5G-EMERGE

5G-EMERGE - Satellite-enhanced edge delivery

A state-of-the-art technology hybrid 5G-satellite networking solution built for cost effective, scalable, efficient, high quality secure and intelligent media delivery.

Keywords

Satellite, Native IP, reachability, hybrid networks, 5G, terrestrial, edge computing, GEO/MEO/LEO satellites, QoS, QoE, scalability, efficient workflow, high quality, media delivery ecosystem, open standards, direct-to-device, direct-to-home, direct-to-edge, direct-to-vehicle, 5G NR NTN.

Executive Summary

5G-EMERGE is a satellite focused, 5G-based, hybrid network ecosystem optimized for media distribution. The aim is to seamlessly feed distributed edges over satellites (with or without return channel), 5G networks and other terrestrial networks. This should enable service providers to deliver video streaming services at scale and cost-effectively, whilst improving user experience across a plethora of use-cases.

This emerging ecosystem is based on a native-IP hybrid infrastructure and on open standards, allowing end-users to seamlessly consume their desired content from a local edge cache via satellite, 5G or broadband link.

5G-EMERGE represents a significant step forward in the field of ubiquitous media distribution, offering unparalleled access, scalability and flexibility; harnessing cloud and edge caching technologies, satellite's matchless coverage and 5G's mobility. The result is supposed to efficiently address the global demand for diverse media content, from live sports to local news, including On-demand assets.

This platform is designed to deliver high-quality media to any device, anytime, and anywhere on land, sea and in the air, overcoming possible network bottlenecks that may arise when popular content is consumed during traffic peaks. The technology is uniquely positioned to serve a wide range of devices on heterogenous networks, making it a cost-effective and adaptable solution for multiple business models.

5G-EMERGE objectives

5G-EMERGE is a consortium of companies deploying a media delivery ecosystem consisting of distributed edges connected via satellite backhaul. The ecosystem supports a multitude of use-cases which may benefit from a better reach, playout quality, application response and traffic optimisation by ingesting popular content as close as possible to the end user. The project is called 5G-EMERGE as it uses 5G technologies to achieve technological convergence between satellite communication and online delivery mechanisms.

The emerging ecosystem is a native-IP hybrid infrastructure, based on open standards. It is complementary to terrestrial internet networks and fully transparent to the audience as their media applications are redirected in the backend to local caches on the far edges. These distributed edges can be deployed, for example, near 5G base stations or at a 5G base station on a ship. Not only 5G mobile networks are addressed but also smaller edges – effectively smart satellite gateways – are targeted in other network head-ends, home networks and in vehicles.

The connected edges implemented during the project host multiple applications – running in Docker containers – on a virtualized cloud stack. As such, the edge network is not restricted to media services only but can, for example, be used for distributing software updates, e-learning or AI appliances. In other words, everything that benefits from a combination of a satellite backhaul and processing power that is closer to the end user.

For content providers, the ecosystem functions as a normal (multi-) CDN setup. Satellite networks, primarily GEO and MEO satellites, are used as a tunnel to deliver multicast streams of popular content, jumping over busy interconnection points. Content to fill this multicast feed is selected by a prefetching engine that predicts popularity in the region covered by the satellite footprint. Data inputs are reverse proxy request, predictions from AI driven recommendation engines and experience drawn from use patterns.

This new approach will improve playout quality and fast startup times. It also works at locations that have limited or no IP coverage as it can fall back to a satellite receive-only mode if required. Network functions can be exposed all the way up to the 5G devices. Where there is no 5G network and device available, the far edge will be the end point. The 5G-EMERGE ecosystem is compliant with a futureproof 5G-architecture approach and can provide a full integrated fallback for non-5G components that already exist in the market.

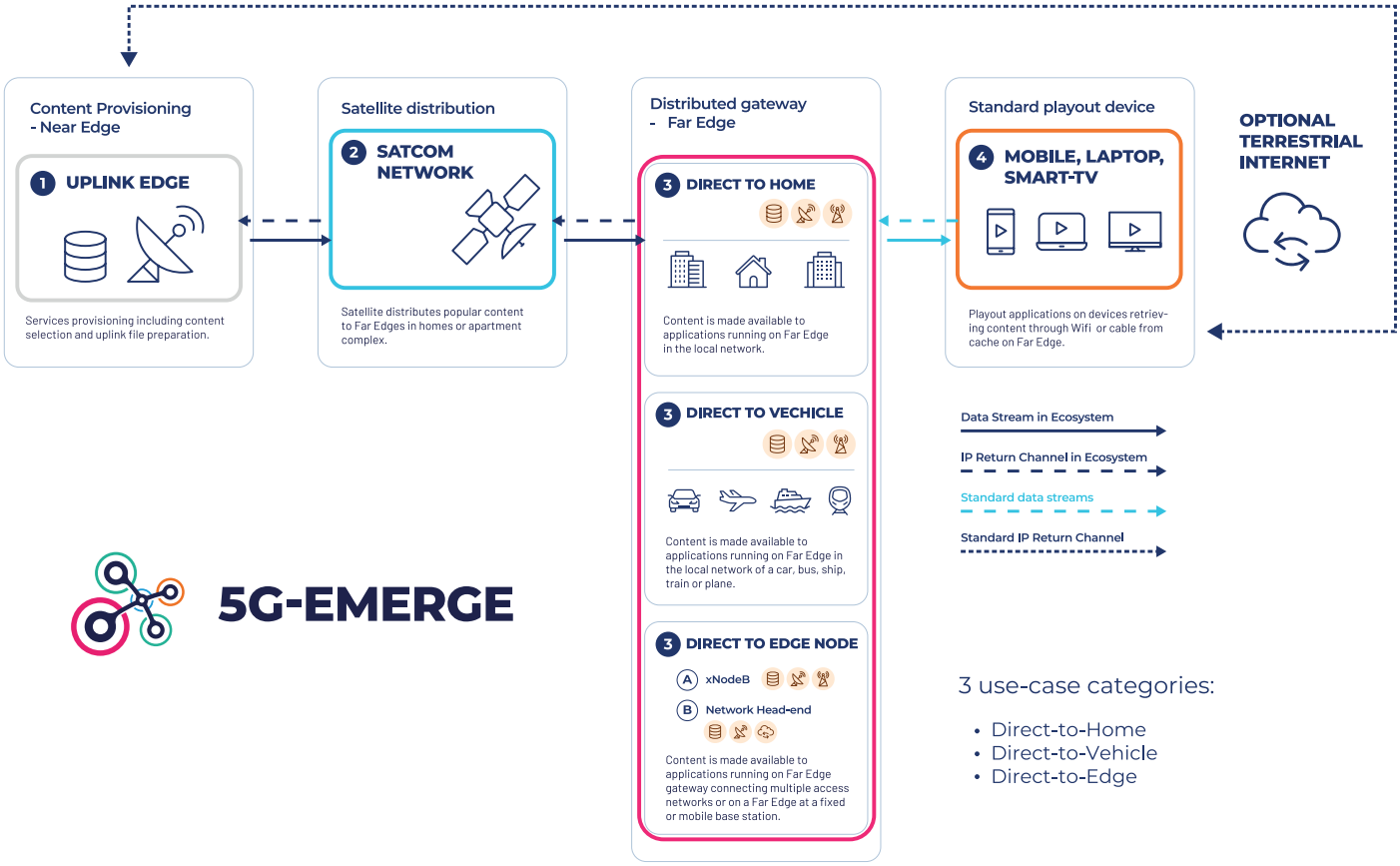
From a business perspective, the provision of new or improved functions is the imperative. Availability of media services at locations that are not covered by fast terrestrial internet, such as a ship or holiday location, are a clear case, with personalization or localization logical extensions. The cloud infrastructure, either as network- or software-as-a-service models can deliver functions to the edges of the internet and beyond.

On top of the edgecast approach, satellite networks introduce operational advantages. They provide a better quality of service than best-effort internet. The fact that a single IP feed spans a vast area, from spot beams covering 200 km to networks that cover a continent, is very efficient for content requested by a certain threshold of users. This translates to a lower energy footprint per user and lower distribution cost compared to normal unicast internet traffic. Moreover, this approach will also relieve expensive or congested network connections in the internet backbone or connecting base stations of mobile networks. Improving delivery-network resilience is another strategic goal.

5G-EMERGE use-cases

5G Emerge identifies three different categories of use-cases, Direct-to-Home, Direct-to-Vehicle and Direct-to-Edge (see Figure 1). For each use-case category, test beds and demonstrators have been developed. In total there are five test beds located in Norway, Sweden, Luxembourg, Italy and Switzerland. These test beds are used to validate the requirements from a functional and operational perspective.

Figure 1 - 5G-EMERGE use-cases



- Direct-to-Home: The content provider aims to deliver media content to the end user in fixed locations such as apartment buildings, apartment blocks, housing communities or individual homes – through a smart home gateway. The use-case explores the provision of media content to remote end-users in the disadvantaged areas that are currently inaccessible for media companies and it presents a case for the de-congestion of ISP's and telecom core networks while providing premium content. This use-case has been extended to consider the nomadic use-case where the content provider aims to deliver media content to end users that are alternating between their main residence and a secondary residence, i.e., a person living in the city in possession of a holiday cabin, without the end-user having two separate subscriptions & gateways.

- Direct-to-Vehicle: Currently connectivity on the move is limited because of incomplete coverage and/or congestion of terrestrial wireless networks. This use-case is focused on the delivery of high-quality media content to three different users: car owners and passengers by providing a local hotspot in the vehicle, supporting media services as well as other applications such as software updates and maintenance monitoring: collective transportation crews & passengers, with particular emphasis on buses, trams, trains and taxis as means of transport; and crew members and passengers of cruise ships, fishing & merchant vessels and oil & gas platforms.

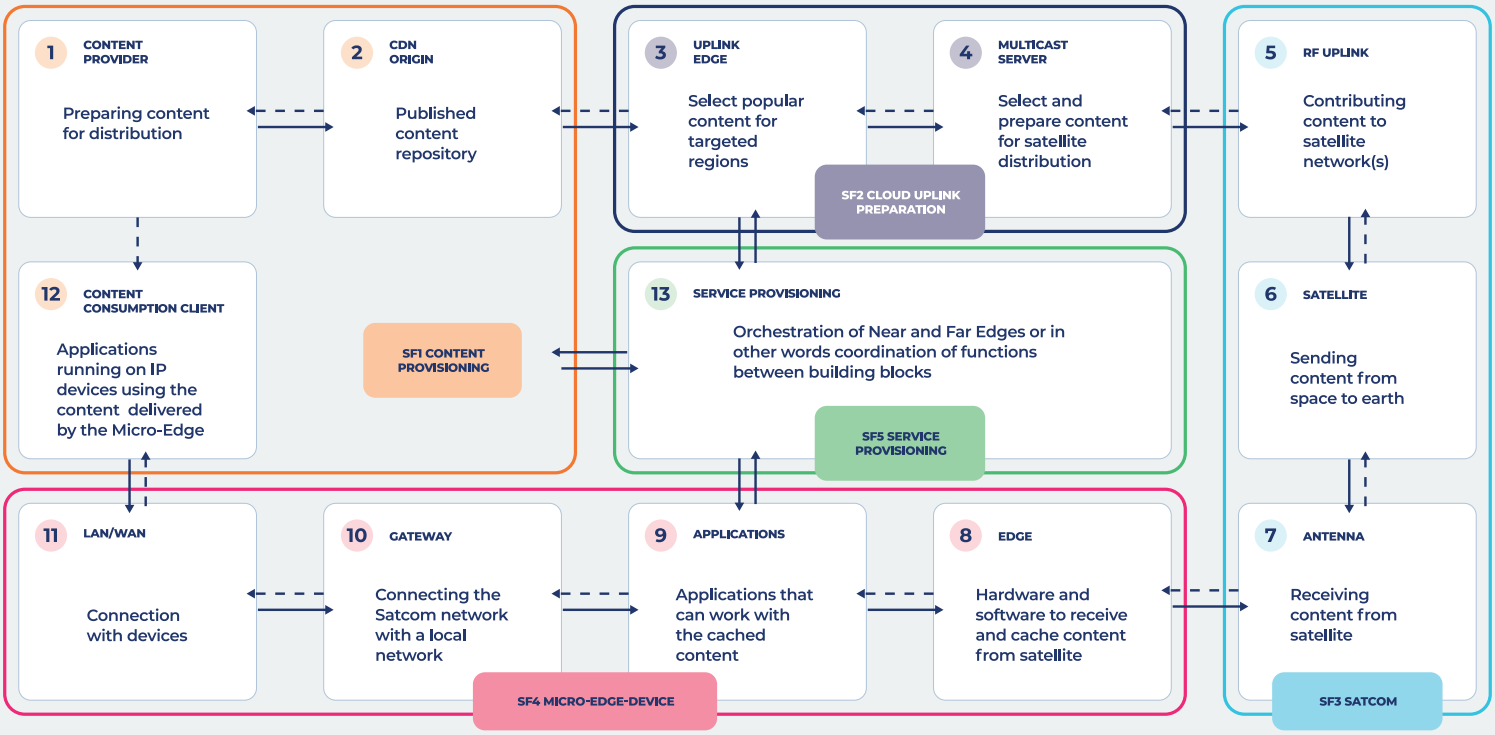
- Direct-to-Edge: This use-case considers the value of providing a smart gateway at network nodes for two differing applications. The first is a 5G base station essentially functioning as an autonomous 5G LAN. The second is a Metropolitan Network Node where a CDN point of presence (POP) would use a satellite connection instead of, or in addition to, a terrestrial connection; the satellite connectivity and the possibility to feed the caches directly from satellite broadcasts enables the POPs to be located in areas where terrestrial connections aren't available or not commercially viable.

Integration of satellite-enhanced edges in 5G-networks open multiple additional possibilities. For example, some LEO satellite constellations are starting to offer Direct-to-Device connectivity. 5G EMERGE will investigate how these new satellite systems could be integrated in 5G EMERGE alongside other networks, with a particularly focus on 5G NR NTN.

5G-EMERGE architecture & solutions

The following System Functionalities (SFs) have been identified in the 5G-EMERGE project (see Figure 2):

- SF1 – Content Provisioning: encodes the key content, pushes it to the origin server and at the other end of the chain, plays it on the device that runs the end-user playout application.
- SF2 – Cloud Uplink Preparation: selects the popular content relative to the used Satellite Communication (SATCOM) network coverage on the basis of data from SF1. It also prepares the content for the Teleport and can receive feedback data from the SATCOM Return Link (RL).
- SF3 – SATCOM: connects the Cloud Uplink Preparation with the Micro-Edge Devices via an Uplink location, satellite network and antenna.
- SF4 – Micro-Edge Device: provides edge functionality and connects to the end user IP Network through use-case specific access technology.
- SF5 – Service Provisioning: manages the ecosystem and exchanges control and performance data.



5G-EMERGE
main building blocks

In turn, each SF consists of several actors/components, which are briefly described below:

1. **Content Provider:** Online delivery starts at the Content Provider (CP) that publishes content via an Origin server.
2. **2CDN Origin:** The Content Delivery Network (CDN) provider picks up the content from the CP Origin.
3. **Uplink Edge:** This is a 5G-EMERGE-specific server that is envisaged to run on a cloud stack in a well-connected Gateway and that manages both the reception from the CDP Origin and the transmission of selected content towards a Teleporter. This Edge server's main function is to cache content that is popular in the region covered by the reference satellite(s). It also can perform content manipulation services to support distributed 5G-EMERGE Micro-Edge device terminals. Together with the Uplink Edge, this is part of the 5G-EMERGE Cloud Uplink, which communicates with the 5G-EMERGE Cloud Service Management layer to receive data about popularity of content and coordinated tasks with the Micro-Edge devices.

4. **Multicast Server:** This server will prepare the content for satellite distribution.
5. **RF Uplink:** It sends the multicast IP stream in a modulated carrier to the satellite. At the same location, data from the RL can be received and demodulated. Existing physical layer protocols shall be used over the satellite link, such as Digital Video Broadcasting – Second Generation Satellite Extensions (DVB-S2X) and Fixed-Interactive Multimedia Services (FSIM).
6. **Satellite:** It broadcasts the signal over a region and provides the RL.
7. **Antenna:** It is the first part of the 5G-EMERGE far edge terminal, which will be optimised for different use-cases including fixed and moving reception.
8. **Edge terminal on the 5G-EMERGE far edge:** It comprises the satellite or 5G networking layer performing the local breakout of user plane traffic towards the virtualized stack that runs the applications and integrates with the northbound Uplink Edge and the Service Provisioning layer.
9. **Applications on the 5G-EMERGE Micro-Edge device:** They transform the received multicast to unicast before other content manipulations can be performed, such as content ingestion for advertisement localisation purposes, transcoding/repackaging optimisation for device playout, etc. In 5G-EMERGE, we concentrate on media processing, but the Edge-based platform also allows other applications to be used, or through the caching function, it can distribute nonmedia popular content such as maps or software updates.
10. **Gateway:** It connects the satellite Micro-Edge device enhanced network with the LAN or MAN.
11. **LAN and WAN:** They are the network access interfaces for the playout devices of the 5G EMERGE Micro-Edge device.
12. **Content Consumption Client:** It comprises all the functions of a typical media client. These functions may be network device discovery protocols (to locate and communicate with the Far-Edge cache server), service discovery protocols (to inform end-users about the services made available to them), and, most importantly, the content decrypt and playback functions. Finally, the analytics subfunction oversees the provision of feedback to the backend about the playback of content, as already discussed.

5G-EMERGE advantages & innovations

Ubiquitous Media Access

As technology evolves, devices for media reception, ranging from smartphones to large TV screens, have become increasingly sophisticated and media-hungry. 5G-EMERGE addresses this by facilitating the transition to native IP transport, ensuring ubiquitous reachability and a common delivery format that can serve multiple markets with a single broadcast/multicast stream. It integrates seamlessly with both legacy distribution networks and modern 4G/5G networks, offering a versatile solution for media access globally.

Innovative Content Delivery

5G-EMERGE is designed to deliver content to any device - home reception devices (STBs), mobile phones, tablets, Wi-Fi enabled devices, and specially equipped vehicles. This multi-screen solution supports a full range of consumer needs, from large groups to individual users, thanks to its multi-tenant architecture. Content distribution and consumption is measured from source to destination and back to the source, allowing a sustainable and resilient offer optimizing the cost of ownership while responding to the demand of consumers.

Scalable and Future-Proof Platform

Designed by a consortium of innovative companies with a global presence in data and media distribution, 5G-EMERGE is both scalable and future-proof. Operators can rapidly launch operations by joining an existing platform, benefiting from shared resources and cost efficiencies. The platform is designed to support native IP transmission technologies and is compatible with both terrestrial and non-terrestrial networks.

Flexibility for Operators

Operators using 5G-EMERGE have the flexibility to deliver their services either through consumer-purchased devices or by providing specialized reception equipment. This flexibility extends to the ability to augment existing distribution services or to establish new operations in underserved territories. The platform's multi-tenant structure allows for easy extension with new technology providers, ensuring it remains at the forefront of media distribution technology. Ensuring content availability across diverse delivery platforms and devices enables media organisations to meet audience expectations for seamless access to their content anytime, anywhere. This flexibility enhances user engagement and satisfaction while accommodating changing consumption patterns.

A Multilayer approach

With the expected growth of OTT distribution, media organisations should allocate resources to enhance their OTT platforms and content delivery networks (CDNs) Balancing Distribution Costs. PSM organisations are carefully evaluating the trade-offs between distribution costs and audience reach for each distribution method. Combining Terrestrial and Satellite in a hybrid IP based approach offers the best balance between reach, reliability, and cost-effectiveness. By leveraging multiple distribution infrastructures media organisations can optimize audience reach, reliability, and cost-effectiveness. A combination of a subset of those IP native infrastructures offers unique advantages and coverage, allowing media organisations to tailor their distribution approach based on a reliable and sustainable service to different audience demographics, geographic factors, and content type.

Disaster Readiness and Recovery

Given the increasing frequency of extreme events, disaster readiness and recovery plans are essential. For example, Public Service Media (PSM) organisations, in coordination with governmental authorities, are preparing to invest in robust infrastructure and redundancy measures to ensure uninterrupted services during peak consumption, special events and emergencies. The resilience of the distribution strategy is critical, especially in the face of increasing frequency and severity of extreme events. By combining multiple infrastructures and implementing disaster readiness measures, such as redundant transmission paths and backup systems, PSM and other media organisations can minimize service disruptions and ensure continuity during emergencies.

Sustainability

The sustainability aspect of the strategy involves making informed decisions about which distribution infrastructures to prioritize on a per-country basis. This may involve assessing factors such as audience reach, cost-effectiveness, technological feasibility, and environmental impact. By optimizing resource allocation and investing in sustainable technologies, media organisations can minimize operational costs and environmental footprint while maximizing long-term viability.

The solution proposed in the frame of the 5G EMERGE project allows the use of a single IP native edgecasting overlay to serve several markets with a single transmission: from DTH edges to Nomadic edges, to network nodes, to collective housing, to vehicular and maritime reception. Additionally, investigating satellite direct-to-device services within the framework of future 5G and 6G networks demonstrates a forward-looking approach to technology integration, ensuring the long-term sustainability and relevance of the satellite-based content delivery ecosystem.

Multiple distribution networks

The overall non-terrestrial system architecture includes multiple space segment layers spanning from geostationary satellites (GEOs) to medium orbit (MEOs) and low orbit (LEOs) satellites, offering a comprehensive approach to satellite-based content delivery.

Each layer contributes to the holistic IP/5G common approach and ensures sustainability:

- **Geostationary Satellites (GEOs):** GEO satellites are optimal for broadcasting, multicasting and edgecasting applications providing wide coverage areas and they are ideal for reaching large audiences with broadcast content. GEO satellites are complemented by smart edges able to receive broadcast and multicast packets enhancing the efficient content delivery to mass audiences.

- **Medium Orbit Satellites (MEOs) and Low Orbit Satellites (LEOs):** MEOs and LEOs are mainly used for broadband unicast connectivity with lower latency, essential for some connectivity applications. Some broadcast and multicast services could also be delivered using LEOs and MEOs, particularly in cases where the area served by those satellites can reach many users at the same time.

IP/5G Common Layer Approach

The integration of different physical layers into a holistic IP/5G common layer approach ensures complementarity and/or seamless interoperability across the various satellite network elements. By standardizing protocols and interfaces, Media companies can streamline content delivery and optimize resource use. This approach enables efficient use of satellite bandwidth and enhances the scalability and flexibility of the network to support evolving user demands.

5G Edgecasting, new products and related protocols

Embracing 5G edgecasting for content delivery provides media organisations with greater flexibility and efficiency. At the same time, new content formats and interactive experiences leveraging 5G capabilities will be necessary to attract new audiences and create additional value. To attract new audiences, it is essential to conceive, develop and industrialize innovative technologies, not only at space segment level but mainly at the end user level. In the 5G EMERGE project, new fixed, nomadic and mobile self-pointing terminals based on innovative digital phased array technologies are being developed. Special attention is dedicated to minimizing the costs of those terminals, starting from consumer terminals to be deployed in millions of units. The ability of each terminal to provide native IP services including interactivity is another key requirement that is combined with the need to be able to manage tens of millions of interactive broadcast terminals at a sustainable operational cost, focusing attention towards highly efficient and flexible protocols.

Conclusion

5G-EMERGE is a comprehensive, adaptable, and future-oriented solution for global media distribution. A baseline offering is already possible with off-the-shelf solutions. Optimalisations will improve performance and quality of experience and integration with current and future workflows. The key value of the 5G EMERGE ecosystem is its ability to deliver diverse content seamlessly across various devices and networks in the constantly evolving landscape of media consumption and distribution.

The 5G-EMERGE concepts and end-to-end ecosystem has already been demonstrated and the aim is to provide market-ready solutions in 2026, to augment 5G network deployments in that timeframe.

About the 5G-EMERGE consortium

The 5G-EMERGE Consortium consists of 25 companies sharing a strategical goal to activate a satellite-enhanced edge delivery ecosystem using 5G as a convergence technology. The work commenced in 5G-EMERGE is led by the EBU and co-funded within the ESA ARTES Industry Driven Partnership programme. The consortium partners are, in alphabetical order: Arthur D. Little, Artic Space, Brightcove, BroadcastCritical, EBU, Eutelsat, G-Core, HPE, Inverto, LINKS Fondazione, MBI, MinWave, NAGRA, Nagravision, RAI, ROMARS, SES, SixSq, Space Villages BV, Telenor ASA, Telenor Maritime, Telenor Satellite, TNO, Varnish Software, Viasat.

Link to the consortium website
www.5G-EMERGE.com

Link to the ESA ARTES project webpage
www.connectivity.esa.int/projects/5gemerge