Intro to Multicast

Introduction

Next Generation Access (NGA) Multicast is a simple GPON solution that provides service providers with the ability to distribute media streams to multiple end users simultaneously.

It can be combined with NGA Evolve and NGA Voice such that, when combined with the service provider's own services and content, enables service providers to offer double or triple play solutions over the Chorus NGA network.

The need to integrate solutions with service providers content distribution networks means that each implementation is a unique solution and needs to be developed and deployed using the Chorus Co—Innovation Model prior to being able to order Multicast to an end customer site.

As such this document should be interpreted as a framework for creating Multicast Solutions and each solution could be different depending on the needs of the service provider. A particular solution may require additional capability or service attributes not documented in this paper.

Each as-built solution will have a dedicated technical whitepaper explaining the consumed options and technical details. Any additional features will be published in this document and made available to existing or future Multicast solutions.

Extensions to the Multicast service description

The following two optional features are extensions to the UFB Multicast Service Definition and can be included in an NGA Multicast solution.

	Feature	Description	Benefits
1	E- AVPL Binding	Combines unicast (E-AVPL) and multicast streams on the same VLAN	May be useful for combined media/data RGW solutions
2	Media Class	A new traffic class supporting a more relaxed SLA for media streaming	Support set-top box traffic buffering and may maximise media streaming quality on some set-top boxes

It is possible to create NGA Multicast solutions without using these optional features.

It is anticipated that there would be a degree of discovery and mutual learning during the Co-Innovation development which could identify additional features that could extend the UFB Multicast Service Definition.

NGA Multicast prototype

Chorus has developed and deployed an NGA Multicast prototype within the Chorus Co-Innovation Laboratory Layer 2 (CCIL-2) environment. Retail service providers with CCIL-2 connectivity can start trialling NGA Multicast using this prototype solution.

This prototype is a specific implementation designed to demonstrate the potential of the technology and utilises a limited set of attributes and parameters. This prototype should not limit consideration of the commercial deployment feature set.

We have provided a case study where Chorus used the NGA Multicast Prototype to demonstrate core NGA Multicast features.

The NGA Multicast prototype and this document

This document outlines the full scope of the commercial service; i.e.it includes features and attributes that are not demonstrated in the NGA Multicast prototype.

NGA Multicast prototype settings will be highlighted in italics.

Objective of NGA Multicast prototype

The objective of the NGA Multicast Prototype is to:

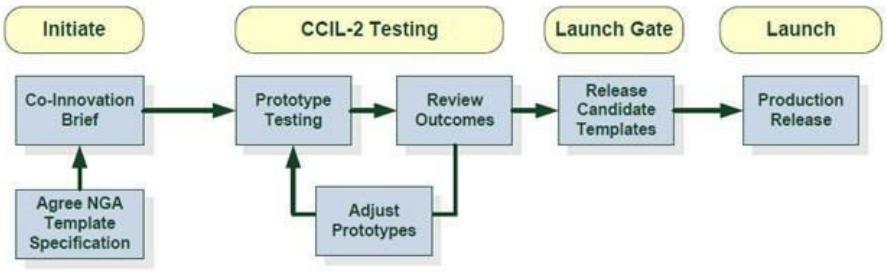
- Provide service providers with an introduction to IP multicast technology Foster ideas on how service providers could use IP multicast commercial
- Hone service provider thinking about what requirements they might have for their multicast solution.
-
- The NGA Multicast prototype provide satrial service with the following configurable variants: Number of channels per Multicast Connection
- Number of channels per Multicast Domain Total Bandwidth per Multicast Domain

The NGA Multicast prototype does not currently limit bandwidth per stream. However this is likely to be limited in commercial NGA Multicast.

Creating an NGA Multicast template

As the Multicast Service requires tight coupling with service provider media broadcast platforms, requests for the creation and modification of a Multicast domain will be implemented and delivered through the Chorus Co-Innovation Model. This process includes pricing, development, testing and the option to combine different NGA Services into a single solution.

The Chorus Co-Innovation Model uses a rapid prototyping development process to develop solutions with the customer, as shown below. This is particularly critical for NGA Multicast due to the high level of integration of both our components, i.e. they need to be configured in alignment to function correctly:



Using rapid prototyping to develop an NGA Multicast solution

NGA Multicast solution

NGA Multicast is an intermediate input service which you can combine with its own network or other products to provide a broadcast video service to your customers.

The Ethernet Multicast Access consists of two product components:

- The Multicast domain; and
- The Multicast connection.

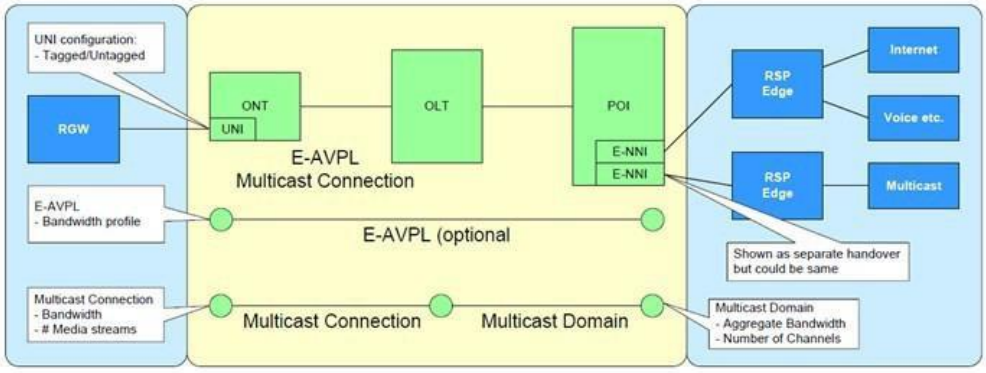
A **Multicast domain** supports the simultaneous transmission of a number of media streams. Traffic is automatically replicated throughout the domain as individual end customer join or leave the individual streams.

A **Multicast connection** allows an end customer to connect to the Multicast Domain and join one or more Multicast streams through IGMP 'Join' and 'Leave' messages.

The Multicast connection can either be delivered as:

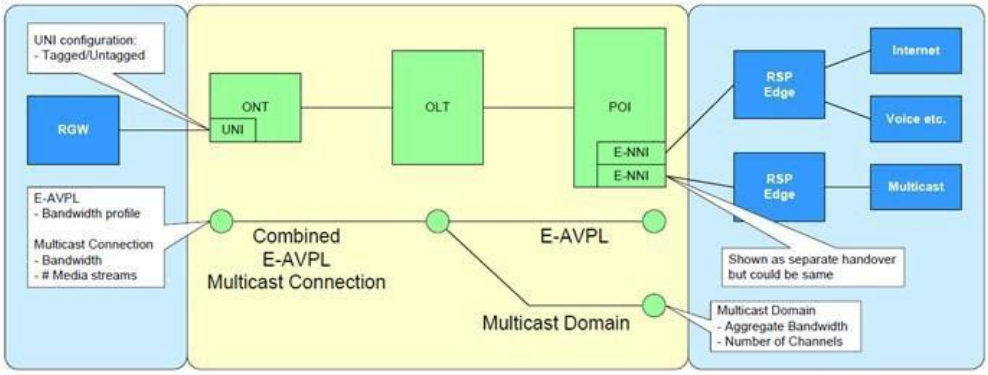
- A separate vlan to an E-AVPL; or
- Combined with E-AVPL on a single vlan (E-AVPL binding)

Multicast connection delivered with separate VLAN



In this case the Multicast Connection may be delivered on the same or different UNI as the (optional) E-AVPL.

Multicast Connection with E-AVPL binding



NGA Multicast Solution – E-AVPL Binding

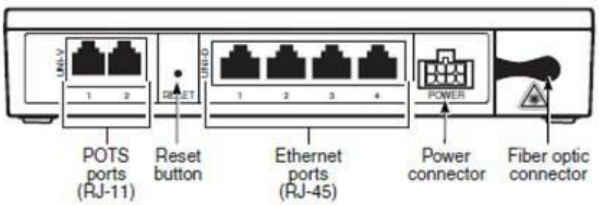
NGA Multicast components

NGA is made up of the key components shown below:

Optical Network Terminal (ONT)

The ONT terminates the GPON services in the end customer premises and provides the end customer NGA interfaces.

The standard ONT includes four Ethernet UNIs and two ATA Voice ports.



ONT back panel

The prototype NGA Multicast is delivered to a dedicated Ethernet UNI.

USER NETWORK INTERFACE (UNI)

The UNI is an RJ-45 100/1000Base-T port located on the ONT that provides the Ethernet interface for NGA. Note that the transmission of Ethernet frames includes additional overheads such as Ethernet preamble, frame delimiters and inter-frame gaps. service providers need to be aware that if the end customer wants to send or receive 100 Mbps of Ethernet throughput, the RGW or similar device must be set to 1000Base-T to allow for this overhead.

MULTICAST CONNECTION

A Multicast connection allows an end customer to connect to the Multicast Domain.

- The Multicast Connection specifies:
- The number of simultaneous channels available to a Customer; The bandwidth of these channels. Only one Multicast Connection is supported per UNI.

Chorus reserves the right to limit the Multicast Bandwidth and/or connections.

If E-AVPL Binding is required then Bitstream and Multicast traffic will be delivered on the same VLAN. Admission Control may be used to limit the number of services per Multicast Connection.

Key considerations for a solution:

- Fast Leave and Fast Channel Change should beenabled so that channels shall beleft immediately on receipt of an IGMP leave report to conserve bandwidth
- Upstream bandwidth needs to be considered for IGMP joins. This may utilise the E-AVPL High Priority bandwidth, although consumed bandwidth should be very small.
- IGMP general query timer and query timeout settings need to be considered, e.g. to limit 'phantom' streams being forwarded for an extended period of time if a set-top box and/or RGW are rebooted. IGMP Forking would allow all IGMP join messages to be forwarded to the handover via the E-AVPL. Summary reporting only will be forwarded via multicast VLAN.

A Multicast Connection can be activated in a non-Multicast Coverage Area. However there would be no multicast traffic for it to receive.

IPv6 is not supported bythe NGA Multicast prototype.

The NGA Multicast prototype Multicast Connection is limited to:

- Untagged UNI;
- Up to four multicast steams can be simultaneously received.
- 1 Mbps of unicast upstream Low Priority traffic per end customer to support signalling. Total Bandwidth is not specified.1

[1] *These are default specifications and can be modified by agreement.*

POINT-OF-INTERCONNECT (POI)

A Point of Interconnect (POI) is one or more Ethernet Aggregation Switches (EASs) where all traffic within that Multicast Coverage Area is aggregated for handover. A service provider will require a Handover Connection to receive or send traffic to end customers within the Multicast Coverage Area.

A Multicast Domain is connected to a single Handover Connection within each Multicast Coverage Area.

HANDOVER CONNECTION

The Handover Connection is a 1 GigE or 10 GigE interface between Chorus' and the Retail service provider's network that performs the External Network to Network Interface (E-NNI) function for NGA.

The Handover Connection may include Link Aggregate Grouping (LAG); see Introduction to NGA whitepaper for more information.

To use the NGA Multicast prototype the service provider must have the capability to access and interconnect with the CCIL-2 as described in Introduction to NGA white paper and the CCIL-21 Handbook.

IP EDGE

NGA Multicast is IP aware and the Multicast Domain needs to be configured to work with the Multicast IP addresses used by the service provider.

MULTICAST SENDER

The Multicast Sender hosts the content and initiates the broadcast streams. Each broadcast stream, or channel, requires a unique Multicast IP address.

MULTICAST RECEIVER

The Multicast Receiver joins individual broadcast streams, up tothe numberof channels configured for that Multicast Connection.

The receiver could be a standalone Set-top box, software inside a PC, or part of a Residential Gateway (RGW).

VIDEO DECODER

The Video Coder takes the broadcast IP stream and decodes the traffic into a Video signal. It may be the same device as the Multicast Receiver.

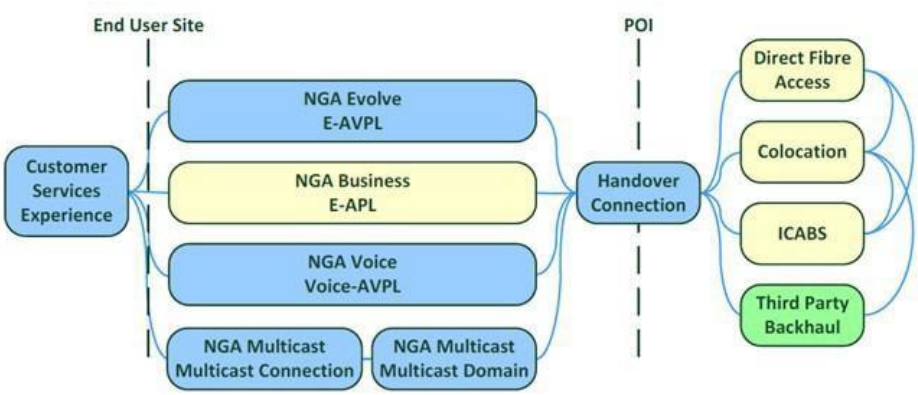
Although this solution presumes NGA Multicast is being used for broadcast IPTV, it can be used for other purposes:

- Radio channels; File distribution;

- Audio/Video conferencing, such as streaming events to multiple users. Unicast can be used from the user to the source.
- Stock ticker applications.

Combining Multicast with other products

Multicast Connections and Domains will often be combined with other Chorus input products as shown below:



Combining NGA Multicast with other UFB products

Multicast Connections can on the same UNI as one or more E-AVPLs.

Multicast Connections can be combined with an E-AVPL and delivered as a single VLAN on the UNI. Multicast Connections cannot be on the same UNI as an E-APLs or NGA Voice.

You may combine the handover connection with other Chorus services, but that is outside this specification.

The NGA Multicast prototype is only available as:

- One NGA Multicast per dedicated UNI, i.e. not with one or more E-AVPLs.
- One NGA Multicast Connection per ONT.

Geographic Availability

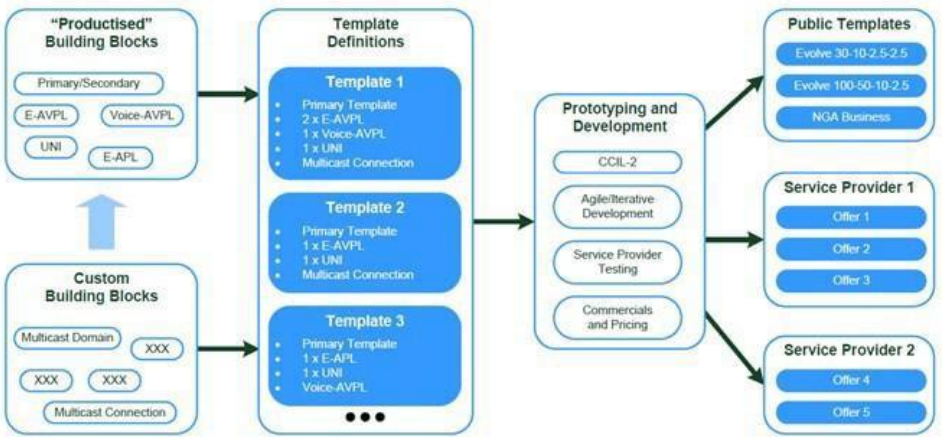
NGA is available where Chorus has GPON coverage. See the Bitstream Operations Manual for more information.

Multicast Domains are enabled on a per-Multicast Coverage Area basis, i.e. it is possible that a Multicast Domain may be limited to one Multicast Coverage Area, or multiple Coverage Areas.

However a separate Handover Connection is required for each Multicast Coverage Area Multicast may be available in GPON-enabled RBI regions although note that in some

cases backhaul between the OLT and the POI may be constrained, limiting the amount of multicast supported to RBI nodes.

Custom NGA Offers



Defining customer NGA offers

See the Chorus Co-Innovation Handbook for more information.

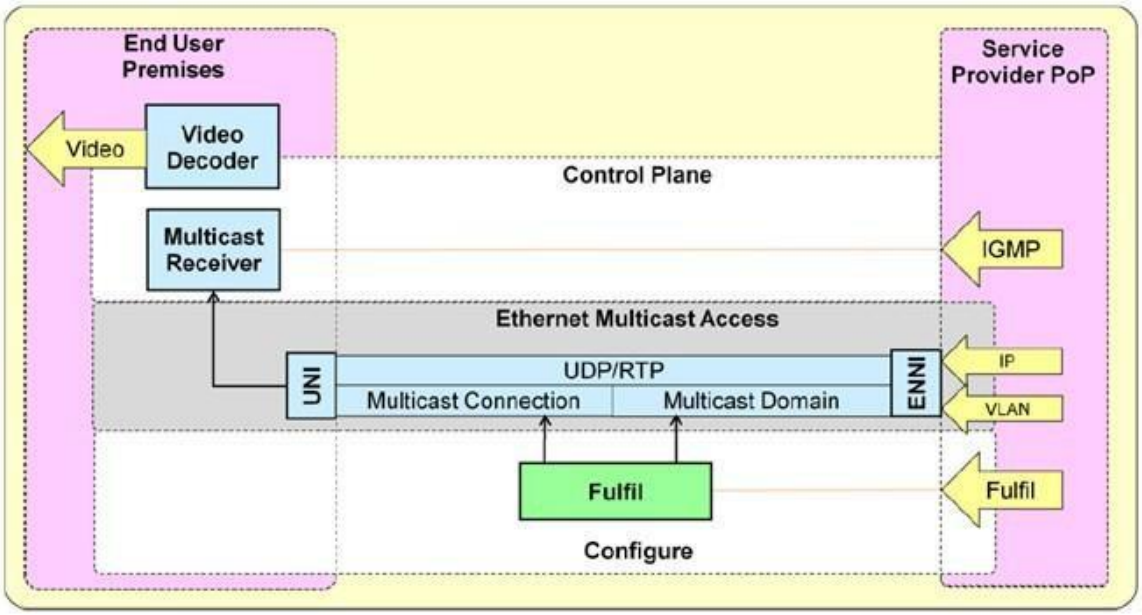
How NGA Multicast works

NGA Multicast is delivered over a GPON access and provides the ability for a service provider to broadcast media streams to designated end customers.

NGA Multicast is IPaware and needs tight integration between the NGA Multicast Service and the service provider IP Multicast solution.

SOLUTION ARCHITECTURE

NGA Multicast requires interaction with service provider functions to operate as follows:



NGA Multicast/service provider integration

FULFIL

Multicast Domains are prebuilt across Multicast Coverage Areas prior to being able to order a per-User Multicast Connection for an end customer in that Multicast Coverage Area. Creating a Multicast Domain, or addingadditional Multicast Coverage Areas to an existing Domain, is done as part of a Co-Innovation Model deployment.

The Fulfil process is required to provision the Multicast Connection. Multicast Connections must be associated with an NGA Evolve template and will be provisioned ona per-end customerusing the standard NGA Offer ordering process.

IGMP CONTROL PLANE

The Internet Group Management Protocol (IGMP) is an IPv4 communications protocol used by Multicast Senders (Hosts) and Multicast Receivers to establish multicast group memberships.

The Chorus network is configured to 'IGMP snoop' the upstream unicast traffic for IGMP control messages. NGA Multicast supports IGMP snooping using IGMP v2 (RFC2236) and IGMP v3 (RFC3376) for IPv4:

- When a valid IGMP 'Join' message is received the Chorus network will replicate the multicast stream to that Multicast Connection.
- When an IGMP 'Leave' message is received the Chorus network will stop the user from access to the multicast group. The Multicast Connection will not be connected to the multicast group if:
- The Admission Control limit for the Multicast Connection has been reached
- The number of active sessions match the per user session limit.

If IGMP is encapsulated within PPP within an E-AVPL then it is passed transparently to the Multicast Solution and the Multicast Connection will not be connected to the Multicast stream. IPv6 is not supported by NGA Multicast at this time.

The NGA Multicast prototype supports IGMP v2 (RFC2236) and IGMP v3 (RFC3376) variants.

UDP/RTP

Most IP Multicast solutions use Multicast over User Datagram Protocol (UDP) or Real-time Transmission Protocol (RTP) for carrying the media

- UDP is a stateless communications protocol popular with many IP Multicast solutions
- RTP defines a standardised packet format for delivering audio and video over IP networks

The choice of protocol is up to the service provider.
Both UDP and RDP are available on the NGA Multicast prototype.

SOLUTION CONSIDERATIONS

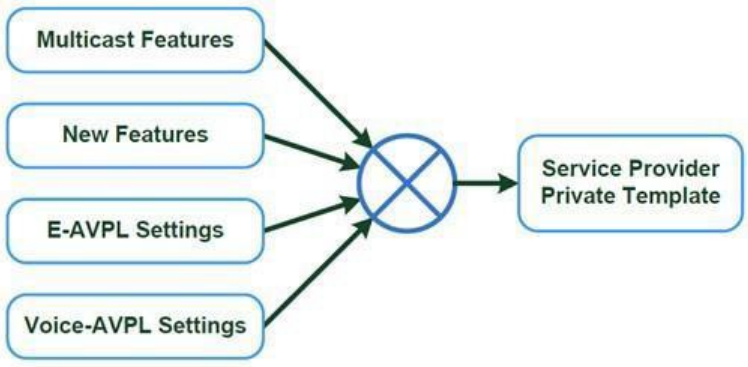
Service providers may want to consider the following as part of their solution:

- Bitrate. Each multicast channel will be constrained to agreed limits and it is recommended content providers intelligently compress the traffic and shape on egress to ensure the per-channel policers do not cause unexpected packet loss.
- Forward Error Correction (FEC). It is recommended that content providers use FEC such as RFC 5052, RFC5510 or RFC5445.
- It is recommended that fast release technology be deployed to allow rapid and smooth channel change experience for the end customers.

NGA Multicast features

NGA Multicast supports a number of optional features that can be included in a solution. Some of these will be mutually exclusive or dependent and could be combined with additional features for a specific solution. These features are expected to be extended over time.

The combination, and associated attribute and attribute values, of features for a particular solution are agreed between Chorus and the service provider as part of the Chorus Co-Innovation Model.



NGA Multicast/service provider integration

The following features are currently available for including in Multicast solutions. Additional features may be available on request:

Feature	MULTICAST DOMAIN	MULTICAST CONNECTION
Multicast Channels	v	
Multicast Bandwidth	v	
Multicast Class of Service	v *	v v
E-AVPL Binding		*
Admission Control		v *
Per User channels		v v
Per User Multicast Bandwidth		* v
Per User Unicast Bandwidth		V
UNI tagging		
Customer Service Experience (CSE		v *

**Not deployed as part of the NGA Multicast prototype*

Multicast Channels	This is the number of channels supported by the Multicast Domain. Each Channel requires: an IP Multicast address; Channel bandwidth profile. Used by the multicast connection for Admission Control if E-AVPL-Binding is on.
Multicast Bandwidth	This is the total bandwidth that can be transmitted from the service provider. This can be less than the sum of the Multicast Channels, but the service provider is responsible for any admission control if this bandwidth is contended.
Multicast Class of Service	This feature allows the use of the Multicast Class of Service rather than High Priority. Multicast Class of Service is optimised for streaming video; see Class of Service Design below.

E-AVPL Binding	This feature allows a Multicast Connection to share the same VLAN on the UNI as the E-AVPL. Multicast traffic will be managed as follows: • Multicast Connection Multicast Group-aware • IGMP joins and leaves are actioned by Chorus • Multicast Aggregate bandwidth managed using Admission Control. E-AVPL • Multicast traffic that is not associated with the Multicast Connection will be passed through the E-AVPL transparently.
Admission Control	This feature is used to manage the bandwidth consumed per user and is required for E-AVPL binding. It works as follows: A Multicast Connections is assigned an Admission Control bandwidth which represents the maximum amount of bandwidth that can be consumed by all media streams on that connection; On a successful join the aggregate bandwidth is decremented by the channel bandwidth; Note that Admission Control bandwidth is calculated on the Channel Bandwidth allowance, i.e. not actual consumed bandwidth; If a join is requested and there is insufficient aggregate bandwidth available then the join will be refused; When a customer releases a channel then the channel bandwidth is released from the aggregate bandwidth.
Per-user Channels	This is the number of multicast streams that can be received by an end customer.
Per-User Multicast Bandwidth	This feature is not current supported as the end customer experience could generate fault calls even though the service is behaving correctly. Per User Multicast bandwidth is the total multicast bandwidth able to be received by the end user. Any variability in bandwidth in excess of this threshold would result in random frame discards that would disrupt all active media streams, degrading end customer experience. While this could theoretically be managed by a service provider using service provider managed Admission Control, any mismatch between the different mechanisms could be difficult to detect.
Per-User Unicast Bandwidth (upstream)	Unicast bandwidth allows the end customer to send IGMP Control Plane traffic to the service provider. It will typically be the same class of service as the Multicast frames. Only UNI to E-NNI traffic is supported, i.e. unicast cannot be sent from one user to another user or from the service provider to the end user.

Uni Tagging	An untagged UNI means that all traffic forwarded from the UNI to the end customer CPE will be stripped of the 802.1q tags. This may be useful where CPE is not 802.1q aware. Note that if E-AVPL binding is used then this attribute is shared by any E-AVPLs on the same UNI.
Customer service experience	This is the agreed customer premises activities done as part of an install. This would allow, for example, customised installation and configuration of a Set-top Box and experience RGW for a triple play install.

Some options may be constrained depending on the commercial model agreed for a solution, e.g. a 100/50 NGA Evolve template might support a Multicast Connection with more per-user Multicast Bandwidth than a 30/10 NGA Evolve template.

The NGA Multicast prototype:

- Does not limit individual Multicast Channels;
- Supports up to four streams.
- Does not have per-user Multicast Bandwidth constraint; Has 1 Mbps of unicast traffic upstream (more than required);
- Uses untagged UNIs.

Customer Service Experience does not apply to the NGA Multicast prototype which is limited to the CCIL- 2.

Class of Service Design

NGA Multicast uses a frame's 802.1p PCP values to classify which Traffic Class should be used as follows:

Class	802.1p	Description
Low Priority	0	Intended to be used by internet applications that are not latency or jitter sensitive, such as browsing, email etc. Policed on ingress
High Priority	4 or 5	Intended to be used by applications that have significant latency constraints, such as VoIP. Policed on ingress
Multicast	4	Optimised for Video. 99th percentile frame delay and frame delay variation is < 40ms (E-NNI->UNI) Shaped on ingress.

High and Low Priority traffic classes have been designed in accordance with the TCF ELAS Specification. Multicast is specifically designed for Video.

Upstream (unicast) may be either High or Low priority as required. Industry Consultation has advised that PCP 5 ispreferred for High Priority.

802.1p PCP values

It is possible to customise the 802.1p to Traffic Class classification rules. These classification rules can be different for the Multicast Domain/Connection and the E-AVPL, although this could be constrained if E- AVPL Binding is used.

Traffic Class classification rules will not impact the traffic class QoS settings; they only affect what class a particular frame is assigned to.

It is the responsibility of the service provider to ensure traffic is tagged with the appropriate priority setting.

For the NGA Multicast Prototype:

- Unicast Frames downstream will be discarded.
- Downstream Multicast Frames with 802.1p tags of 0, 1, 2, 3, 5, 6 and 7 will be discarded; Downstream Multicast Frames with 802.1p tags of 4 will be treated as High Priority;
- Upstream Frames with 802.1p tags of 1, 2, 3, 4, 5, 6 and 7 will be discarded;
- Upstream Frames with 802.1p tags of 0 will be treated as Low Priority;
- Upstream untagged frames will be tagged and marked as 0 and treated as Low Priority

Service Specification

NGA Multicast can be delivered using multiple Classes of Service as shown below:

	FRAME DELAY	FRAME DELAY VARIATION	FRAME LOSS
High Priority	≤ 5 ms	≤ 1 ms	≤ 0.1%
Low Priority	n/a	n/a	≤ 2%
Multicast	99th percentile frame delay and frame delay variation is < 40 ms		0.01%

Note that High Priority and Low Priority SLAs may be modified for Right Performing templates.

Performance is from UNI to E-NNI and excludes frames that are submitted outside the NGA Multicast traffic profile.

NGA Multicast bandwidth is independent of E-AVPL, E-APL or Voice-AVPL traffic policies, e.g. if an end customer has 30 Mbps NGA Evolve bandwidth, this would not reduce when they use the 10 Mbps NGA Multicast service.

End-to-end performance will depend on a number of external factors; see Introduction to NGA whitepaper for more information.

NGA Multicast is designed around a default bandwidth of 10Mbps per channel.

TRAFFIC	HIGH PRIORITY CBS	EBS	LOWPRIORITY CBS	EBS
Domain Aggregate	600 kb	N/A	N/A	N/A
Domain Channel*	N/A	N/A	N/A	N/A
Connection*	N/A	N/A	N/A	N/A
Unicast	N/A	N/A	N/A	100 kB

* Not set for NGA Multicast prototype.

CBS and EBS values required for each solution will be agreed as part of the Co-Innovation development of the NGA Multicast solution. These will need to be compatible with other NGA services.

MANAGING END CUSTOMER PERFORMANCE

The Service Specification parameters only apply to traffic submitted within profile. Out of profile frames will be dropped but not included in the service Frame Loss or Frame Delay Variation values.

Any sustained packet loss will result in adverse end customer experience so it is important for service providers to define their interface egress policies correctly to match the Chorus ingress policies.

IP ADDRESSING

NGA Multicast requires IP addressing information to be configured:

- The multicast group addresses at the E-NNI. One IP address must be configured per multicast channel, from the following range:
  224.0.0.0/4

- An IP address in the client subnet;
  This IP address is inserted in the GPON Access Node as a source address for IGMP queries. Some OS/applications require the IGMP packet's source address to be in the subnet of their interface or traffic is dropped, e.g. if 0.0.0.0 is used. This may not be required for all client solutions.
- A single IPv4 address can be used for the entire network, depedning on the IP address architecture deployed.

For the NGA Multicast Prototype a single IPv4 address is required.

Note the following IP Subnets are reserved for Chorus internal use and should not be allocated to the client.

192.168.1.0/24
192.168.2.0/24

Client IP addressing can be statically assigned or allocated using DHCP through the N:1 VLAN. IP addressing should be compatible with the above IP address.

DHCP option 82 Circuit ID and Remote ID insertion is not currently supported on the Multicast Connection.

SERVICE COMPONENT IDENTIFIERS

Port IDs, Service IDs and VLAN IDs are used for interaction between Chorus and service providers:

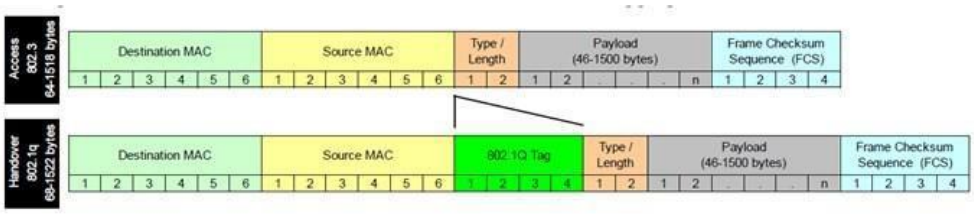
ID	WHAT IT USED FOR	VISIBILITY TO SP	WHEN DOES IT CHANGE
Product Instance ID	Reference to Multicast Coverage Area	Provided as part of deployment. Reference for new Orders Reference for Billing Reference for Assure	Addition of new Multicast Coverage Area Static for life of each Multicast Coverage Area
Product Instance ID	Reference to Product Offer including Multicast Connection	Included in provisioning Service Order. Reference for new Orders Reference for Billing Reference for Assure Optionally inserted into DHCP option 82 requests (E-AVPL only)	New Product Instance Change Address Transfer
VLAN IDs (SVID)	Unique VLAN at each Ethernet handover so service provider can send and receive traffic	Preset for Handover Connection for Multicast Coverage Area	Addition of new Multicast Coverage Area Change Handover Connection

NGA Multicast Ethernet Architecture

E-NNI traffic is typically single-tagged 802.1ad

NGA Multicast Traffic Profile

The figure below shows the format of the Ethernet frames for tagging NGA Multicast traffic



Enhanced Frames Format

Refer to Introduction to NGA for more information.

The NGA Multicast Prototype requires untagged frames at the UNI and single-tagged frames at the E-NNI.

Security

Each Multicast Domain is delivered to the service provider as a dedicated VLAN and while traffic is aggregated, it is not possible for data to 'leak' between Domains.

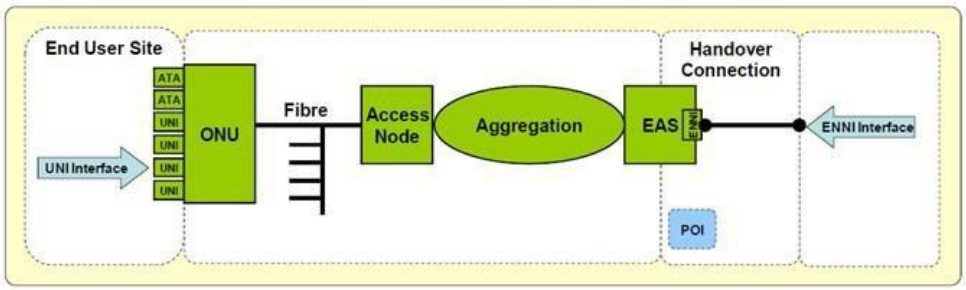
An end customer cannot access a Multicast Domain unless they have been subscribed to it through an NGA Offer. It is not possible for an end customer to spoof a neighbour's VLAN or access a multicast stream from a Multicast Domain they have not subscribed to.

The Channel IP addresses are unique to a Multicast Domain, i.e. different domains can use the same Channel IP addresses without problems.

A Multicast Connection will provide access to all channels in a Multicast Domain. It is recommended that service providers support encryption if they want to limit individual end customers to particular channels. Note that it would be useful to have at least one channel that is not encrypted for test purposes.

Technical interfaces

This section describes the technical interface specifications needed to connect end customer or service provider equipment to Chorus's NGA service, as shown below:



Technical interfaces

UNI INTERFACE	
IGMP	IGMP snooping using IGMP v2 (RFC2236) and v3 (RFC3376) for IPv4.
Ethernet	Ethernet II or 802.3 untagged interface; or 802.1q tagged interface with VLAN id = as agreed with service provider (default = 10). 802.1p = 0 (Low Priority) – unicast only 802.1p = 4 or 5 (High Priority); or 802.1p = 4 (Multicast Priority)
UNI	ONT supports: • 4 x UNI; • 2 x ATA Voice ports; Per UNI: • 100/1000Base-T; • IEEE 802.3 – 2005 or 802.1q;
Multicast VLAN	N:1 VLAN MTU 2000 Bytes Unicast Frame Delivery = as agreed * Multicast Frame Delivery = as agreed Broadcast Frame Delivery = as agreed * * As agreed with Chorus as necessary to support multicast traffic during the Chorus Co-Innovation process. Layer 2 Control Protocols Processing = Initially none (but may be amended from time to time)

E-NNI INTERFACE	
UFB Handover Connection (E-NNI)	Ethernet 802.1ad VLAN (SVID, CVID or single-tagged 802.1q); or Double tagged Q in Q.

End customer interface security settings

The following rules will be applied unless otherwise agreed as part of the Co-Innovation Model:

Upstream

- IGMP will be carried outside E-AVPL traffic contract;
- If IGMP forking is enabled then IGMP will consume upstream E-AVPL bandwidth based on the frame's PCP value;
- Delivered on E-NNI as single-tagged 802.1ad frames with 802.1p of 5

Downstream

- Multicast Class is used
- Multicast SVID 802.1p values of 4 will be treated as Multicast traffic and passed as per template specification
- Other SVID 802.1p values will be remarked as 4 and treated as Multicast traffic and passed as per template specification
- Multicast frames will be shaped on ingress. Frames that exceed the shaper profile will be discarded; High Priority Class is used
- Multicast frames with SVID 802.1p values of 4 or 5, as agreed, will be treated as High Priority traffic and passed as per template specification
- Multicast frames with other SVID 802.1p values will be remarked as 4 or 5, as agreed, and treated as High Priority traffic and passed as per template specification
- High Priority frames will be policed on ingress. Frames that exceed the policer profile will be discarded;
- Unicast Frames will be discarded
- Incorrect Ether type frames will be discarded Incorrect VLAN marked traffic discarded
- Frames in excess of 2000 bytes discarded. frames in excess of 2000 bytes discarded.

Note that the 2000 byte frame size includes the SVID inserted by the OLT for transport across the Local Aggregation Path. Thus any 802.1q frames larger than 1996 bytes will be discarded.

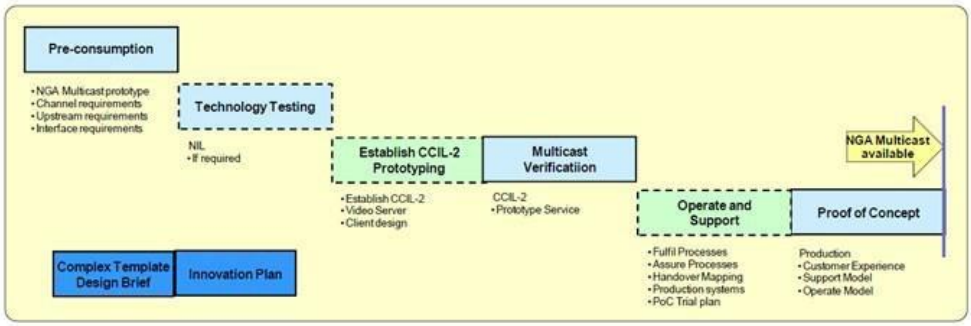
The NGA Multicast prototype uses an untagged UNI and all 802.1q traffic will be discarded on ingress. The E-NNI is configured for single-tagged frames.

Consuming NGA Multicast

Before a service provider can consume NGA Multicast they need to ensure their IP Multicast solution is configured to work with the NGA Multicast settings.

STEPS TO INTRODUCE MULTICAST

NGA Multicast requires the Chorus Co-Innovation Model before service providers can start consuming the service to ensure tight coupling between the Chorus Multicast and the service provider's IP Multicast solution. The following diagram gives an overview of the likely steps:



Consuming NGA Multicast

The NGA Multicast prototype is intended to allow service providers to start trying NGA Multicast. It is not considered a baseline service and is not intended to be available in production.

PRE-CONSUMPTION

Prior to consuming NGA Multicast Chorus will work with the service provider to determine the requirements for the solution, e.g.:

- Multicast features required e.g.;
- How many channels are required;
- Size of each channel;
- Upstream requirements
- Non-Multicast attributes, e.g. E-AVPL or Voice-AVPL settings;
- Interface specifications.

Note that these requirements can evolve through the Co-Innovation process, particularly during CCIL-2 prototyping to couple the service provider and Chorus input service together.

TECHNOLOGY TESTING - NIL

The Network Integration laboratory provides a facility for formal technical and business acceptance testing. This is available if needed although not expected to be used for most solutions.

NGA MULTICAST VERIFICATION

The CCIL-2 environment provides a facility for Retail service providers to prototype and test NGA Multicast within their own laboratory environments. CCIL-2 is a GPON Layer two solutions prototyping and testing facility that provides connectivity from Chorus's live network test environment to the Retail service provider's test facility, located at their premises. This includes UNI and E-NNI components that can be configured with a variety

The objective of NGA Multicast Verification is to get an operational Multicast service with the service provider. This includes any combined templates, i.e. combinations of:

- NGA Multicast; and
- NGA Evolve E-AVPL; and/or NGA Voice.
- NGA Multicast can be offered with NGA Business, but must be on a separate UNI.

NGA Multicast can be offered with NGA Business, but must be on a separate UNI.

To use the CCIL-2 to develop an NGA Multicast solution the Retail service provider must have the following capabilities:

- A connection to CCIL-2 with sufficient ONTs for NGA Multicast testing.
- CPE capable of receiving and using IP Multicast, and any appropriate upstream traffic An IP Edge to allocate an IP address to the CPE.
- A Video Server configured to work with the NGA Multicast solution.

As part of this process it is recommended that various fault scenarios be tested to identify symptoms and ability to detect and correct these. Scenarios might include:

- Fibre cut (unplug ONT);
- Turn of ONT power;
- IP address mismatches;
- Attempting to access too many simultaneous multicast streams
- Attempting to access an unauthorised multicast stream.

PROOF OF CONCEPT

It is recommended NGA Multicast be trialled in the production network before full commercial deployment. This trial can be used to:

- Iron out design kinks or subtle differences in the live network from the test environments.
- Test and tune Operate and Support processes.

OPERATE AND SUPPORT

Prior to Proof of Concept, the Retail service provider should set up the Operate and Support parameters in order to manage the lifecycle of the Multicast Solution

Multicast Domain Settings

- Number of Channels required;
- Total bandwidth
- For each channel:
- IP Multicast address;
- Channel bandwidth(ingress traffic contract);

Multicast Connection Settings

- Number of Channels required;
- Total bandwidth;
- Admission Control bandwidth;
- Tagged/untagged interface;
- VLAN ID;
- E-AVPL specifications.

Infrastructure

- Handover Connection(s) and appropriate backhaul services;
- Security Design and deployment;

Processes

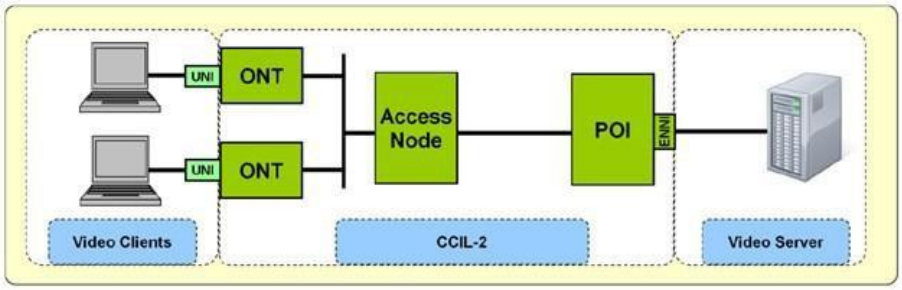
- Establishment process;

- Order/Change NGA Multicast Domain;
- Fulfil process;
- Order/Change NGA Multicast Connection;
- Assure processes;
- Fault reception and identification;
- Reporting faults;
- Truck Rolls/Site visits;
- CPE Spares management;
- Issue escalation.

Case Study: NGA Multicast Demonstration

This section describes a case study of an implementation of the NGA Multicast prototype for background purposes. This implementation was used to demonstrate the NGA Multicast prototype and the ability to join or leave multicast streams.

CASE STUDY ENVIRONMENT



NGA Multicast demonstration case study

The solution deployed consisted of:

- One Video Server broadcasting three public domain video-streams looping continuously.
- Each channel was encoded with an h.264 codec with an x64 encoder and a 10 Mbps peak bitrate.
- A Multicast Domain supporting 40 Mbps of broadcast bandwidth.
- Two ONTs.
- Two PCs (Desktop and Laptop) running command line VLC.

Multicast Sender: Video Content Server

The video server for end is configured as follows

Hardware	HP Proliant DL385G7 server	
Software	Debian OS 6.0 with Debian Multimedia repository vlc (1.1.3-1squeeze6)	

Configuration	IP Address:	10.1.37.1/24
	Routes	224.0.0.0/4
		10.1.37.0/24
Handover Point	Single-tagged	SVID = 2
Channels	Channel 1	224.0.0.1/4
	Channel 2	224.0.0.2/4
	Channel 3	224.0.0.3/4

Multicast Receiver: PC with VLC

Hardware	Laptop and Desktop PC Video: x264 hardware decoding (e.g. NVIDA GT240)	
Software	Ubuntu 11.10 (Windows 7 client also tested) vlc 1.1.12-2~oneiric1 (amd64 binary)	
Configuratio	PC 1: IP Address:	10.1.37.2/24
	PC 1: Number of Channels	2
	PC 2: IP Address	10.1.37.3/24
	PC 2: Number of Channels	1
	Routes	224.0.0.0/4
		0.0.0.0/0
UNI	Untagged	

DEMONSTRATING NGA MULTICAST

The following scenarios could be demonstrated:

Scenario	Description	PC 1 Outcome	PC 2 Outcome
1	PC 1 and PC 2 watch Channel 1	Channel 1	Channel 1

2	PC 1 attempts to join Channel 2	Channel 1 and 2	Channel 1
3	PC 2 attempts to join Channel 2	Channel 1 and 2	Channel 1
4	PC 1 attempts to join Channel 3	Channel 1 and 2	Channel 1
5	PC 2 leaves channel 1 and joins channel 3	Channel 1 and 2	Channel 3
6	PC 2 leaves channel 3 and joins channel 2	Channel 1 and 2	Channel 2
7	PC 1 leaves channel 1 and joins channel 3	Channel 2 and 3	Channel 3