RTT TECHNOLOGY TOPIC
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DOT.SPACE
ABOVE THE CLOUD COMPUTING

At a 3GPP Technical Standards Group (TSG) meeting in March this year, it was agreed that a 5G and non-terrestrial networks (NTN) study would be produced as part of the 3GPP Release 15 standards process (New Radio NTN, NR-NTN).

The participating companies in the group include Thales, Inmarsat, Ligado, Motorola, The Indian Institute of Technology and the Airbus Group (the manufacturing partner for OneWeb). The work programme is scheduled to start in August.

It could be argued that this initiative is late and modest in scale but at least it has started the process of raising awareness of the positive contribution that the satellite industry can and will make to 5G delivery economics.

The 5G community remains remarkably unaware of the transformational technology and commercial change that is taking place in the satellite industry and the ways in which this transformation will change the way in which vertical markets including vertical IOT markets will be serviced over the next 30 years.

Today there are approximately 1300 fully operational communication satellites in near space orbits including GSO (geostationary orbit) satellites at 35,000 kilometres, MEO (medium earth orbit) satellites at 10,000 kilometres and LEO (low earth orbit) satellites between 350 and 1200 kilometres.

The MEO satellites include GNSS (GPS, Glonass, Beidou and Galileo in L band) and the SES/O3B constellation (a combination of the 03B MEO constellation and SES GSO). The LEO satellites include Iridium (L band) and Globalstar (L band and S band) and Orbcomm (VHF).

The RF bandwidth available from these satellites scales from a 1 MHz duplex pass band (Orbcomm VHF) to a 10 MHz duplex pass band (Iridium L band) to pass bands of >3GHz from high throughput (HTS) Ku-band and Ka-band GSO transponders (Inmarsat Global Express and Intelsat EPIC and SES 2 for example).

All of these operators are currently upgrading their constellations to deliver more RF power and enhanced functionality. The Iridium Next Constellation for example uses the strong Doppler signature from each satellite (a function of the 27,000 kilometre orbital speed), high flux density (relative to GPS) and absolute time reference (an atomic clock reference distributed across the Iridium inter satellite switch matrix) to provide the GNSS independent Iridium Satellite Time and Location System. The clock reference allows terrestrial mobile devices to combine GPS/GNSS independent positioning with accurate dead reckoning.

In parallel, the ‘NEW SATS’, One Web, Space X (with Tesla founder Elon Musk as a founding investor), Sky Space Global, LEOSAT and Boeing have between them announced plans to launch over 10,000 LEOS with some combination of Ku-band, Ka-band and V band transponders (The Boeing proposal is at 50 GHz). Thousands of satellites and tens of GHz of uplink and downlink bandwidth will together change the dynamics and delivery economics of the satellite sector. Mr Musk, not a man to be underestimated, believes the Space X constellation could deliver 50 percent of all terrestrial backhaul communications traffic and up to 10 percent of local internet traffic in high-density cities.

This might be considered a pipedream but we are talking about 10,000 LEOS with 250 watt Ka-band transponders with a 3.5 GHz+3.5 GHz pass band with line of sight visibility into two to three kilometre radius cells covering every square metre of the earth's surface. The LEOS last for twenty years, have a free and renewable electricity supply and do not have to bother with landlords.

They are competing with or hopefully complementing terrestrial 4G and 5G terrestrial networks which in broad terms in ten years' time could be supporting 10 million base stations with 20 watt transceivers with limited line of sight visibility and at most 250 MHz of aggregated pass band. Most of the power in these 4G and 5G terrestrial networks, particularly networks implemented in the centimetre and millimetre band, will be absorbed by surface scatter.

But the story is not just about connectivity. As delivery bandwidth expands, storage bandwidth and server bandwidth expands. In this month's technology topic we explore the technical and commercial logic of putting servers in space, the dot.com to dot.space transition to above the cloud connectivity and the related implications for 5G and 5G vertical markets.

Read on

Imagine you are a flat panel phased array antenna sitting in a deckchair staring into space. Depending on your latitude you will have RF visibility to at least 50 satellites and this is before those 10,000 LEOS arrive in orbit. The smart phone by your side will have RF visibility to at most six cellular sites.

It takes twenty minutes for a LEO to travel into space, significantly faster than a truck drop to a cellular site. Having unfurled its antennas, the LEO is ready to go and depending on how it is configured can stay in space for up to 20 years. Outside the earth's atmosphere, solar energy density is 1,350 W/m2. At the earth's surface it is 1,000 W/m2. It is sunnier in space. It doesn't rain in space. Multi junction solar panel cells are now achieving 40% efficiency. So that's twenty years of free RF power and no rent to pay. Network densification is also easier (less expensive) in space. (There is more space in space). It is also cold in space (-270.45 Celsius) so there is none of that air conditioning nonsense to worry about.

If I want to do some high frequency trading from my deck chair I can get to the other side of the world significantly faster over an inter satellite switched LEO constellation. Light travels faster in free space than it does in a fibre optic cable. Once a fibre optic cable reaches a certain length (about 5500 kilometres), the free space speed advantage outweighs the round trip distance (1400 kilometres).

So let us say my deckchair is on the beach at Bournemouth, a popular UK south coast resort, I can get to Singapore in 120 milliseconds. That is at least 60 milliseconds faster than fibre. LEOSAT are basing their LEO business model on this time differential. And if I really wanted to speed things up then the transaction server would not be in Singapore but in the constellation (with interesting tax implications).

By contrast if I used my smart phone, my journey to Singapore will be via the local 4G or 5G network, across a microwave link or fibre, cable or copper backhaul then to Singapore which could be along a number of possible routes then into a Singapore network and finally into the Singapore server.

This highlights two points. I have no visibility to the end to end delay across multiple 4G and 5G mobile broadband and backhaul networks. Additionally I have no control over the latency variability (also known as jitter). Apart from introducing uncertainty into the timing of the trade it also makes authentication harder to manage. Challenge and response algorithms depend on deterministic round trip latency and minimal jitter. In comparison, my end to end journey over the LEO constellation gives me absolute control of the end to end channel.

But I also forgot to mention that my deck chair has wheels and an electric motor. It is the Mother of All Deckchairs. And my LEO based server tells me it is sunnier and less crowded at the other end of the beach.

I now have two choices. I can self-navigate myself along the beach using the dead reckoning (enabled by the real time high accuracy clock pulse coming down from my nearest LEO satellite) or I can let the LEO drive me. It is probably easier to let the LEO take charge as it knows where all the other deck chairs are and knows that my battery is about to go flat so can take me to the beach hut recharging point where I can take on some power and the latest software upgrade and buy some suntan lotion, a sun hat and an ice cream.

This is a trivial example but probably explains why Mr Musk is keen to launch his own LEO satellite network. It will be extremely hard to deliver a totally safe semi-autonomous or fully autonomous driving or terrestrial travel experience over multiple terrestrial cellular networks. It will be relatively easy to deliver a totally safe semi-autonomous or fully autonomous driving or travel experience over a LEO network. Mr Musk may also have plans to conquer the mobile deckchair market, another $50 billion dollar opportunity?

But this highlights a more general point. Server bandwidth on its own does not confer added value. The value comes from the control that accrues from the data held on the server and the algorithms used to mine and manage that data. This is of course a blindingly obvious statement but explains why the cloud comes (apparently) for free.

There are many stationary and moving objects that are already monitored and managed from space. Inmarsat supply connectivity and management and monitoring systems to 11,000 aircraft. If my deck chair was on a Royal Caribbean cruise ship it would be connected to the internet via the 03B MEO constellation. The constellation is also helping to ensure the cruise ship doesn't crash into other cruise ships all heading towards Bournemouth (O3B provides complementary support to the Maritime Automatic Identification System). Caterpillar, John Deere, Komatsu and those other manufacturers of massive machines that dig very large holes and crop the wheat fields of America are shipped with Orbcomm VHF modems for asset tracking and (low bandwidth) telemetry and telecommand.

So all we are describing is an expansion of services that are already well established. Inmarsat started providing mobile satellite service in 1982 and a terrestrial service in 1989. Iridium Globalstar and Orbcomm have been providing mobile connectivity for twenty years but these legacy services are based on two way voice and data transmission rather than cloud connectivity.

The combination of more satellites and more bandwidth and more on board processing power and storage bandwidth significantly changes the market positioning of the satellite industry and brings it closer to emerging 5G business models.

OneWeb have stated publicly that they are confident they can substantially reduce 5G backhaul costs both in dense urban and deep rural areas and provide more cost effective mobile and fixed broadband geographic coverage for rural connectivity. This includes IOT connectivity and developing market connectivity where base station electricity is particularly expensive. In developed markets, the proposition could be particularly persuasive for operators presently over dependent on fibre owned and managed by their competitors.

The proposed merger or co-operation with Intelsat (twenty GSO satellites including their new 'Epic' constellation) to create a combined LEO/GSO constellation would be a particularly powerful proposition. SES/O3B has a similar combined constellation proposal coupling the O3B (**O**ther **T**hree **B**illion) MEO satellites to the SES GSO constellation, a combination which also has many potential performance and cost benefits.

Connection to a LEO, particularly a LEO constellation with hundreds of satellites will be line of sight more often than a point to point and point to multipoint terrestrial link. This will be particularly advantageous for Ku-band and Ka–band and is part of the advocacy narrative from the satellite industry that the economics of 5G terrestrial broadband are likely to be more favourable in sub 6 GHz spectrum including existing sub 1 GHz spectrum (see last month's technology topic on Sub G 5G) and less favourable in the centimetre and millimetre band.

Add in the benefits of end to end latency control and faster than fibre connectivity over transoceanic links and on board server bandwidth and you have a compelling 5G satellite centimetre and millimetre band market proposition.

It has always been possible to do some things more efficiently from space. We are now moving to a model where most things can be done faster and more efficiently from space at lower cost using less energy, all of which is renewable and free.

The race for dot.space has started and may happen faster than people realize or expect.

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