RTT TECHNOLOGY TOPIC
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Space Storage

In our May 2017 technology, *Dot Space, Above the Cloud Computing* we set out the arguments for putting memory and storage bandwidth into space on the basis of economics, performance and power.

The economic argument was based on the rapid reduction of launch costs coupled to mass production techniques now being applied to satellite manufacturing.

The performance benefit argument was based on the 'faster than fibre connectivity' that can be achieved from inter-satellite switching, exploiting the free space advantage over fibre to achieve shorter end to end and round trip latency over distances of more than 10,000 kilometres. We also referenced the benefits of end to end routing visibility in satellite networks delivering stable latency compared to the variable latency introduced by multiple hop fibre or copper or cable connectivity.

The power benefit argument was based on the fact that it is sunnier in space, solar energy density in space is 1350 W/m2 compared to 1000 W/m2 on the earth's surface. It also doesn't rain in space. It is also cold in space.

Terrestrial data centres take up large amounts of space, a typical data centre covers several million square feet and consume large amounts of energy, over 400 terawatt hours in 2016, more than the whole of the UK's energy requirement. Data centres create large amounts of heat. Moisture also has to be managed which increases the air conditioning load.

Some of the heat can be reused for local heating in cold countries, for example a new town is being built near Bergen in Norway which according to its promotors will produce an energy positive city

However, even with these initiatives, the electricity demands of data centres globally could soon be producing a carbon footprint that is bigger than the entire aviation industry with an energy load that is doubling every four years.

Contemporary research suggests that the ICT industry could be producing 14% of total global emissions footprint by 2040 which would be equivalent to 50% of the current relative contribution of the entire global transport industry.
http://www.electronicsilentspring.com/wp-content/uploads/2015/02/ICT-Global-Emissions-Footprint-Online-version.pdf

ICT energy consumption is a combination of data centres, desktops, lap tops, displays and smart phones.

Assuming cloud services are also increasingly distributed to meet local latency requirements and assuming that at least part of this cloud storage ends up at the edge of 4G and 5 G networks then a percentage of the total power consumption of mobile broadband networks needs to be added to this figure.

Smart phones are significant because they represent significant localised storage and processing but their power is from batteries so there is an additional efficiency loss to factor in to their energy and carbon footprint. The same argument applies to any battery powered IOT device.

The offsetting factor normally cited is that ICT saves energy by reducing the need to travel. In parallel, smart grids, smart homes, smart buildings, smart factories and smart cities improve delivery efficiency and consumption efficiency.

However air travel and transport miles continue to increase and consumer items such as televisions get ever bigger and more powerful countering realisable efficiency gains. Consumer products such as televisions and smart phones also have short life spans so the energy needed to produce replacement products and dispose of obsolete products continues to increase as does the environmental impact of mining the rare earth metals required. On this basis, electric cars do not look great either.

Data centres run continuously and their useful life is of the order of ten years so the contribution of production energy tends to be negligible compared to their annual energy consumption.

Smart phones by comparison have a much higher percentage of production energy in their carbon footprint. The modelling suggests the carbon footprint emissions that can be coupled to smart phones have increased by 730% in the last ten years.

The Answer?

It would be counter intuitive to imagine that this problem can be solved by ‘sending it upwards’ but bizarrely this might be the answer.

The rate of cost decline associated with the deployment of storage, processing and communications bandwidth into space is reducing at a rapid rate though the rate of that reduction has as yet not been convincingly modelled, at least in the public domain.

But consider; the lift weight launch capability of the latest rockets from Mr Musk and Mr Bezos has increased within the last five years by an order of magnitude. This means that a 5000 kilogram 15 kilowatt satellite can now potentially be replaced with a 50,000 kilogram 150 kilowatt satellite sent up on a single rocket. The same payload could accommodate 6000 Cube SATS. As rockets get larger they become more efficient, as satellites get bigger and or as satellite count increases in a constellation, efficiency increases.

Self-evidently a rocket launch is never going to be carbon footprint friendly but once satellites are in orbit they become carbon neutral.

The counter argument is that terrestrial base stations can also be solar powered but they need large expensive back up power sources and have unavoidable real estate capex and opex costs which increase on a year by year basis. Network densification will increase these costs, compounded by an increase in backhaul cost and backhaul power consumption.

So as we have stated before, **terrestrial wireless broadband delivery costs** for urban, semi urban, rural and deep rural connectivity **are increasing on a per bit basis** whereas **satellite delivery costs are reducing.** Satellite is already the lower cost option for deep rural connectivity (and the only option for maritime connectivity) but could become the lower cost option for rural and some percentage of outer urban and urban fixed and mobile access.

The question then arises as to whether the same cross over point applies to storage cost, calculated on a **per byte basis**.

There is a difference in that delivery cost is partly a function of RF hardware costs which do not scale with Moore’s Law.

Storage cost does scale with Moore’s Law so any savings in launch cost are multiplied by the relative increase in storage density per kilogram of space payload.

Perhaps more important is to question where the biggest margins are achievable.

The margins being realised by Alphabet, Amazon, Ten Cent, Ali Baba and Baidu from their third party hosting services are a clear indication of how value has shifted over the past twenty years from access to storage with delivery as a means to an end (literally so in Amazon's case).

The growth of cloud based services, particularly latency sensitive cloud based services, shifts some of the value away from centralised storage in data centres to distributed storage.

Terrestrial mobile broadband operators are assuming that base stations will be an efficient localised cache point but this is only valid for repetitive access models. In theory, distributed storage reduces the need to move data in and out of the network core. In practice only some of the required information will be in the right place at the right time. If this model is scaled globally then satellites become an increasingly efficient data distribution system.

Satellites have another advantage in that they can be repositioned to follow changing patterns of demand. Changing orbit position used to be limited by the amount of hydrazine loaded on the satellite. The increasing use of electric satellites powered by ion thrusters removes this constraint though the notion of multiple constellations capable of constantly changing their orbital topology implies more closely controlled inter constellation coordination both at a practical and regulatory level.

As with the satellite delivery model, the real efficiency gains of space based storage will be realised when there is closer integration between LEO, MEO and GSO satellite systems at which point the cost of space based storage rockets downwards and realised added value rockets upwards. That crossover point might happen sooner than we might expect.

Latest Book - 5G and Satellite Spectrum, Standards and Scale

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