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# MR-316
# Multi-Service Broadband Network Architecture Evolution

Extract from one of the latest Broadband Forum's Marketing Reports (White Papers)

***This white paper aims at describing the evolution of the Multi-Service Broadband Network Architecture, highlighting the key topics defined in the published BBF Technical Reports and explaining the relationships among the different BBF documents, in the context of the Multi-Service Broadband Network Architecture.***

Starting from the challenges Service Providers have been facing, this document explains how the Multi-Service Broadband Network Architecture is able to fulfill the Service Providers' business requirement enabling the convergence of different types of services, residential and business, fixed and mobile, retail and wholesale, on a common network infrastructure. The document also highlights the flexibility of the Multi-Service Broadband Network Architecture in order to support emerging cloud and virtualized services.

The Broadband Forum has been driving the evolution of Broadband Network Architectures for the last 12 years. During this timeframe Broadband Network operators have been facing several challenges and additional technical options have been introduced:

- the evolution from ATM to Ethernet to connect subscribers to their edge nodes;
- The evolution towards using MPLS as a virtualization technology in access and aggregation networks;
- the introduction of IPoE and Ethernet Sessions to complement PPPoE sessions;
- the deployment of IP multicast to support IPTV services;
- the migration from IPv4 to IPv6;
- the Interworking between next generation fixed and wireless access;
- the introduction of Cloud and virtualized services

The Technical Reports published by Broadband Forum in order to address Service Providers' business requirements and use cases, have been playing a critical role in helping the industry to face these challenges.

The goal of this white paper is to familiarize readers with the evolution of Multi-Service Broadband Network Architectures. It describes the major issues faced by the Service Providers in moving from legacy networks (ATM/TDM); to today's networks (capable of handling triple-play traffic); to future networks (capable of handling not-only Machine-to-Machine and Internet-of-Things traffic, but also supporting a variety of services in the Cloud).

This white paper provides an overview of ongoing and past work in the Broadband Forum in this area.

As to Broadband Forum work, this document highlights the key topics contained in each document, and explains the relationships among the different BBF documents in the context of the Multi-service Broadband Architecture defined in *Technical Report (TR)-144*[1], *TR-145*[2] and *Working Text-178*[3].

**Main Challenges for the Network Operator Introducing Multi-Service support**

During the early 2000s the obsolesce of ATM, as aggregation technology, together with the desire to offer triple play residential services (data, voice, video/IPTV) led the operators to start defining a new aggregation network based on Ethernet technology. This architecture is defined in *TR-101*[4], and the *TR-101 Service Model* is still the basis for the current broadband architectures.

The introduction of video services not only required the creation of a new aggregation network, but also introduced new requirements in terms of forwarding models and Subscribers Sessions. One of the key differences of the IPTV service compared to traditional services, like data and ►


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voice, is the requirement for Multicast forwarding. The use of multicast forwarding reduces utilization of network links between the video server and the customer by sending only a single copy of a media stream into the network.

Handling Multicast together with PPPoE sessions can be seen as complex, thus a requirement for a simple construct of Sessions came up. The DHCP protocol was introduced as an alternative to PPP for IP address configuration and service provisioning. The use of DHCP in Broadband Networks started getting popular and DHCP based Sessions (defined in BBF terminology, IP Sessions) became an alternative to PPPoE Sessions for residential services, in scenarios where "always on" connectivity and simple IP based architecture were/are important requirements.

Augmenting the support of PPPoE Sessions with IPoE Sessions introduced additional challenges, mainly related to define new concepts for IPoE that were traditionally available for free with PPPoE, like authentications and monitoring of the session state. Not all the Service Providers have the same set or the same level of requirements in terms of Subscribers Sessions, thus different models have been defined. In addition in such environment a new type of Session, Layer2/Ethernet Sessions, came up.

After starting designing a new aggregation network for IPTV and triple play residential services, the Service Providers immediately saw the opportunity to use this new network to carry not only the traffic of residential customers but also traffic coming from business and wholesale clients. The next step in the evolution of the Multi-Service architecture was the possibility to transport fixed and mobile traffic over a common network architecture: this opened up for Mobile Backhauling initially of 2G/3G traffic, more recently of LTE/4G.

**Migrating from IPv4 to IPv6**

The Internet Assigned Numbers Authority (IANA) ran out of IPv4 addresses in February 2011: the world is now facing the fundamental problem of IPv4 address space exhaustion. There is a huge demand for IP addresses resulting from the explosive growth of mobile devices, including smart phones, portable gaming consoles, tablets, laptops and netbooks, and machine-to machine modules. The IPv6 protocol is designed to meet these requirements and to enable a global environment where network addressing is again transparent to the applications. Continuous growth of the Internet requires the overall network architecture to evolve: Broadband network architectures are deeply impacted by the introduction of the IPv6 support not only in terms of migration towards IPv6, but also in terms of co-existence of IPv4 and IPv6 in Service Providers networks.

Broadband Forum started working on IPv6 migration back in 2008, defining the evolution of the Broadband network architecture from an IPv4 only network to a dual-stack IPv4/IPv6 network. As the IPv6 protocol is not backward-compatible with IPv4, a lot of work has been done on different IPv4 to IPv6 migration technologies in order to allow a smooth migration from IPv4 to IPv6; section 3 will explain in more details the Technical Reports that define this key topic.

**The Usage of MPLS in the Multi-Service Broadband Network**

IP/MPLS is a standard and mature technology widely deployed in several multi-vendors networks all over the world. IP/MPLS was initially deployed in core/backbone networks, given its flexibility to simply address different scenarios; it then became also very popular in the aggregation networks for delivering residential, business and mobile backhauling services, as a supporting technology for the *TR-101 Ethernet Service Layer* that interconnects CPE equipment with the IP Service Nodes. This model leverages Ethernet Access Nodes.

Extending IP/MPLS to the access network appears, for some Service Provides, the natural next step in building a single network architecture based on a common technology. Using the same technology end-to-end in different network segments, from core to aggregation towards the access, introduces several benefits:

- Simplifies the provisioning chain by minimizing the provisioning points;
- Allows for flexible Service Node placement in the network;
- Improves the network scalability;
- Removes the need for a legacy (ATM, TDM) aggregation and access network.

Different Service Providers may have different visions in terms of how much complexity and which functionality is needed and/or can be supported on the Access Node (AN). These different views led to the definition of two different approaches for extending IP/MPLS to the access network:

- Seamless MPLS model
- Full MPLS model

In case of Seamless MPLS model the MPLS functionalities are extended to the AN minimizing the impact on the nodes themselves. In particular IP Routing is introduced in its simplest form by only using *static routes* from the AN to the aggregation nodes, while in order to achieve high scalability MPLS label distribution is performed by using the LDP Downstream On Demand model. The Full MPLS model represents the complete extension of all the IP/MPLS and Layer 3/ dynamic routing functionalities to the AN. In this case the AN becomes functional equivalent to an aggregation node and in some cases can also host Broadband Network Gateway (BNG) functions.

For several different business reasons not all the Service Provides may be ready or willing to jump from Ethernet access network to an MPLS based access network. The choice amongst an Ethernet access network or a MPLS based access network using Seamless or Full MPLS functions, depends on the Service Provider's requirements and his current network architecture. All the three possible options are still considered valid and defined in BBF Technical Reports.

**Interworking between next generation fixed and 3GPP wireless access**

Service providers demand for the interworking and, in some cases, convergence between Broadband Forum and 3GPP networks. The Broadband Forum responds to these demands by working towards aligning the telecom industry by defining the interworking requirements between 3GPP Evolved Packet Core architecture and the Broadband Forum architectures.

The main convergence aspects addressed by the BBF – 3GPP interworking activities are:

- Converged business and services
- Converged network and infrastructure
- Converged user management and terminals

The main interworking use cases driving such technology developments, and the architectural frameworks devised to enable them are presented in *TR-203*[5]. This document presents several technical evolution steps that can be taken from the present non-converged fixed and mobile networks towards a Fixed/Mobile Converged network. The nodal requirements derived from such architectures are specified in *WT-291*[6].

Industry trends and business opportunities driving Fixed/Mobile Convergence are highlighted in . In there, it is also included an overview of the standardization organizations active in defining the open-standards that are an essential component to build a profitable and sustainable converged network, enabling feature rich, interoperable solutions and smooth deployment of novel customer services.

**Introducing Cloud and Virtualized Services**

Service providers are struggling with the constant need to increase market share, pressures around average revenue per user (ARPU) and service pricing, low and declining margins on hosted and co-located services, increasing capital and operating expenses, infrastructure complexity, speed of provisioning, and the demand for constant service innovation.

In most IT organizations, the process for data center application and infrastructure service requests is complex and expensive. Each request is often treated as a separate project, requiring approvals and exceptions. The result is a time-consuming and inefficient series of manual steps, involving requirements validation and architecture reviews. Optimizing IT operations in order to speed up this process is clearly becoming an urgent need for several organizations.

The concept of Cloud computing as a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort is becoming a dominant paradigm in today's networks. Cloud computing can be seen as the next step in the evolution of the Internet. Clouds are fundamentally changing the way that businesses and people consume services: enabling IT to be delivered as a service. Cloud has the potential to have a massively positive impact on Capital Expenditure and Operational Expenditure.

In such environment Broadband Service Providers have a unique reach to customers: being able to leverage and improve current network architectures to offer Cloud and virtualized services is a key goal for Service Providers that see the Cloud computing as an innovative source for revenues. Cloud Computing will play a key role in generating new business as Broadband Service Providers can break into the IT services market using their existing assets. Cloud computing will have a significant impact on broadband networks going forward.

Network Function Virtualization (NFV) is next logical step towards virtualization. NFV attempts to offload (some of the) network embedded functions onto x86-based computing platforms, allowing tighter integration into datacenter/cloud based orchestration systems. NFV is currently one of the main forward looking topics discussed at the Broadband Forum.


*1) TR-144 Broadband Multi-Service Architecture & Framework Requirements, Broadband Forum 2007*

*2) TR-145 Multi-service Broadband Network Functional Modules and Architecture, 2012*

*3) WT-178 Multi-service Broadband Network Architecture and Nodal Requirements, Broadband Forum*

*4) TR-101 Migration to Ethernet-Based Broadband Aggregation, Broadband Forum 2011*

*5) TR-203 Interworking between Next Generation Fixed and 3GPP Wireless Networks, Broadband Forum 2012*

*6) WT-291 Nodal Requirements for Interworking between Next Generation Fixed and 3GPP Wireless Access, Broadband Forum*


**The full version of this report is available from:**
http://www.broadband-forum.org/marketing/download/mktgdocs/MR-316.pdf

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