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Hybrid FSS satellite/terrestrial network architecture for high speed broadband access

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Foreword

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Modal verbs terminology

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Executive summary

The present document proposes and analyses an hybrid access network combining one or several terrestrial access technologies (Fixed or Mobile Service) together with a satellite broadband access network (Fixed Satellite Service) in order to enhance end users' Quality of Experience of broadband service delivery primarily in under-served areas where Internet service is available over terrestrial access technologies but delivering rates below that expected of Next Generation Access.

This hybrid access network will support all the telecommunications services typically offered on Next generation access technologies, including high bandwidth applications such as video conferencing, live streaming and video on demand via the satellite link along with the latency sensitive applications such as highly interactive online game play via the relatively slow terrestrial link.

Intelligent Gateways route the traffic between terrestrial and satellite access technologies according to the Quality of Service requirements associated to the various service components with the objective to maximize the overall Quality of Experience for the users (large bandwidth and low latency). In addition, the hybrid network ensures a higher resiliency towards potential interruption of service on the terrestrial access link.

The present document aims at:

- Providing an overall description of the hybrid access network architecture with special emphasis on integration aspects with a public packet switched core network on one hand and the home network environment on the other hand;
- Proposing suitable metrics to compare the Quality of Experience (QoE) over such hybrid access network with respect to single access network technology;
- Identifying existing standards that have to be modified and additional standards that have to be created for enabling this kind of scheme.

1 Scope

The present document details the benefit of an intelligent combination of satellite and terrestrial broadband access technologies for the benefits of users mainly in underserved areas.

2 References

2.1 Normative references

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

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

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2.2 Informative references

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NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

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

[i.1] ETSI EN 302 307 (V1.3.1) (2013-03): "Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)".

[i.2] ETSI TS 101 545-1: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 1: Overview and System Level specification".

[i.3] ETSI EN 301 545-2 (V1.1.1): "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard".

[i.4] Recommendation ITU-T E.800: "Quality of Telecommunication Services: Concepts, Models, Objectives and Dependability Planning. Terms and Definitions Related to the Quality of Telecommunication Services".

[i.5] IETF RFC 3697: "IPv6 Flow Label Specification".

[i.6] IETF RFC 3917: "Requirements for IP Flow Information Export (IPFIX)".

[i.7] Recommendation ITU-T M.3400.

[i.8] IETF RFC 2722: "Traffic Flow Measurement: Architecture".

[i.9] IEEE 802.1Q: "IEEE Standard for Local and Metropolitan Area Networks - Virtual Bridged Local Area Networks".

[i.10] ETSI TR 102 274: "Human Factors (HF); Guidelines for real-time person-to-person communication services".

[i.11] IETF RFC 4594: "Configuration Guidelines for DiffServ Service Classes".

[i.12] TR-069 DSL Forum.

[i.13] Recommendation ITU-T P.10: "Vocabulary for performance and quality of service".

[i.14] ITU TD 109rev2 (PLEN/12): "Definition of quality of experience (QoE)".

[i.15] Recommendation ITU.T G.100: "Definitions used in Recommendations on general characteristics of international telephone connections and circuits".

3 Definitions and abbreviations

3.1 Definitions

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

access link: link established between the IUG and the ING via a satellite or a terrestrial network

NOTE: One access link corresponds to one network interface.

application: program running on a device that requests or generates data that will form a Traffic Flow through a Network Interface

broadband access: service rate is greater or equal to 2 Mbps on the downlink

high speed broadband: service rate is greater or equal to 30 Mbps on the downlink (Target set by the Digital Agenda for Europe)

hybrid access network: access networks combining a satellite component and a terrestrial component in parallel where the delivery of a service using both the satellite component and the terrestrial component intelligently to maximize the Quality of Experience for end users in under-served areas

Intelligent User Gateway (IUG): Intelligent User Gateway (IUG) is a home device providing broadband access, security, cached storage capacity and QoE provisioning in an hybrid access network

intelligent network gateway: intelligent network gateway is the counterpart device of the IUG in an hybrid access network

network Interface: interface that connects the IUG or ING to an access link

next generation access network: access network with high speed broadband capabilities

Quality of Experience (QoE): subjective measure of the user's experiences with a service or an application (e.g. web browsing, phone call, TV, call to a Call Centre)

Quality of Service (QoS): objective measure of a service delivered by a network

service component: application may carry out multiple functions each producing a unique traffic flow

NOTE: The resultant set of traffic flows related to one application is referred to as a service component.

traffic flows: sequence of packets sent from a particular source to a particular unicast, anycast, or multicast destination that the source desires to label as a flow (see in IETF RFC 3697 [i.5])

NOTE: More specifically it refers to a set of IP packets passing an observation point in the network during a certain time interval (see IETF RFC 3917 [i.6]).

under-served area: area where Internet Service is available via a terrestrial access network but with no Next Generation Access capabilities

3.2 Abbreviations

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

.mpg	file extension for Moving Picture Experts Group video and audio compression
3D	Three Dimensions
ACM	Adaptive Code and Modulation
BSS	Business Support System
CDN	Content Delivery Network
CoS	Class of Service
CPE	Customer Premise Equipment
DSLAM	Digital subscriber line access multiplexer
E2E	End to End
FCAPS	Fault, Configuration, Accounting, Performance, and Security
FR	Full Reference
GEO	Geostationary satellite
HD	High Definition
HD/3D	High Definition/3 dimension (TV format)
HDTV	High Definition Television
HSPA	High Speed Packet Access
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
ING	Intelligent Network Gateway
IP	Internet Protocol
ISP	Internet Service Provider
ITU	International Telecommunication Union
IUG	Intelligent User Gateway
IUG	Intelligent User Gateway
LAN	Local Area Network
MDI	Media Delivery Index
ModCod	Modulation and Coding index
MOS	Mean Opinion Score
MPLS	Multiprotocol Label Switching
MTOSI	Multi-Technology Operations System Interface
NCC	Network Control Centre
NGA	Next Generation Access Network
NI	Network Interface
NMS	Network Management System
NR	No Reference
OAM	Operations, administration and management
OSS	Operations Support System
OTT	Over The Top multimedia content
PEP	Performance Enhancing Proxy
QoE	Quality of Experience
QoS	Quality of Service
RF	Radio Frequency
RFC	Request For Comment (IETF document)
RR	Reduced Reference
RTD	Round Trip Delay
Satco	Satellite Service Company
SCC	Satellite Control Centre
SCN	Satellite Communication and Navigation
SLA	Service Level Agreement
TTC	Telemetry, Tracking and Control susb-system
TV	Television
TX	Transmit
VDSL	Very high bit-rate Digital subscriber line
VoD	Video On Demand
WAN	Wide Area Network
xDSL	Digital Subscriber Line (any version)

4 Hybrid access network for high speed broadband access

4.1 Concept and rational

The proposed hybrid access network aims at delivering a resilient High Speed BroadBand service especially in 'underserved' areas at a comparable quality of experience to Next Generation Access networks capabilities.

The underlying concept can be illustrated with the following use cases:

- Business: Mrs McMiggins needs to work from home - a challenge with a highly IT intensive job. She frequently needs to upload and download large data files, typically several Gbytes. The download time experienced using a small capacity rural ADSL service causes problems, with on-line collaborators having to wait whilst files are transferred. They install an hybrid access which selects the satellite communications system to provide massive capacity on demand and also copes well with the bursty demand: this solves the problem.

- Gaming: John, their 12 year old son has a friend who lives 13 km away. They enjoy playing competitive pseudo-sport games using their game console stations. But when parents and sister also use on-line applications the contention between the traffic types causes delays and glitches in the games which were no-longer playable. However, the hybrid network solves this problem by routing data that needs low latency over the terrestrial ADSL system (e.g. the game console connection), with the satellite link used for delay-tolerant higher capacity services (e.g. down-streaming video from an internet multimedia server - a habit of his sister Jane who is particularly enthusiast about this internet multimedia server).

- Resilience: with the hybrid network installed, Mrs McMiggins can work from home whilst the children play computer games etc. On one occasion other residents complain that a construction company has cut through the Telco cables and cut off the telephone lines and the connection to the mobile mast in the village. Most people's phones and Internet will be cut off for over a week. However, at the McMiggins house all the traffic has been routed automatically over the satellite with very little loss of performance.

4.2 General architecture

The general architecture of the hybrid access network delivering High speed broadband service is depicted in Figure 1 below:

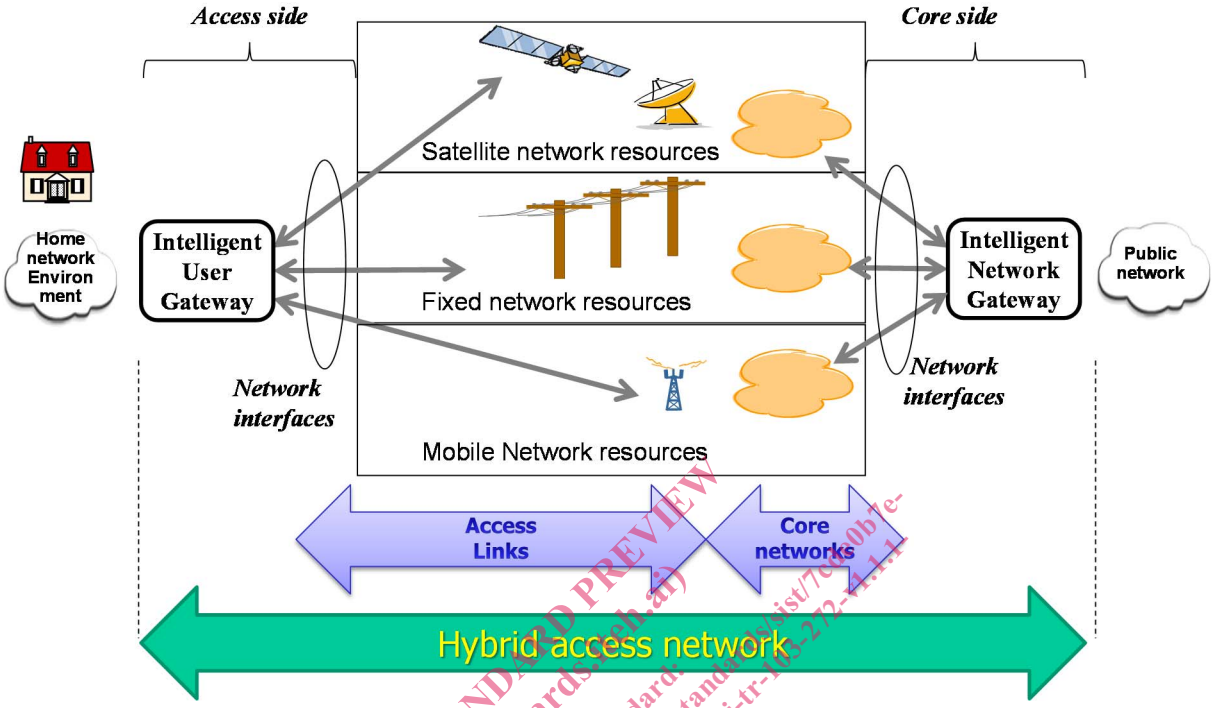

Figure 1: Hybrid access network architecture

On both edges of the hybrid access network, access and core side, a traffic classifier and a routing entity are located. These will be in the IUG and ING. While the first aims at identifying the type of application or service component, the latter selects the most suitable access link to transmit a certain flow of traffic. The criteria for this selection is threefold:

- first, the QoS requirements of the traffic are taken into account;
- second the capabilities of the available access links are considered; and
- finally policies defined by operator and/or subscriber might have an impact.

The Intelligent User Gateway (IUG) is a Customer Premises Equipment (CPE) providing secured broadband access, cached storage capacity and QoS provisioning. It not only provides an interface to several access links, but the IUG will select access delivery routes in multi operator and service provider domains, matched to the QoE needs of the different applications and service components. The IUG would be able to determine in real time the QoS requirements of each application or service component and accordingly make routing decisions to optimize the QoE. It also exploits the storage resources of the IUG for high bandwidth low priority traffic caching during off-peak hours, to support applications such as OTT TV service.

The Intelligent Network Gateway (ING) of is a counterpart device of the IUG and is located at the core side. It is a convergence point for the different user traffic flows handled in the different access links (e.g. satellite, xDSL, Mobile network resources). The ING works in conjunction with the IUG to select the relevant individual or combined access links for the forwarding of the different traffic flows for the downlink direction (traffic from the Public network to the end user premises).

In order to allow for operating with several different network technologies used for the links between the IUG and ING, a link abstraction is implemented at each Network interface (NI) and exploited by the routing decision in both the IUG and the ING. This link abstraction will define the network performances solely by certain key parameters including for example bandwidth, latency, jitter, error rate and cost, all of which may vary over time. The different characteristics of each individual link can be described in a systematic and efficient manner by this set of well-defined parameters.

4.3 Satellite network technology

4.3.1 Overview

A GEO based satellite access network is typically composed of the following parts:

- A space segment composed of one or more High Throughput satellites in geostationary orbit. The satellite connects the GWs of the ground segment to the user terminals, thanks to a set of feeder and user beams.
- A ground segment which includes:
  - A main Network Control Centre (NCC) which has the responsibility to control and synchronize the overall network.
  - A main Network Management System (NMS) which handles the management of the resources in the network.
  - A Satellite Control Centre (SCC) which aims at monitoring and controlling the space segment.
  - A Telemetry Tracking and Control (TTC) station to transmit and receive information to or from the space segment.
  - A set of Gateways operating which are in charge of transmitting and receiving data, control and management traffic to or from the user terminals. Each Gateway is equipped with their own local NCC/NMS to ensure their individuality and their operation sequence in case of a total system malfunction originating from a main NCC/NMS failure. The Gateways provide access to the public internet via an Internet Point of Presence.
  - An aggregation network segment or backbone interconnecting the Gateways.
- A user segment which is composed of a set of user terminals.

The network that interconnects the User Terminals with the Gateways is based on the DVB-S2/DVB-RCS2 standard and their future variants (see references [i.1], [i.2] and [i.3]).

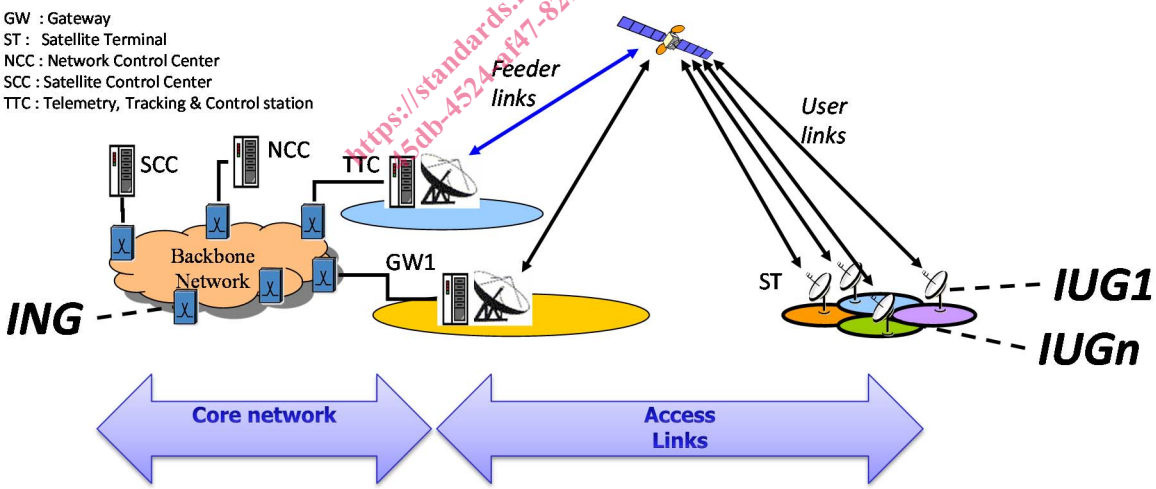

Figure 2: Satellite access network architecture with the IUG and ING

The Gateways interface with the Intelligent Network Gateways (INGs) while each User Terminal interfaces with an Intelligent User Gateway (IUG). Each IUG connects to one ING, while the INGs may connect to multiple IUGs.

Typical performances for Satellite broadband network is reported here under.

Table 1: Typical performances of GEO based satellite network roadmap

TIMELINE	2005	2010	2015	2020
Technology	Ku-band satellites	1st Gen Multi beam Ka-band satellites	2nd Gen multi beam Ka-band satellites	3rd Gen multi beam Ka-band satellites
Typical Max service rate (downstream)	2 Mbps to 3 Mbps	10 Mbps to 20 Mbps	30 Mbps to 50 Mbps	100 Mbps

In addition the typical RTD over a GEO based satellite access network is approximately 600 ms.

4.3.2 Multicast over satellite

In addition to the management of unicast traffic the potential of multicasting selected streams of OTT video content and selected cached OTT video content to reduce the total satellite traffic has been identified. The multicast data will be sent on one of the forward link carriers in each spot beam so the user terminal may implement a second receiver.

The potential benefit of applying group ACM for the multicast traffic lies in a useful bandwidth increase. The anticipated scheme sets the modcod for multicast transmission to the modcod needed for delivering successfully the data in unicast transmission to 99,x % of the targeted user terminals (where x is to be defined).The multicast traffic would be created in the core network and sent over the satellite access network and converted back to unicast transmissions in the IUG. This would be implemented in a transparent fashion so that no changes would be required in the content provider and CDN systems nor in the end user devices.

4.4 Terrestrial network technology

This clause considers here only broadband network technologies deployed in underserved areas.

The xDSL access technologies that are currently available are listed in Table 2.

Table 2: Typical performance of xDSL network technologies

Technology	Max Downstream rate	Max Upstream rate	Typical range (Modem to DSLAM using 0.4mm cable)	Typical RTD
ADSL2	12 Mbps	3 Mbps	5 460 m	< 100 ms
ADSL2+	24 Mbps	3 Mbps	2 400 m	< 100 ms
VDSL2	50 Mbps	50 Mbps	1 500 m	< 100 ms

Given the focus on the more remote under-served locations it is likely that if the end user has xDSL it will be at the end of a long link ADSL2 or VDSL delivering rates somewhat below the maximum rates stated above which are only available in short range.

The mobile network technologies available are depicted in Table 3.

Table 3: Mobile network technologies

Technology	Max Downstream rate	Max Upstream Rate	Typical Cell Range (Macrocells)	Typical RTD
EDGE	236,8 kbps	236,8 kbps	500 m - urban 5 000 m -rural	< 300 ms
UMTS	384 kbps	384 kbps	500 m - urban 5 000 m -rural	< 200 ms
HSPA	7,2 Mbps	2 Mbps	3 500 m	< 100 ms
LTE	300 Mbps	75 Mbps	> 10 km depending on location and antennas	< 50 ms