Integration of 5G and Satcom

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Introduction

- Satcom could be used to enhance terrestrial mobile communication systems
- Satcom even has certain benefits in remote areas
    - But usage costs are not among those
- Better integration and reuse of common technology could reduce the costs in addition to developments in satellite technology
    - Launch and satellite costs
- Beginning of 2018 3GPP took satellite as a part of 5G development
- This presentation offers a snapshot of this integration

Pent-pipe = amplify and forward (old style)

Regenerative or on-board processing = gNB functions could be in satellite

Inter-satellite links = routing to/from ground stations (in regenerative)

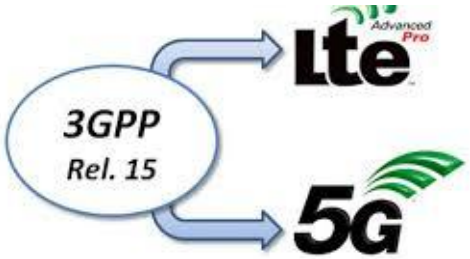
End-to end delay depends also on where ground stations are located

3GPP Status

- Two documents created

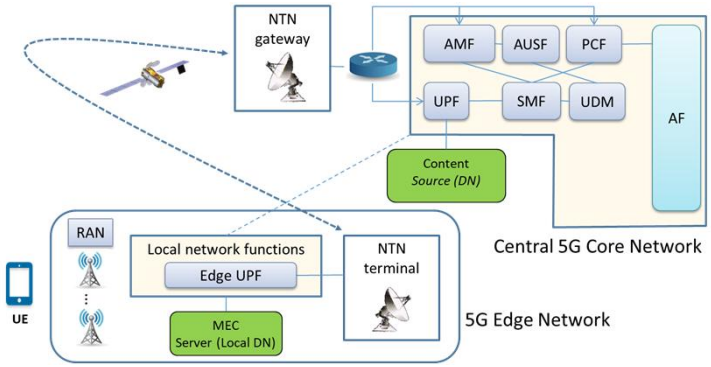
1. TS38.811 Study on New Radio (NR) to support non-terrestrial networks
2. TS38.821 Solutions for NR to support non-terrestrial networks

- These define
  - Architecture options
  - Channel models including propagation delay, Doppler and Doppler change rate for various cases: GEO, MEO, LEO, HAPS
  - Detected open problems
  - First solutions to some of these problems
- Work continues

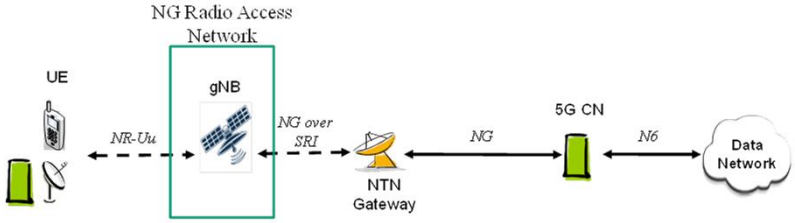


Use cases

- Backhaul
  - gNB and 5GC are separated by a satellite link (NTN)
  - Two options:
  1. legacy or non-3GPP satellite signal is used
     - Satellite delay effects to gNB and core functions or interactions, virtualization, etc
  2. 5G NR is used also in the satellite system
     - Satellite delay and channel effects to PHY and access layer in addition to pervious



- Direct (UE) access
  - Satellite system is providing gNB services
  - Obviously similar problems than in the backhaul case where 5G NR used



Mobile base stations!
- timing advance values
- handovers
  *beam, satellite

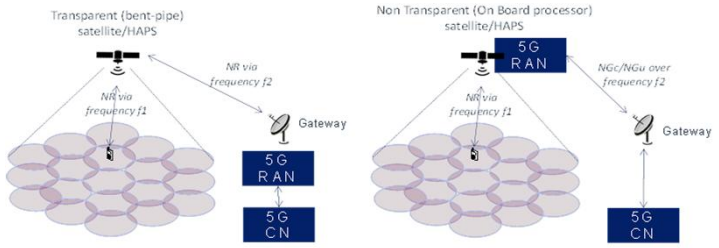
Satellite Channel

- Propagation delay
  - LEO up from 600 km
  - GEO over 35 000 km
  - Exceeds the usual cell size by a high margin
    - Delay problem in timers, RACH process, …
- Doppler frequency shift
    - Up to 720 kHz @ 30 GHz LEO
    - Change rate up to 8 kHz/s @ 30 GHz LEO
  - Worst case exceeds terrestrial values by high margins
  - Depends on a satellite system and an operating frequency

- SNR in existing DVB systems > -3 dB
  - 5G NR design goal is -6 dB (at least for PSS detection)
  - Nice match here
- Satellite “cell size” may be a bit larger than terrestrial
  - Beam capacity is shared between users in a beam

Table 4.6-1: Typical beam foot print size

Attributes	GEO	Non-GEO	Aerial
Beam foot print size in diameter	200 – 1000 km	100 – 500 km	5 - 200 km



Integration

- Should take many levels into account (or could be in many levels)

- 5G Doppler effects at PHY
  - Total failure if too large frequency uncertainty in the receiver
- Delay effects in access et al
  - Timing advance, random access process, …
  - HARQ process

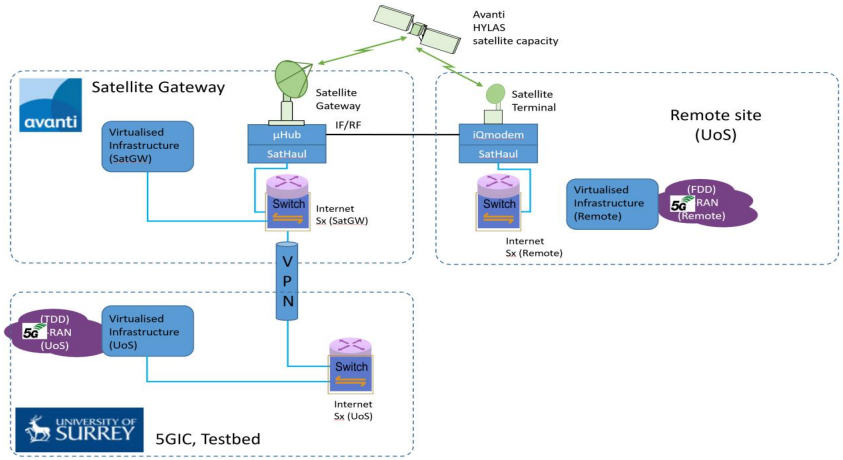
- Higher layers
  - In interactions between core and distributed functions
  - Network function virtualization
  - Slicing
  - Management and orchestration
  - Multiple access computing
- Technology level
    - Standard, chips, …

Considering the mentioned integration aspects in a wide scale.

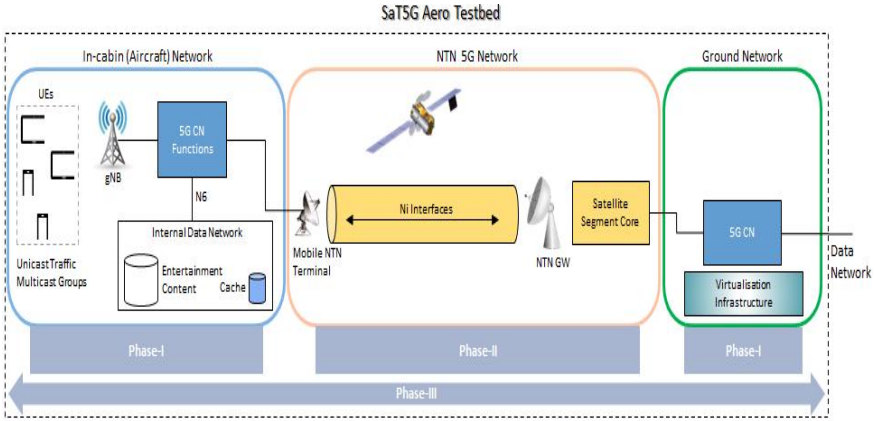
Active in standardization bodies.

Web page: http://sat5g-project.eu/
Lead: Avanti
EU H2020 project

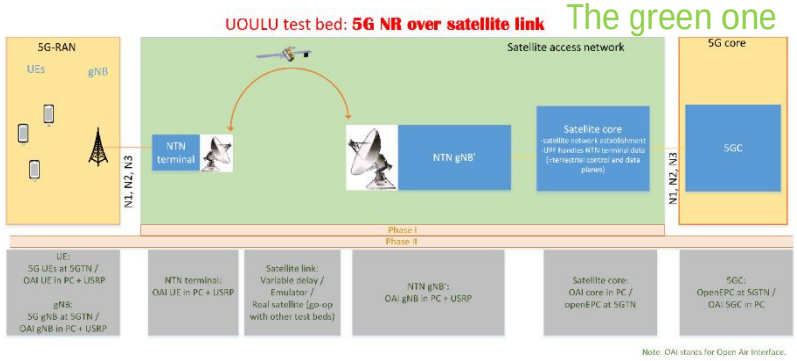
Test beds



University of Surrey: virtualization, multicast

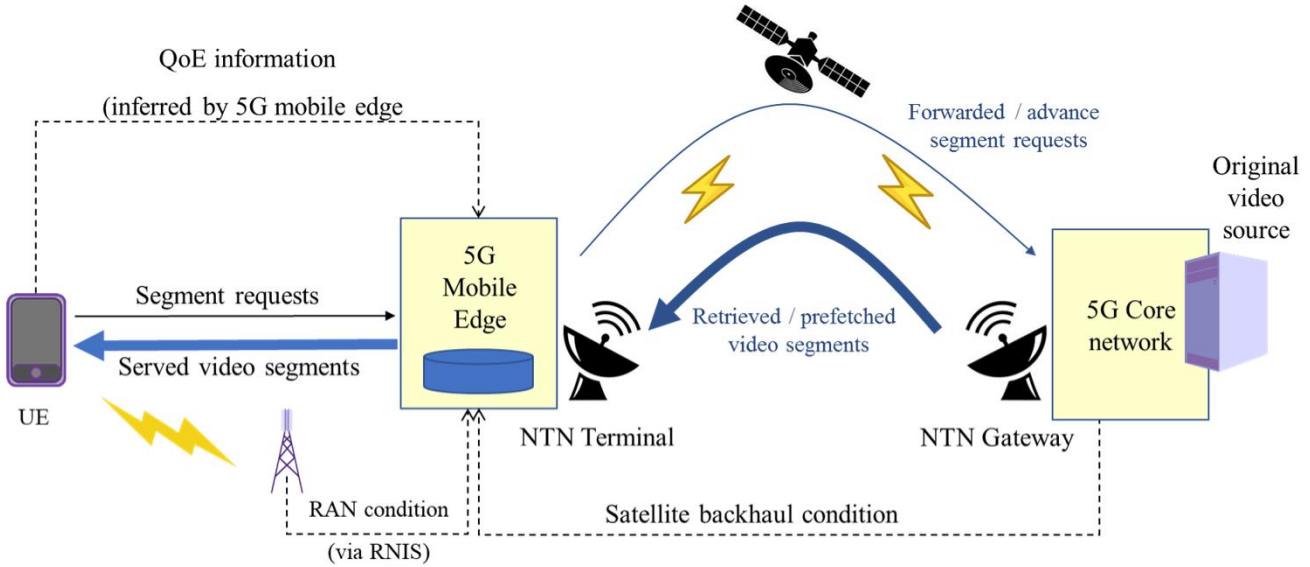


Zodiac (Munich): On-the-move (aircraft)



SaT5G Content Delivery Scenario 2: EuCNC2018 demo

Prefetching of VoD DASH video content through satellite links



- Challenge: Suboptimal end-to-end TCP throughput over long-latency content distribution path.
- Solution: Leverage edge computing which enables real-time prefetching of DASH video segments at the 5G mobile edge and ensure pre-fetched segments are available at the 5G mobile edge just in time before user requests on them coming in.

EuCNC2018 Demo Setup

One end at the spot, other at Surrey, satellite gateway in between.