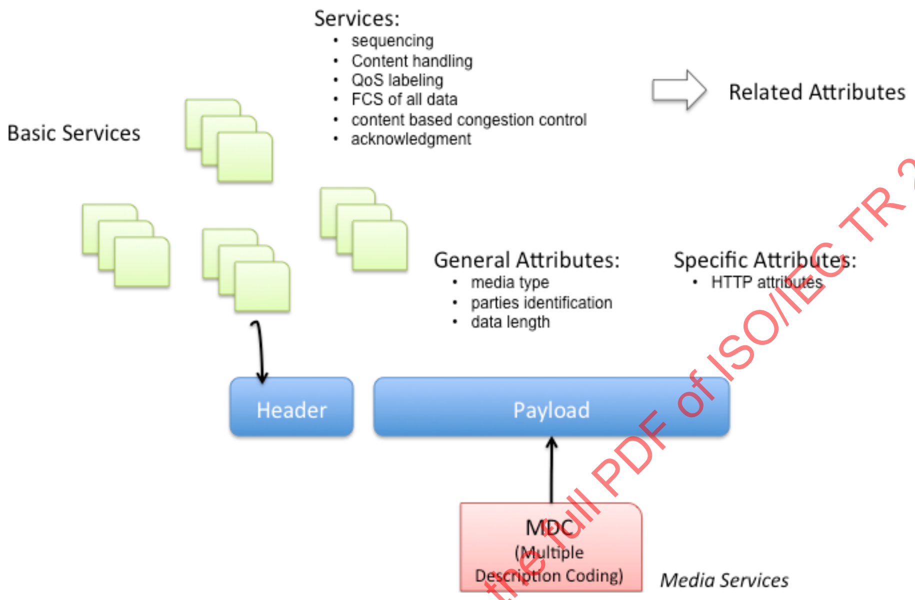

Figure A.3 — Services for web browsing

A.3 Media Aware Network Element

A.3.1 Content-aware based congestion control

Media Aware Network Elements are intended to be the network elements with higher functionalities related to media transport instead of a mere data relays. MANEs have capability to be aware of the contents that is being conveyed and reacts over them accordingly to the rules defined, depended on the type of media content, and being aware of network event, such as congestion.

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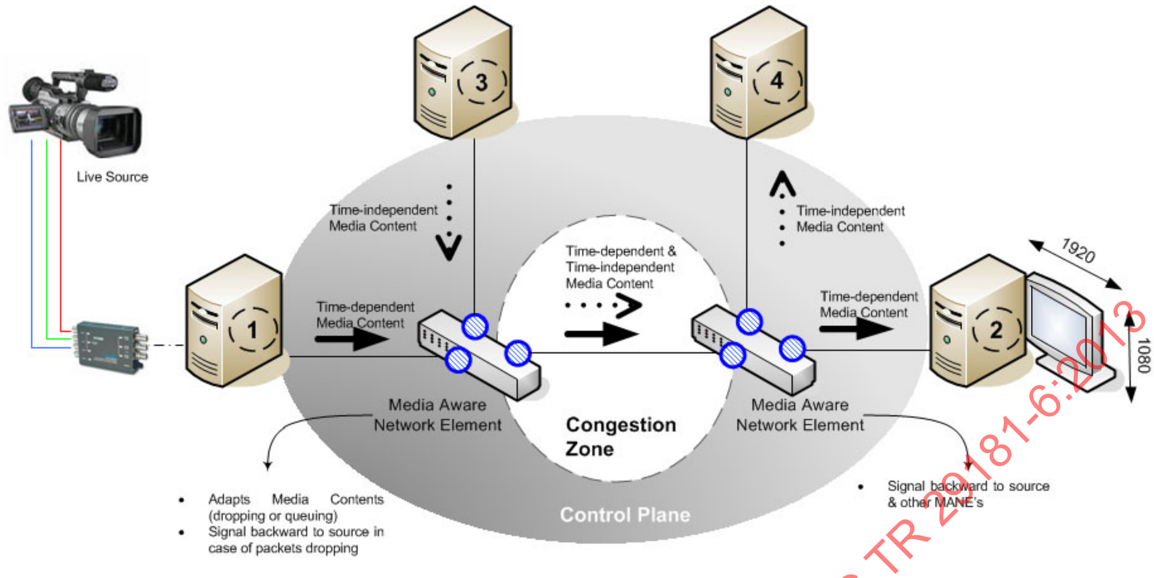

Figure A.4 — MANE reacting to congestion

As shown in Figure A-4, there are two main streams, one conveying time-dependent media data and the other time-independent. In case of congestion, MANE's reacts by adapting media contents accordingly to the characteristic of the media content. In the case of time-independent content, data may be queued and sent at bursts instead of following a continuous stream. In case of time-dependent media, MANE may performed different actions depending on its capabilities and the characteristics of the content, such as dropping less important packets of an scalable content or adapting the content to the network status. In both cases, a signal of congestion is sent backward to notify the source for the source to make rightful adjustment.

A.3.2 Decision-making

Users can have different devices connected to various types of network. The FN should be scalable and adaptable to support this heterogeneity environment. MANE should be able to make decision according to the control plane. For example, in the case of video transmission, MANE will be in charge of adapting the content or relaying as many sub-streams (from a scalable video coded video stream) as needed to each devices behind its network. Figure A-5 shows a multistreaming transmission of a video content using a MDC scheme to split the content into several pieces in order to reach as many users as possible. MANE relays the each pieces to each peer according to their capabilities. MANE also report the transmission status through the control plane.

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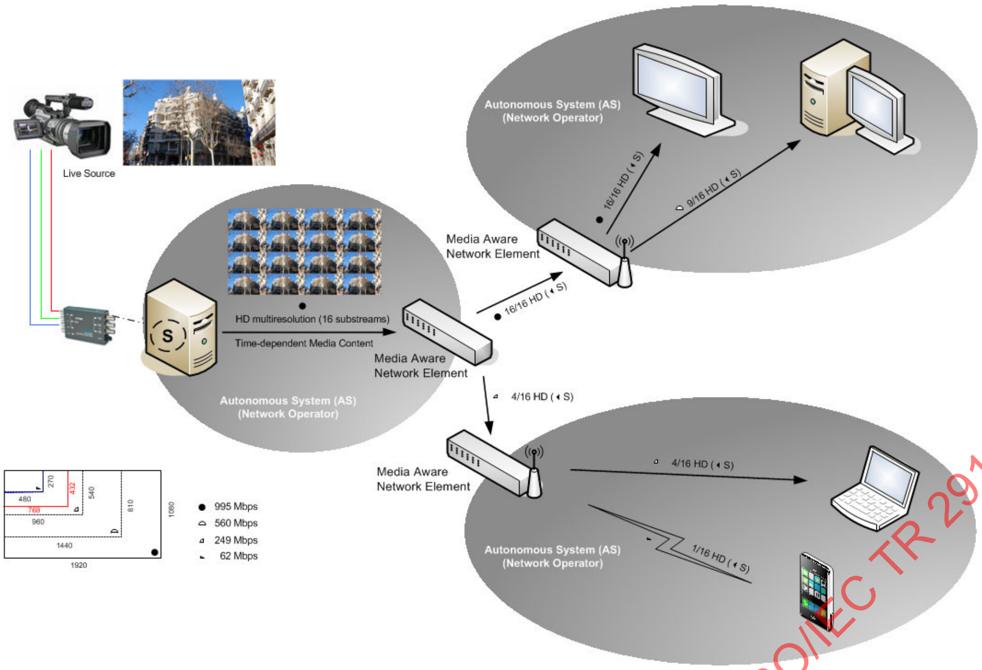

Figure A.5 — MANE relaying on the required media data

A.3.3 Seamless mobility

A user may be watching an online TV program on his/her smartphone connected through a cellular network operated by Operator A. Upon arriving at home, user would like to continuously watch the online TV program on the TV in the living room with full HD support which is operated by a cable Operator B, without interruption. This is called media mobility. Media mobility inside the same network can be performed by the MANE placed inside the LAN, operated by the same manager. In the case of media mobility between different network, MANE has to be placed in the interconnection point for easy handoff. This is an important point, because user does not care who provides the service. He/she wants to consume that specific media content regardless of the device or the location.

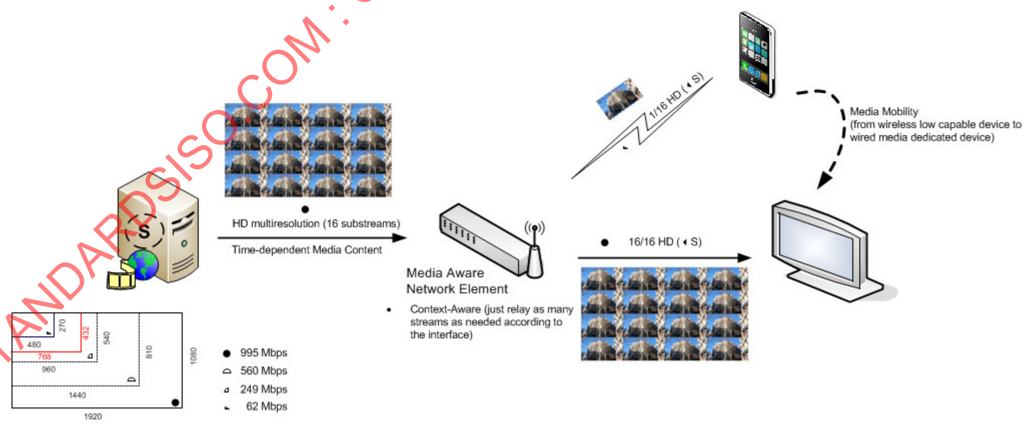

Figure A.6 — Media mobility inside an AS

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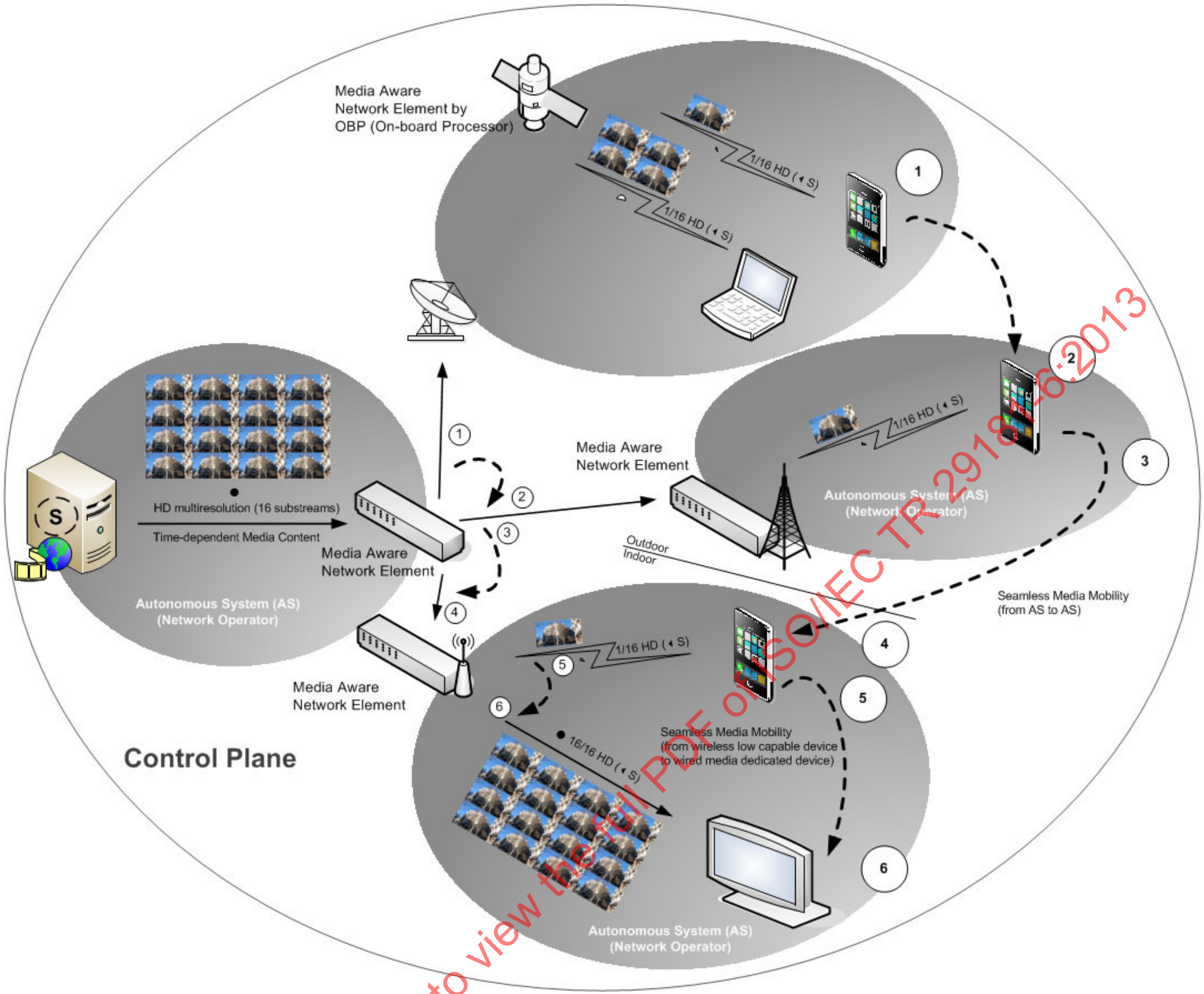

Figure A.7 — Media mobility among several AS

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Annex B
(informative)

Related standardization and research activities

B.1 MMT (MPEG Media Transport)

MMT(MPEG Media Transport) is a standard developed by the ISO/IEC JTC 1/SC 29 which aims to resolve various problems of the existing multimedia transport, such as MPEG-2 TS and RTP. The MPEG-2 TS and RTP are not suitable for the current and future network and service environment with broadcasting and mobile convergence. MMT aims to provide efficient solution for the transport of various types of MPEG media in the heterogeneous network environment.

The main objective of MMT is defined in the “MPEG Media Transport (MMT) Context and Objective” which is listed as follows [14]:

- Efficient delivery of media in an adaptive fashion over various networks with the main emphasis on IP based networks, including terrestrial, satellite and cable broadcast networks. The standard will enable building interoperable solutions for delivery and consumption of media in this context.
- Enable the use of cross-layer designs to improve the Quality of Service/Experience (QoS/QoE). By incorporating QoS/QoE-related information from different layers, the delivery and consumption of media would be optimized.
- Enable building integrated services with multiple components for hybrid delivery over heterogeneous network environments. The specification shall provide the capability of seamless and efficient use of heterogeneous network environments, including broadcast, multicast, storage media and mobile networks.
- Enable bi-directional low delay services and applications, such as online gaming and conversational services.
- Enable efficient signaling, delivery and utilization of multiple content protection and rights management tools.
- Enable efficient content forwarding and relaying.
- Enable efficient one-to-many delivery.
- Provision means for error immunity, including burst errors.

MMT considers cross-layer design to deliver media adaptively to various types of network. It monitors the network status to respond to the changes of the network conditions by periodically collecting QoS-related parameters such as signal strength, available buffer size, packet loss ratio, delays, etc. This information is conveyed to the application layer to conduct media adaptation.

The mechanism defined in MMT for cross-layer design that can be considered in the inter-modular information exchange concept defined in this document.

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B.2 SMART of Ambient Network

Ambient Networks is a network integration design that seeks to solve problems relating to switching between networks to maintain contact with the outside world. This project aims to develop a network software-driven infrastructure that will run on top of all current or future network physical infrastructures to provide a way for devices to connect to each other, and through each other to the outside world [15].

Ambient Networks is a large-scale collaborative project within the European Union's Sixth Framework Programme that investigates future communications systems beyond today's fixed and 3rd generation mobile networks [16].

Ambient Networks defines SMART (Smart Multimedia Routing and Transport) for media delivery in the heterogeneous network environment including mobile network. SMART provides distribution, adaptation, and caching of the media in the network in accordance with the context of the end-user with various end-user terminals and network capability in the heterogeneous network. Each service are provided in the overlay network, SSON(Service-specific Overlay Network), to deliver the appropriate media to the end-users. The figure shows the mapping of the media server(MS)/media client(MS) in the SSON with the routers in the underlying network.

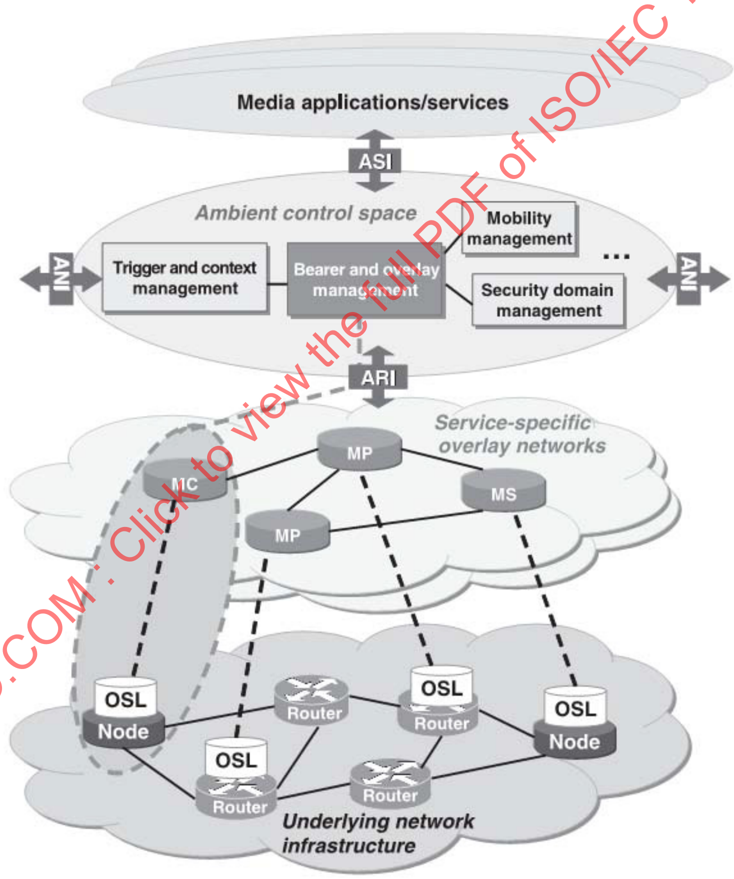

Figure B.1 — SMART Multimedia Routing and Transport Architecture

Although the ambient network defines SMART for media delivery operating on the overlay fashion the functionality of SMART. The media routing in the SMART has some resemblance with MANE. Features such as media routing table and media caching/adaptation are part of the features that is considered in the FN media transport.

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B.3 MEDIEVAL (MultimEDia transport for mobIlE Video AppLications)

MEDIEVAL [17] is a Small or medium-scale focused research project (STREP) of the 7th Framework Programme of the European Commission, addressing the core of the strategic objective "The Network of the Future". MEDIEVAL defines a mobile video architecture with cross-layer mechanisms to provide high quality of experience to users.

It has identified five key issues.

- Specification of an interface between the video services and the underlying network mechanisms.
- Enhanced wireless access to optimize video performance.
- Design of a novel dynamic mobility architecture adapted to video service requirements.
- Optimization of the video delivery by means of Quality of Experience (QoE) driven network mechanisms.
- Support for broadcast and multicast video services, including Internet TV and Personal Broadcasting.

The key components of the MEDIEVAL architecture are illustrated in the figure.

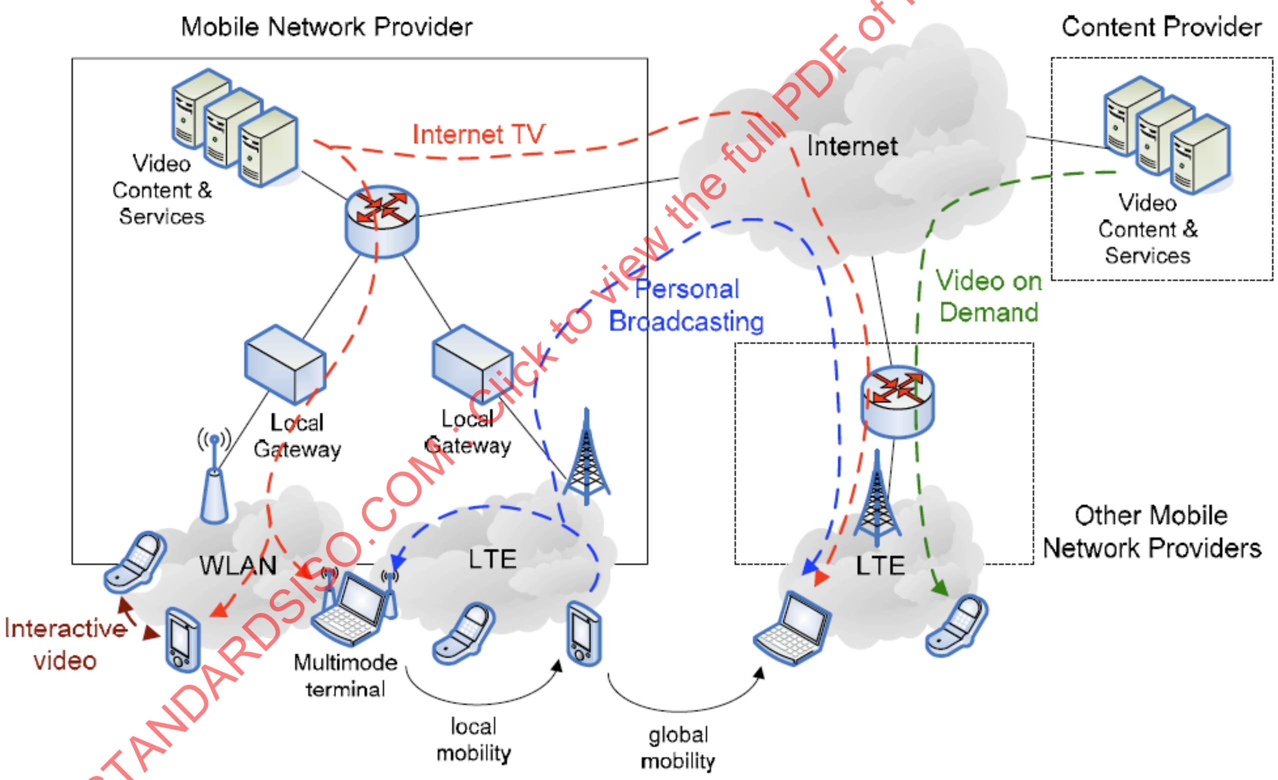

Figure B.2 — MEDIEVAL Vision

The MEDIEVAL architecture comprises of five key functionalities:

- Interaction with the underlying network to allow video services optimally customise the network behaviour.
- Enhanced wireless access to optimise video performance by exploiting the features of each wireless technology.

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