Content delivery over 5G Non-Terrestrial Networks: Use Cases, Devices, Requirements

Non-Terrestrial Networks (NTNs) may use satellites, for example, to provide connectivity over large geographical areas. In particular, NTNs may deliver Internet and media content to poorly served areas as well as to moving platforms (e.g. cars, trains, aeroplanes) beyond the reach of terrestrial infrastructure.

This report provides a high-level overview of the types of payload, connection and device that might be used to access services on NTNs.

The document goes on to define a set of use cases and requirements identified as relevant to media content distribution over NTNs. These include the use of point-to-point, point-to-multipoint and broadcast delivery mechanisms for the delivery of content to different types of device. Several challenges and opportunities to optimize content delivery related to broadcast scenarios and multicast scenarios are also presented. This is done with the application in mind and not assuming any specific exiting technology.

The use case descriptions in this document are intended to lead on to subsequent work reviewing 3GPP specifications to analyse the functional match and, based on this, to identify and document any gaps. This subsequent gap analysis will identify the areas which may require adaptation to support the NTN scenarios, and is intended as an input to the 3GPP SA Technical Specification Groups.

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1. NTN Payload types

The proposed network architecture including NTNs incorporates an Application Server (AS) or Content Delivery Network (CDN) located outside the 5G Core. The Radio Access Network (RAN) is distributed across ground and satellite segments.

In the context of 3GPP NTNs, the choice of payload type significantly influences the satellite communication system's architecture and capabilities. The two primary options are described in 3GPP TR 38.811[1] and are summarised below.

1.1. Transparent payload ("bent pipe")

The satellite acts as a simple analogue radio frequency amplifier and signal repeater, transmitting signals directly from the feeder link to the service link (and *vice versa*) without any on-board processing of the bitstream. This approach reduces complexity but may have limitations in terms of signal quality and flexibility.

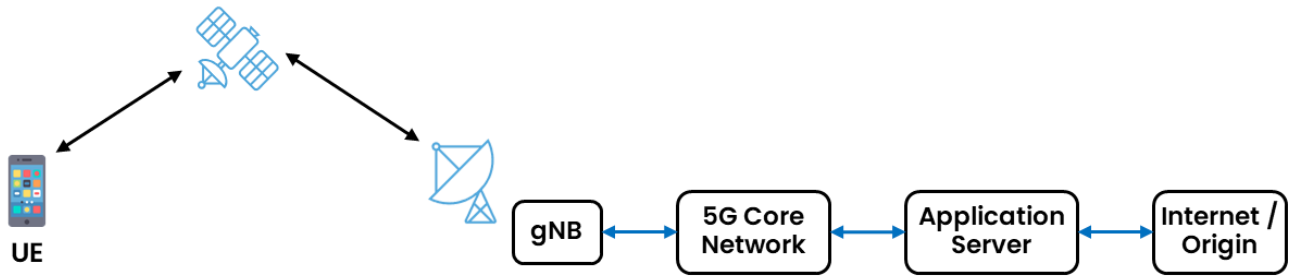

Figure 1. High-level architecture with transparent payload.
The gNodeB is here deployed at the ground station.

1.2. Non-transparent payload ("regenerative")

The satellite performs on-board processing of the signal received on the feeder link prior to transmission on the service link (and *vice versa*), including demodulation, decoding, bitstream processing, re-encoding, and re-modulation. This enables some or all gNodeB functionalities to be deployed on board. It also provides greater control over signal quality and flexibility but increases complexity and cost. Note that this option is not available in 3GPP Rel-18 specifications.

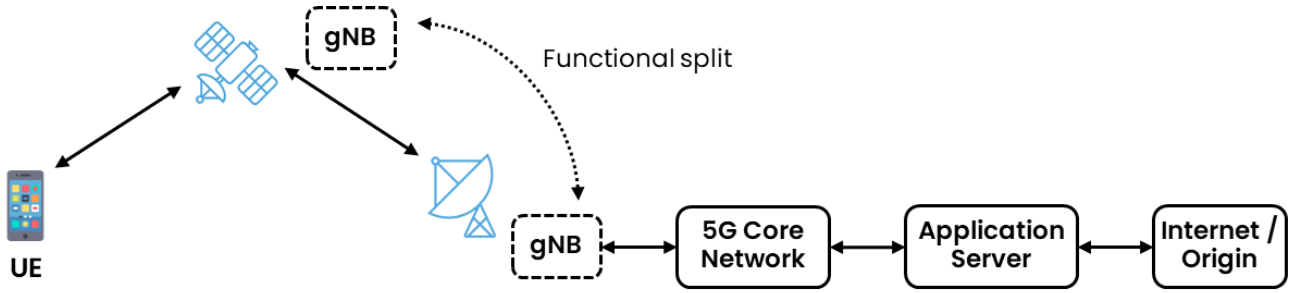

Figure 2. High-level architecture with regenerative payload.
The gNodeB is here deployed as part of the satellite infrastructure.

1 3GPP TR 38.811 "Study on New Radio (NR) to support non-terrestrial networks" (Release 15)

2. NTN connection types

Two primary scenarios are considered for end-user device connection.

2.1. Direct connection

The end-user terminal device directly connects to or receives data from the NTN without any intermediary equipment. This scenario offers a straightforward and efficient communication path.

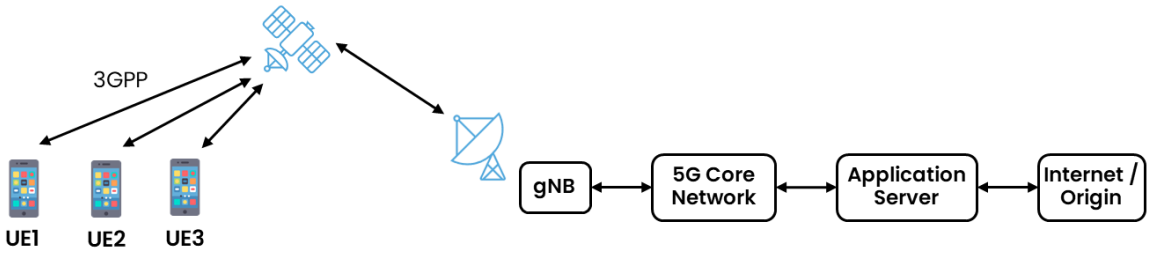

Figure 3. Conceptual architecture considering direct connection to end-user devices.

2.2. Indirect connection

An intermediary device sits between the NTN and the end-user terminal device. This can be realized in two different ways:

- **Gateway:** A device including the functions of a User Equipment (UE) that allows non-UE terminal devices to obtain connectivity using non-3GPP connectivity technologies such as Wi-Fi. This provides a convenient way to extend the NTN's reach.

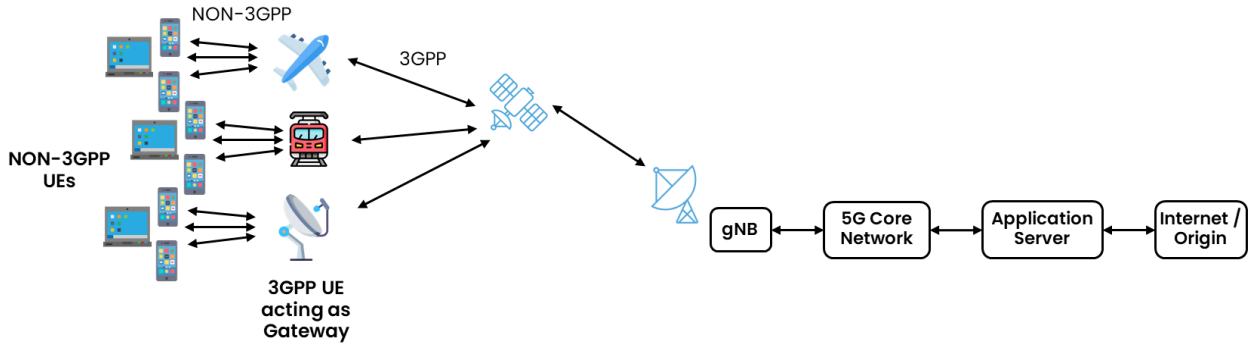

Figure 4. Conceptual architecture considering a UE acting as a gateway.

- **Mobile Relay Node:** A moving platform, such as a drone or vehicle, equipped with NTN capabilities can create a localized 3GPP network. This enables seamless connectivity for 3GPP UEs in areas with limited or no terrestrial infrastructure.

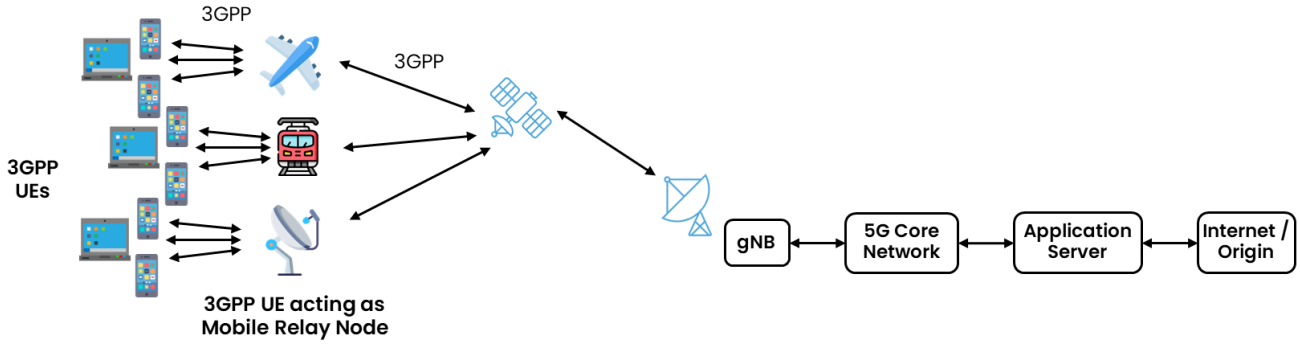

Figure 5. Conceptual architecture considering an intermediate mobile relay node.

3. Types of User Equipment for accessing NTNs

A number of combinations of types of devices, UE environment, satellite orbits, connectivity capabilities and indicative throughput relevant for 3GPP Non-Terrestrial Network (NTN) deployments are outlined below. For simplicity, only the Transparent Payload deployment architecture is depicted in each figure, but the (non-transparent) Regenerative Payload deployment model is equally applicable in all cases.

3.1. Handheld UE

A 3GPP UE terminal device (e.g. a smartphone) that is able to connect to and/or receive directly from the NTN.

UE Environment	Orbit	Connectivity capability	Download/Upload bit rates
Outdoor Mobile	NGSO (LEO)	UE with uplink & downlink	Download up to 10–30 Mbps Upload up to 4–5 Mbps
Outdoor Mobile	NGSO (LEO/MEO)	UE without uplink	Download up to 20–30 Mbps
Outdoor Mobile	GEO	UE without uplink	Download up to hundreds of Kbps

3.2. Car-mounted UE with external antenna

A mounted UE equipped with an external antenna (e.g. 20×20 cm) that connects to the NTN. It can act as a service endpoint in its own right (e.g. infotainment system) or as a gateway for terminal devices in the car (e.g. via Wi-Fi) or as a Mobile Relay Node for 3GPP UEs (see section 3.4).

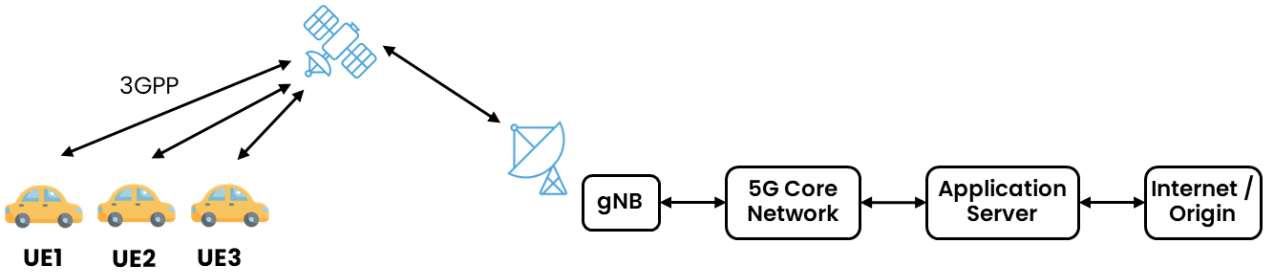

Figure 6. Conceptual architecture considering handheld and car-mounted UEs.

UE Environment	Orbit	Connectivity capability	Download/Upload bit rates
Outdoor Mobile	NGSO (LEO/MEO)	UE with uplink & downlink	Download up to 20 - 50 Mbps Upload up to 10 Mbps
Outdoor Mobile	GEO	UE without uplink	Download up to hundreds of Kbps

3.3. Very Small Aperture Terminal (VSAT) UE with mechanically or electronically steered antenna

For GEO, a UE equipped with an external antenna (e.g. 60 cm equivalent UE antenna aperture) that connects to the NTN. It can act as a gateway or Mobile Relay Node.

For NGSO, a UE equipped with an external antenna (e.g. a 50×30 cm flat panel) that connects to the NTN. It can act as a gateway or Mobile Relay Node. With a built-in modem and non-

moving or moving parts, the terminal is optimized for operation over a LEO/MEO satellite constellation.

The UE can be the same for GEO access and NGSO access in case of multi-orbit deployment, in such case the UE selects the appropriate orbit based on QoS requirements for the requested service (e.g. end-to-end latency). This kind of UE costs more (up to 10 times) than one dedicated for GEO to receive media.

UE Environment	Orbit	Connectivity capability	Download/Upload bit rates
Outdoor Fixed/Mobile	GEO	UE with uplink & downlink	Download up to 50 - 100 Mbps Upload throughput to be analysed
Outdoor Fixed/Mobile	NGSO	UE with uplink & downlink	Download up to 100 - 200 Mbps Upload up to 30-50 Mbps

3.4. Mobile Relay Node for moving platform with external antenna

Equipment in a moving platform with an external antenna (outdoors) connected to the NTN. An indoor network (e.g. a public or non-public 3GPP network) serves UEs within the moving platform and may integrate a local CDN node. The frequency bands used by the two network segments are different.

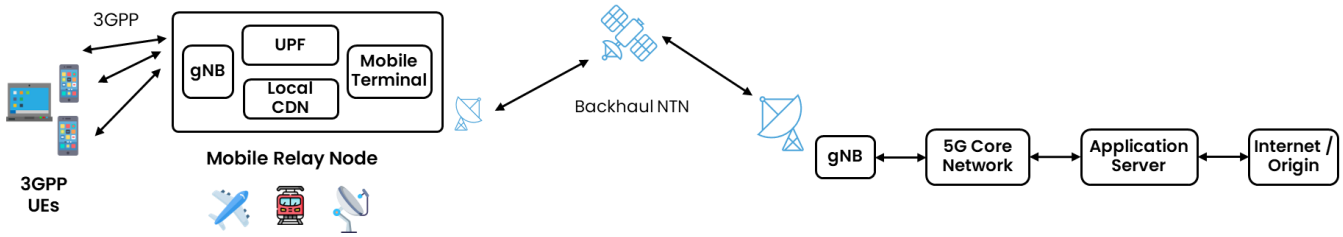

Figure 7. Device architecture for a Mobile Relay Node

UE Environment	Orbit	Connectivity capability	Download/Upload bit rates
Indoor UE with Outdoor Relay	NGSO (LEO/MEO)	UE with uplink & downlink	Download up to 20 - 60 Mbps Upload up to 10 Mbps

A Mobile Relay Node has a similar protocol stack to a UE, but with additional relaying functionalities. There are two types of access point for the Mobile Relay Node depending on the local deployment on board of the moving platform:

- *Layer 2 relay* with only gNodeB base station functionality alongside the backhaul-facing **Mobile Terminal** entity. In this simple Mobile Relay Node, the gNodeB base station's RLC/MAC stacks are the client of the relay functionalities in the Mobile Terminal entity. The gNodeB uses, for example, a specific Service Access Point mapped to the relay functionality.
- *Layer 7 gateway* with a **Local CDN node** and an edge User Plane Function (**UPF**) on board the moving platform in addition to a local gNodeB base station functionality and the backhaul-facing Mobile Terminal entity. The Local CDN and edge UPF are the client of the SDAP/PDCP stacks of the Mobile Terminal entity. The local CDN and edge UPF use, for example, a specific Service Access Point mapped to the data connectivity to set up a tunnel with the remote UPF.

4. Example user services delivered over NTNs

4.1. Media: Live and on-demand Audio/Video streaming services

Audio and video streaming applications are commonly used by users to access services on connected devices. For example, a significant proportion of audio streaming (IP-delivered radio listening) is on the move (e.g., in cars or trains, at sporting events, in the park, etc.) which is reliant on broadband networks for the delivery of the services. Some locations, for example rural areas and at sea (e.g. on fishing vessels, boats and ferries), may have limited access to terrestrial mobile network connectivity. These may be served by Non-Terrestrial Networks.

For reference, the table below shows an example of existing segmented media streaming services such those offered by BBC Sounds for audio/radio services.

Audio bit rates (kbps)	Protocols	Segment durations (s)
320, 128, 96, and 48	HLS and MPEG-DASH	6.4

The following table refers to BBC iPlayer for TV/video services.

Video bit rates (kbps)	Audio bit rates (kbps)	Protocols	Resolution and codecs
3200, 5000	128	HLS and MPEG-DASH	1280×720 (720p), H.264

Bit rate is not the only measure of desirable network performance for media distribution: low latency operation is also desirable. For example, Project Timbre recommends that the 99.9th percentile, or higher, of the segment delivery latency should be less than a few seconds.

4.2. Public Warning System (PWS): Emergency Alert Services

The following bullet points provide examples for the provision of emergency alert services, which reflect the European Electronic Communications Code:

- Public warnings should be provided by publicly available electronic communications services other than mobile number-based interpersonal communications services or by mobile applications via Internet access services.
- Users should receive information on the available Public Warning System (PWS) by means of the Short Message Service (SMS), without undue delay and free of charge, including by means of mobile terminal equipment not enabled for Internet access services. Users should configure their device to receive alerts.
- Public warnings should be transmitted to end users in an easily receivable manner.
- Where a PWS relies on an application, it should not require users to log in or register with the authorities or the application provider.
- A PWS should be able to target the affected population by specific geography so as not to cause widespread panic. In case of PWS delivered through satellite, the delimitation of the target area should be well mapped within wide beam coverage.
- The PWS should be able to reach the population anywhere by combining Terrestrial Network and Non-Terrestrial Network infrastructure.
- Alert messages should be sent in real time within seconds, with a high degree of reliability, and should reach a high percentage of people in the targeted area, both home and roaming UEs.

5. Requirements for content delivery over NTN

The following colour code is used to annotate the network links in the diagrams in this section:

- The blue colour represents unicast traffic delivered over a point-to-point links.
- The green colour represents multicast traffic delivered over a point-to-multipoint or point-to-point link.
- The red colour represents multicast traffic delivered over broadcast without the need for UE registration (i.e. receive-only broadcast mode).

For simplicity, only the Transparent Payload deployment architecture is depicted in each figure, but the Regenerative Payload deployment model is equally applicable in all cases.

5.1. Point-to-point communication

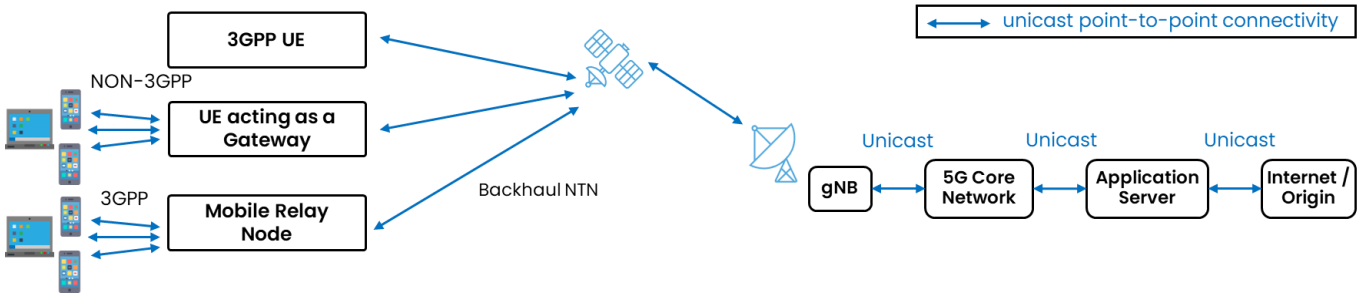

Figure 8. NTN with point-to-point unicast communication.

Application Service Provider

- An Application Service Provider makes available over the Internet services (e.g. TV, radio, any linear/live streaming service) which users can access through an application installed on their devices (e.g. a smartphone, a smart TV, tablet, etc.).

Network and access to services

- The gNodeB of the NTN ("Donor gNodeB") is deployed either at the ground station (Transparent Payload architecture) or on board the spacecraft (Regenerative Payload, not illustrated).
- The NTN operator offers mobile broadband access to its subscribed users.
- Optionally, the NTN operator may collaborate with the Application Service Provider to ensure the delivery of content with a desired Quality of Service, including the provisioning of Network Assistance and/or UE data collection and reporting, among other functionalities.

Device considerations

- User Equipment directly connected to the NTN (including UEs or a Mobile Relay Node within a moving platform) requires subscription and registration with the NTN operator in order to obtain mobile broadband connectivity and access to the desired services.
- User Equipment connected to a Mobile Relay Node within a moving platform requires either subscription and registration with the moving platform network operator (which could be the same as or different from the NPN operator), or directly with the NTN operator in order to obtain mobile broadband connectivity and access to the desired services.

Mobility, handover, service interruption and reliability requirements

- For critical media applications, lossless mobility without interruption should be guaranteed when users transit across different coverage areas, even when those different coverage areas are served by different NTNs.

- For media services with less stringent requirements, some level of interruption may be tolerable when users transit across different coverage areas, including when those different coverage areas are served by different NTNs.

5.2. Broadcast communication

5.2.1. Broadcast delivery of multicast content to registered devices

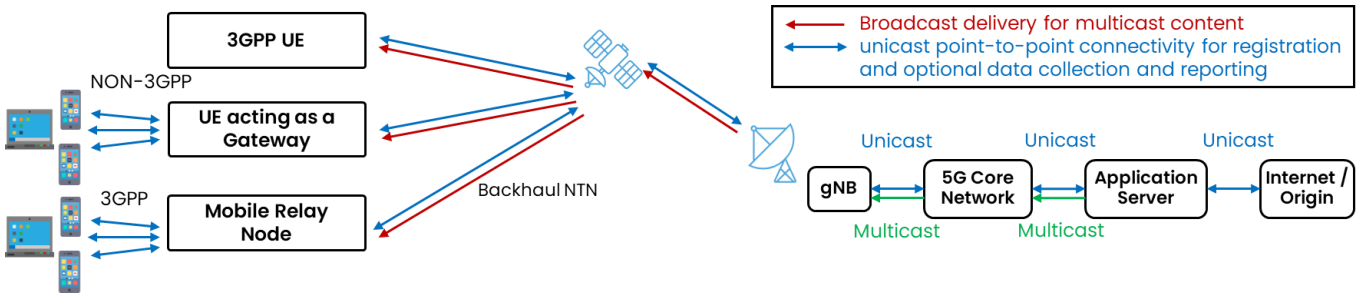

Figure 9. NTN with broadcast delivery of multicast content to registered UEs.

Application Service Provider

- An Application Service Provider makes available over the Internet services (e.g. TV, radio, any linear/live streaming service) which users can access and through an application installed on their devices (e.g. a smartphone, a smart TV, tablet, etc.).
- The Application Service Provider additionally provisions these as multicast services in the 5G Core of the NTN.

Network and access to services

- The gNodeB of the NTN ("Donor gNodeB") is deployed either at the ground station (Transparent Payload architecture) or on board the spacecraft (Regenerative Payload, not illustrated).
- The Donor gNodeB is statically configured to deliver content using broadcast communication, but also unicast uplink interaction to support ancillary services.
- The NTN operator may offer access to mobile broadband to its subscribed users or instead just offer access to certain services over broadcast communication.
- The NTN supports multicast user services.
- A set of multicast services is provisioned in the NTN that deliver content to UEs using broadcast communication.
- Optionally, the NTN operator may collaborate with the Application Service Provider to ensure the delivery of content with a desired Quality of Service, including the provisioning of Network Assistance or UE data collection and reporting, among other functionalities.
- Optionally, UEs with additional independent broadband capabilities may participate in UE data collection and reporting, enabling the NTN operator or the Application Service Provider to detect concurrent consumption of services delivered using unicast and make a corresponding multicast service additionally available over broadcast at certain times of high demand. The client at the UE may be able to switch between different delivery mechanisms for a given service.

Device considerations

- User Equipment directly connected to the NTN requires subscription and registration with the NTN operator in order to obtain connectivity and access to the desired services.
- User Equipment connected to a Mobile Relay Node within a moving platform requires either subscription and registration with the moving platform network operator (e.g. an NPN) or directly with the NTN operator in order to obtain connectivity and access to the desired

services. Note that UEs may only consume services over broadcast communication from the Mobile Relay Node. In a such case, the Mobile Relay Node is able to set up point-to-point communication in the NTN backhaul link to deliver data to a Local CDN node using mechanisms to ensure reliability and in-sequence delivery. Data is then delivered to UEs in the moving platform via broadcast communication.

Mobility, handover, service interruption and reliability requirements

- The provision of content over broadcast communication may rely on mechanisms to ensure reliability and in-sequence delivery. User Equipment may be able to request repair of imperfectly received data (e.g., over unicast point-to-point connectivity) to increase service reliability.
- For critical applications, lossless mobility without interruption should be guaranteed when users transit across different coverage areas even when those different coverage areas are served by different network operators. In addition, lossless mobility without interruption should be guaranteed when a client switches from consuming content delivered via broadcast to point-to-point unicast and *vice versa*.
- For services with less stringent requirements some level of interruption may be tolerated when a UE transits across different coverage areas, even when those different coverage areas are served by different network operators. In addition, some level of interruption may be tolerable when a client switches from consuming content delivered via broadcast to point-to-point unicast and *vice versa*.

5.2.2. Broadcast delivery of multicast content to unregistered devices

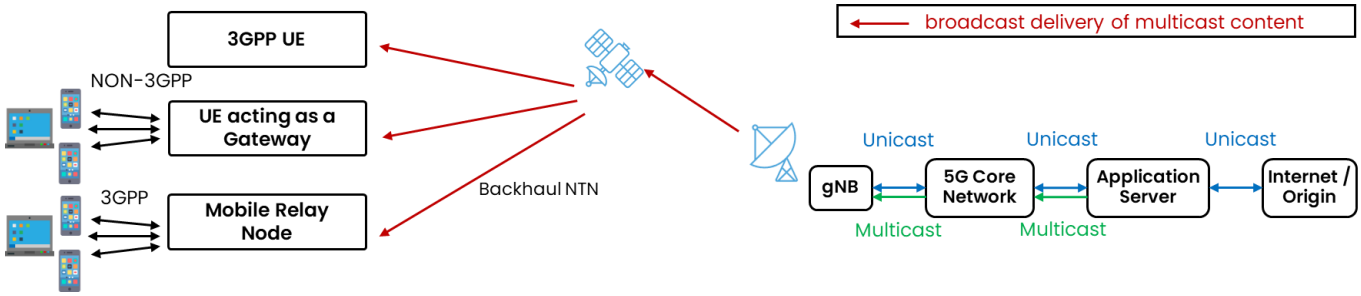

Figure 10. NTN with broadcast delivery of multicast content to unregistered UEs.

Application Service Provider

- An Application Service Provider makes available over the Internet services (e.g. TV, radio, any linear/live streaming service) which users can access through an application installed on their devices (e.g. a smartphone, a smart TV, tablet, etc.).
- The Application Service Provider additionally provisions these as multicast services in the 5G Core of the NTN.

Network and access to services

- The gNodeB of the NTN ("Donor gNodeB") is deployed either at the ground station (Transparent Payload architecture) or on board the spacecraft (Regenerative Payload, not illustrated).
- The Donor gNodeB is statically configured to deliver content using broadcast communication without uplink interaction.
- The NTN supports multicast user services.
- A set of multicast user services is provisioned in the NTN to deliver content to UEs using broadcast communication without the need to subscribe, register or use any uplink interaction in order to consume the services.

- Optionally, the NTN operator may collaborate with the Application Service Provider to ensure the delivery of content with a desired Quality of Service.
- Optionally, and not illustrated in Figure 10, UEs with additional independent broadband capabilities may participate in UE data collection and reporting, enabling the NTN operator or the Application Service Provider to detect concurrent consumption of services delivered using unicast and make a corresponding multicast service additionally available as broadcast at certain times of high demand. The client at the UE may be able to switch between different delivery mechanism for a given service.

Device considerations

- User Equipment does not require subscription or registration with the NTN operator in order to access to the desired services delivered over broadcast communication. Therefore, any UE with no uplink capabilities should be able to consume content over broadcast communication within the coverage area.
- UEs may consume services from the Mobile Relay Node using broadcast communication. In such case, the Mobile Relay Node is able to set up point-to-point communication in the NTN backhaul link to deliver data to the Local CDN node using mechanisms to ensure reliability and in-sequence delivery. Data is then delivered to UEs.

Mobility, handover, service interruption and reliability requirements

- The provision of content over broadcast may rely on mechanisms to ensure reliability and in-sequence delivery. Optionally, when the UE has an independent broadband connection (not depicted in Figure 10), the device may be able to request repair over point-to-point unicast communication to increase delivery reliability.
- Some level of interruption may be tolerable when a UE transits across different broadcast coverage areas, even when those different coverage areas are served by different network operators. In addition, when the UE has an independent broadband connection, lossless mobility without interruption may be guaranteed when the client switches from consuming content via broadcast to point-to-point unicast and *vice versa*.

5.3. Point-to-multipoint communication

5.3.1. Delivery of multicast content with autonomous RAN switching between point-to-point and point-to-multipoint

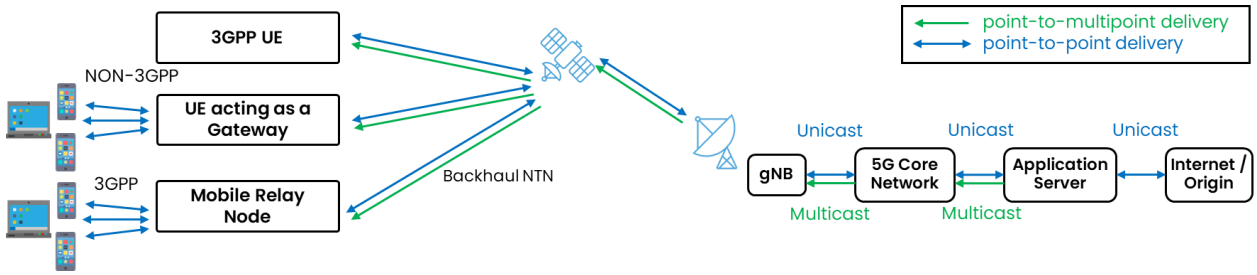

Figure 11. NTN with point-to-multipoint delivery of multicast content.

Application Service Provider

- An Application Service Provider makes available over the Internet services (e.g. TV, radio, any linear/live streaming service) which users can access through an application installed on their devices (e.g. a smartphone, a smart TV, tablet, etc.).
- The Application Service Provider additionally provisions these as multicast services in the 5G Core of the NTN.

Network and access to services

- The gNodeB of the NTN ("Donor gNodeB") is deployed either at the ground station (Transparent Payload architecture) or on board the spacecraft (Regenerative Payload, not illustrated).
- The NTN operator offers mobile broadband access to their subscribed users.
- The NTN supports multicast user services.
- A set of multicast services is provisioned in the NTN that deliver content to UEs using either point-to-point or point-to-multipoint multicast communication, at the discretion of the Donor gNodeB.
- Optionally, the NTN operator may collaborate with the Application Service Provider to ensure the delivery of content with a desired Quality of Service, including the provision of network assistance and/or UE data collection and reporting, among other functionalities.
- The NTN has the ability to detect concurrent consumption of services by multiple users and may use parameters such as session counting to trigger unicast-to-multicast switching at upper layers.
- The Donor gNodeB is able to autonomously switch the delivery mode of multicast packets between point-to-point to point-to-multipoint according to the number of UEs attempting to receive multicast user services concurrently.

Device considerations

- User Equipment directly connected to the NTN (including UEs or a Mobile Relay Node in a moving platform) requires subscription and registration with the NTN operator in order to obtain mobile broadband connectivity and access to the desired services.
- In addition, the NTN operator authorises UEs that are able to consume multicast user services.
- In order to obtain network connectivity and access to the desired services, User Equipment connected to a Mobile Relay Node within a moving platform requires either subscription and registration with the moving platform network operator (which could be the same as or different from the NPN) or directly with the NTN operator.

Mobility, handover, service interruption and reliability requirements

- The delivery of multicast data packets using point-to-point or point-to-multipoint transmission should rely on mechanisms that ensure reliability and in-sequence delivery. User Equipment should be able to request repair of faulty or lost multicast data packets to increase delivery reliability.
- For critical applications, lossless mobility without interruption should be guaranteed when UEs transit across different satellite coverage areas, even when those different coverage areas are served by different NTNs operated by the same NTN operator (e.g. from LEO to GEO with a common 5G Core). Interruption-free multicast user service should be guaranteed when a UE is served from a gNodeB which switches multicast packet delivery from point-to-multipoint to point-to-point communication and *vice versa*.
- For services with less stringent requirements, some level of multicast user service interruption may be tolerable when a UE transits across different coverage areas, including when those different coverage areas are served by different NTNs. Some level of interruption may be tolerable when a UE is served from a gNodeB which switches multicast packet delivery from point-to-multipoint to point-to-point communication and *vice versa*.

6. Delivery of content via a Mobile Relay Node

Five different deployment scenarios are further elaborated below when delivering content to UEs in a local network provided by a Mobile Relay Nodes. In these cases:

- UEs may be connected to a multicast session from end to end. The Mobile Relay Node sets up point-to-point or point-to-multipoint communication in the NTN backhaul link to relay received multicast data packets directly to UEs over the local network, which can be a Non-Public Network (NPN).
- UEs might not be connected to a multicast session from end to end, consuming data only from the Mobile Relay Node. In such cases, the Mobile Relay Node sets up point-to-point or point-to-multipoint communication in the NTN backhaul link to receive multicast data packets. Data is stored in a local CDN node from where multicast packets are finally delivered to UEs using point-to-point or point-to-multipoint communication, at the choice of the local gNodeB.
- Where content is delivered using multicast packets, point-to-point or point-to-multipoint (including broadcast) delivery can be used.

6.1. Unicast fronthaul and unicast backhaul

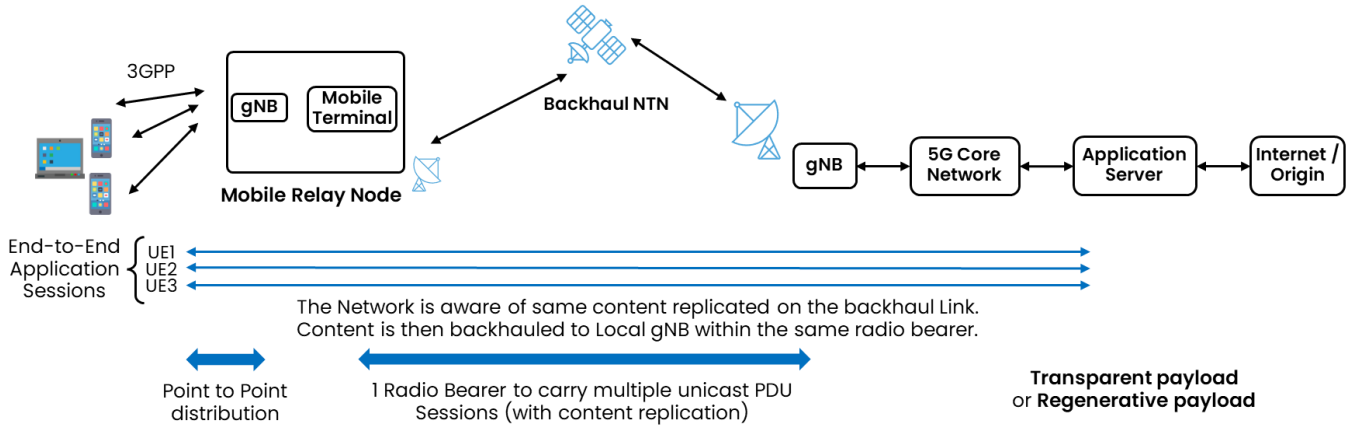

Figure 12. Mobile Relay Node deployment with unicast fronthaul and unicast backhaul.

In this deployment scenario, unicast content streams are delivered independently to each UE in the moving platform, but they share a common radio bearer on the NTN backhaul link:

- Multiple UEs on a moving platform consume content with a similar QoS requirement.
- Each UE has an individual end-to-end unicast session with the Application Server.
- The Mobile Relay Node establishes point-to-point unicast communication with the Donor gNodeB over the NTN. This ensures reliable and in-sequence delivery over the NTN backhaul link.
- The Donor gNodeB may apply traffic optimization policies based on 5G Core rules.
- The local gNodeB delivers data to UEs via point-to-point unicast communication. This allows UEs to access the network using a local link. Hence, delivery of RLC PDUs can be independently optimized for the satellite backhaul NTN link and the local link.

6.2. Unicast fronthaul and unicast backhaul with local CDN node

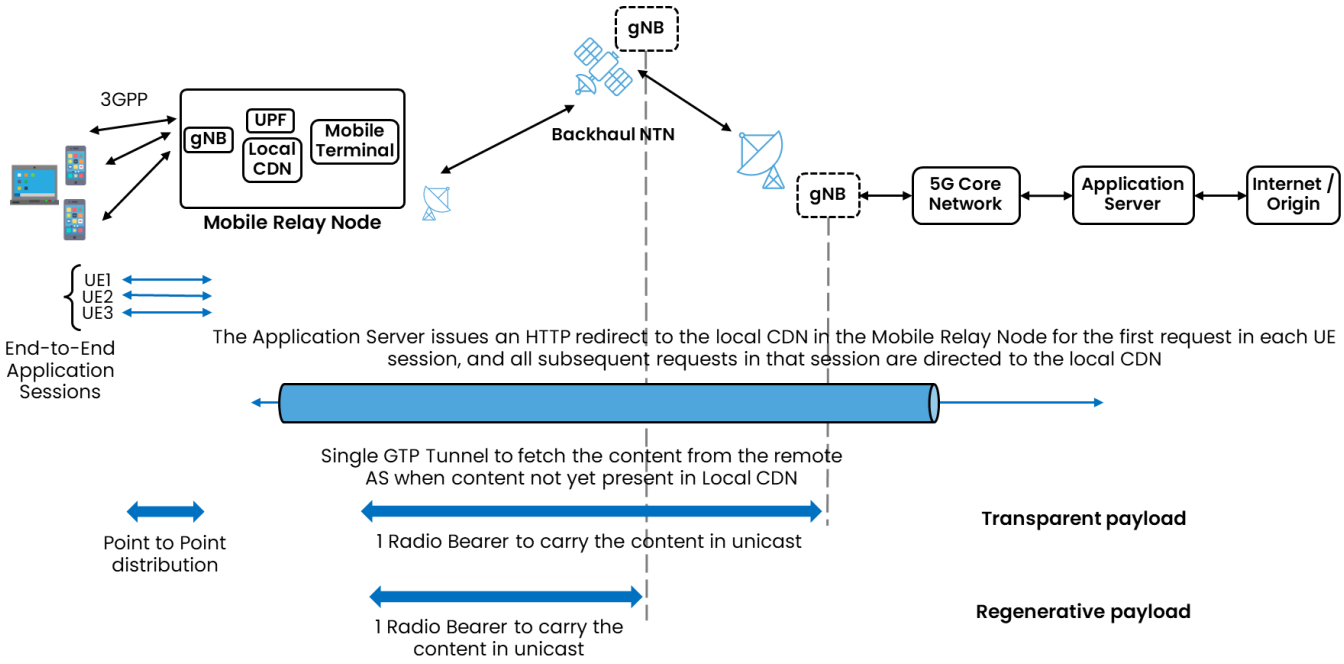

Figure 13: Mobile Relay Node deployment with unicast fronthaul and unicast backhaul with local CDN node.

In this deployment scenario, content is delivered once to a local CDN in the Mobile Relay Node and is redistributed by the local CDN to multiple UEs in the moving platform wishing to consume it:

- Multiple UEs on a moving platform consume the same content from an Application Server.
- A Local CDN node (supported by an edge UPF) is deployed in the Mobile Relay Node with the aim of enhancing network QoS in the moving platform local network (and, thus, enhancing the QoE experienced by end users).
- The UEs all maintain separate unicast PDU Sessions with the edge UPF to consume content from the Local CDN. When the content is not yet present on the Local CDN, it fetches the content once from the remote Application Server via a single PDU Session on a radio bearer that terminates at the Donor gNodeB.
- The edge UPF establishes a unique GTP tunnel (mapped into one radio bearer on the NTN link between the Donor gNodeB and the Mobile Relay Node) to carry one copy of the traffic to the CDN which is then forwarded to the local UEs of the moving platform using individual unicast PDU Sessions over point-to-point delivery. Hence all the other UEs in the local network that need to consume the same content will retrieve it directly from the local CDN without an additional HTTP redirect. The reliability is improved since the backhaul NTN link will be less contended when UEs are willing to consume the same content.

6.3. Multicast fronthaul and multicast backhaul (multicast PDU session relay)

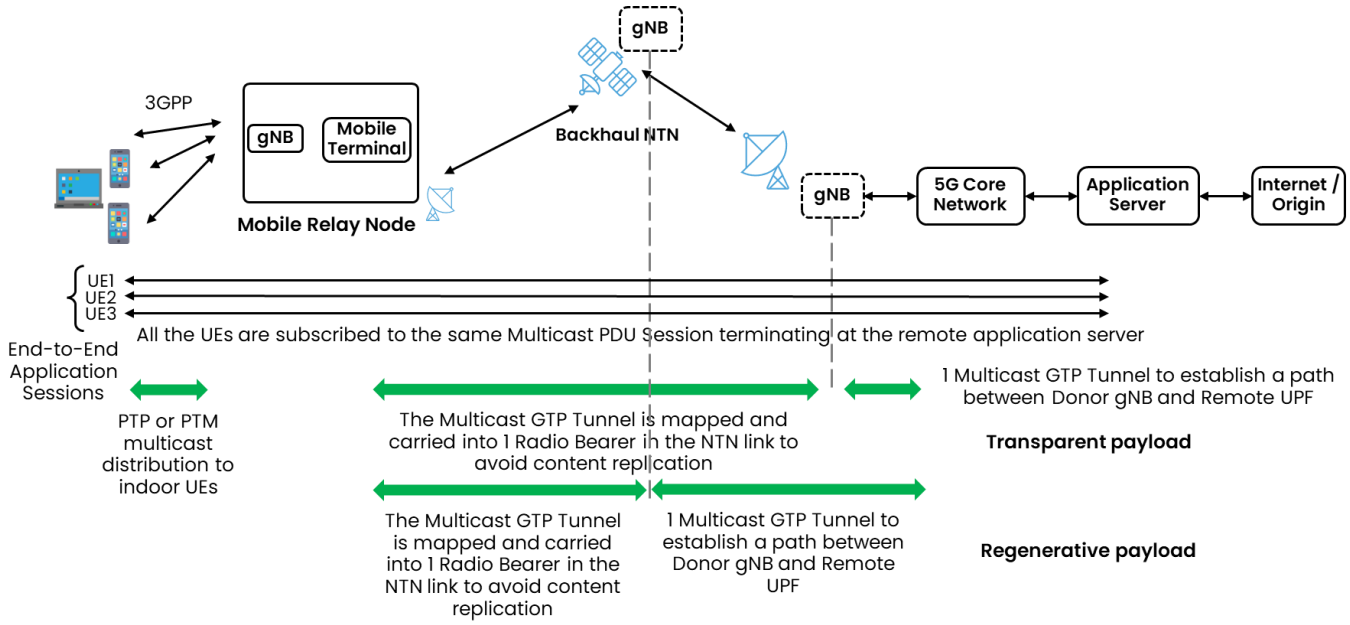

Figure 14. Mobile Relay Node as multicast PDU session relay with multicast fronthaul and multicast backhaul.

In this deployment scenario, UEs in the moving platform are connected to a multicast shared delivery session from end to end.

- The shared delivery session is distributed once over the backhaul NTN from the Donor gNodeB to the local gNodeB where it is redistributed to the UE consumers.
- The Mobile Relay Node joins a multicast session on its NTN backhaul link to deliver multicast packets to end UEs.
- The Donor gNodeB in the backhaul NTN may choose between point-to-point or point-to-multipoint communication to deliver multicast packets, depending on the number and location of current multicast subscribers.

6.4. Multicast fronthaul and multicast backhaul with local CDN node

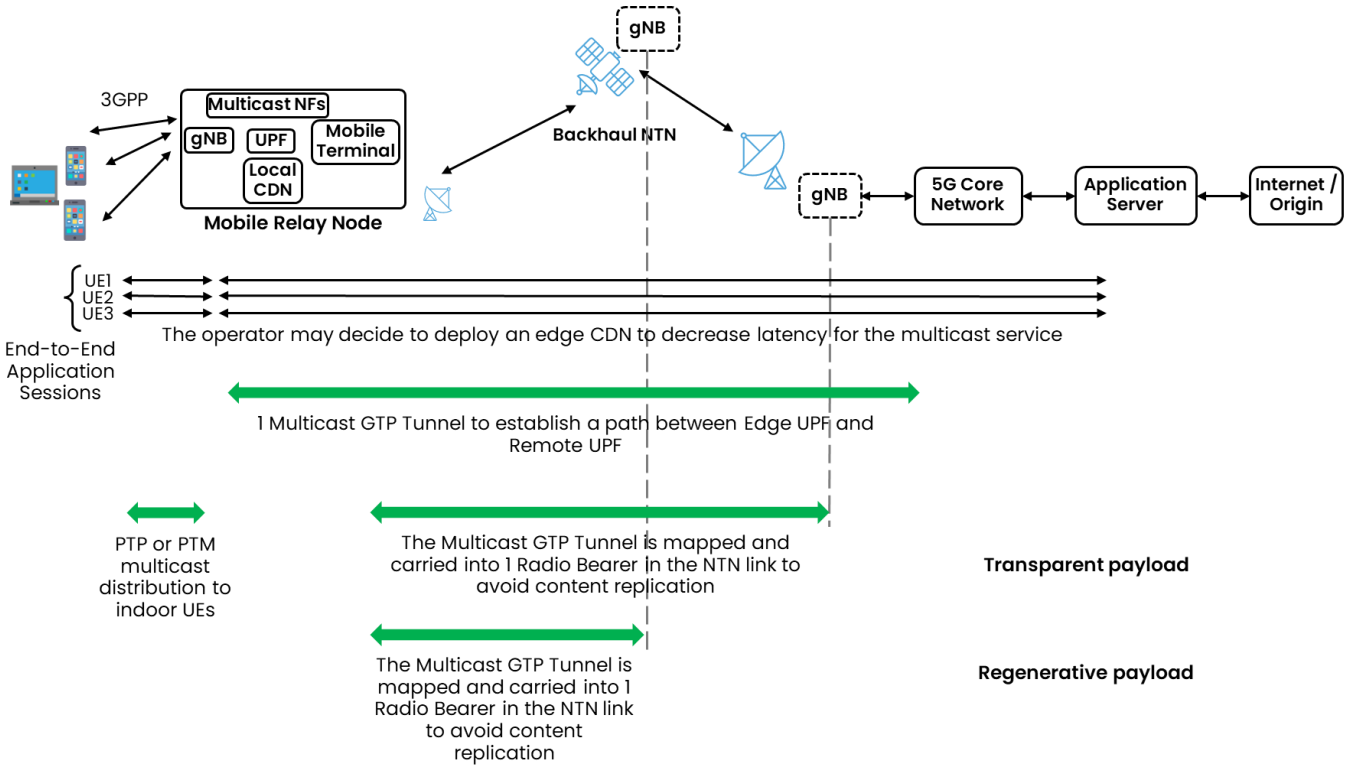

Figure 15. Mobile Relay Node deployment with Multicast fronthaul and multicast backhaul, including local CDN node.

In this deployment scenario, UEs are connected to a concatenated pair of multicast sessions from end to end.

- A single multicast delivery session distributes content from the Donor gNodeB to the Mobile Relay Node.
- The Mobile Relay Node is equipped with a local CDN node and multicast-capable Network Functions.
- A local CDN node stores content and the local network redistributes it to UEs via a separate multicast delivery session.
- The Mobile Terminal of the Mobile Relay Node sets up a tunnel with the remote UPF to receive multicast packets and cache them in the local CDN node. This tunnel is mapped into a specific bearer in the backhaul NTN link known by both the Donor gNodeB and the Mobile Relay Node.
- Each UE establishes a multicast session with the multicast-capable Network Functions in the Mobile Relay Node. The gNodeB in the Mobile Relay Node may choose to use point-to-point or point-to-multipoint delivery of the multicast packets to UE multicast subscribers.
- Combined with the (shared) multicast session on the backhaul NTN link, this effectively creates an end-to-end application session terminating at the Application Server.
- Multicast packets are not replicated on the NTN backhaul link, thereby reducing radio resource usage on the satellite spectrum.
- Content can also be acquired from the local CDN of the moving platform via unicast point-to-point communication by means of routing features in the edge UPF.
- The UEs are reachable thanks to the Mobile Relay Node, while maintaining homogenous handling of multicast traffic, i.e. the same packet routing technology is used in the different network segments (indoor link of the moving platform, NTN service link, NTN feeder link).

6.5. Multicast fronthaul and unicast backhaul with local CDN node

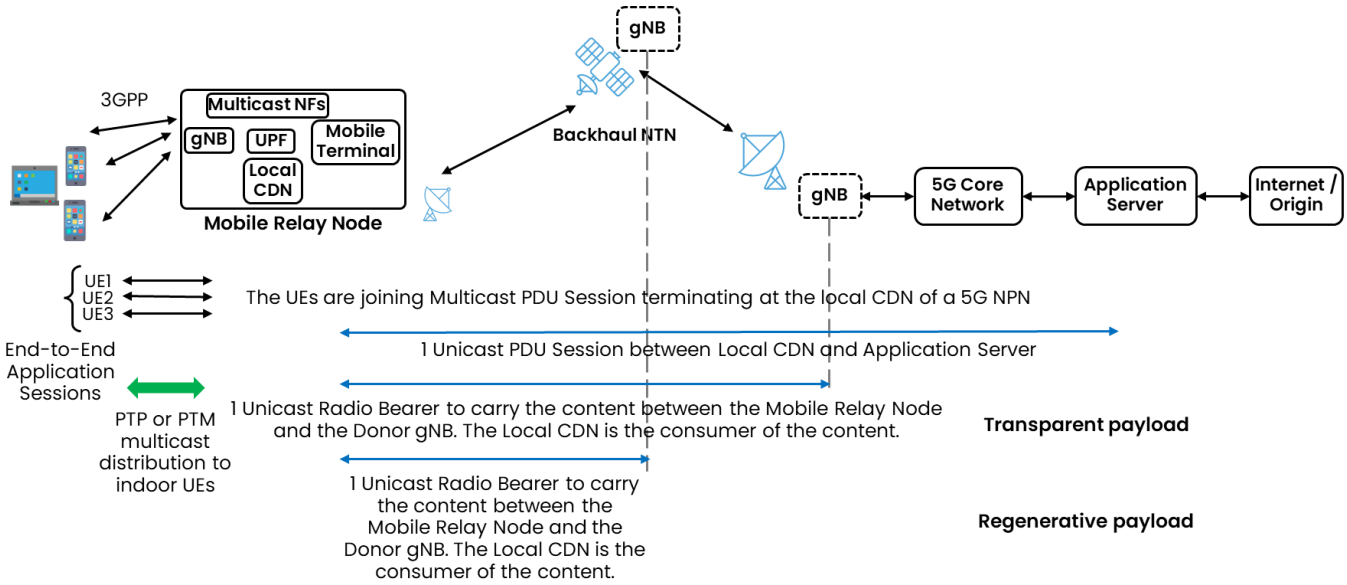

Figure 16. Multicast fronthaul and unicast backhaul with local CDN node.

In this deployment scenario, UEs connect to a multicast session terminating at the multicast-capable Network Functions of the Mobile Relay Node. These acquire content from the local CDN which, in turn, acquires content from the Application Server via a unicast PDU Session carried by the backhaul NTN.

- In this case, the local network can be seen as an independent network (e.g. an NPN).
- The local CDN acts as a proxy client application consuming the content from the Application Server. The Mobile Relay Node is seen as a single UE subscriber by the NTN. A single copy of the content is acquired by the local CDN node from the AS via a unicast PDU session carried over the backhaul NTN link.
- Communications between the local CDN node and the NTN happens in unicast. The local gNodeB in the moving platform determines autonomously whether to distribute multicast content to the UEs using point-to-point or point-to-multipoint delivery depending on multiple criteria (e.g. number of UEs requesting the same content, level of required reliability of the requested service, radio conditions, requested traffic load, etc.).

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