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Carrier Aggregation Aggravation

It was clear from last week's MWC show in Barcelona that peak per user data rates still capture mobile broadband marketing headlines.

One way of achieving this in an LTE or HSPA network is to couple (aggregate) two carriers together either side by side within a band (intra band contiguous carrier aggregation) or from anywhere in the band (intra band non-contiguous) or to couple channels together from separate bands (inter band carrier aggregation).

A similar approach is being adopted in Wi Fi. However Wi Fi only needs to support two bands and is deployed at low power and generally just bonds channels together to increase channel bandwidth rather than setting up multiple carriers. In LTE and HSPA a combination of multiple technologies, more band combinations, higher power and larger dynamic range mean that aggregation is a far more challenging design task.

The engineering consequence is that user device design teams, already needing to accommodate MIMO front ends that introduce additional unwanted insertion loss to receiver paths now need to support a bewilderingly large number of potentially problematic carrier aggregation options.

In this month's technology topic we explore the technical and commercial challenges that this creates.

Release 11 Carrier Aggregation Options – US requirements

Release 11 inter band options for the US market include an AT and T requirement to support Band 17 (704-716, 734-746 MHz) coupled with Band 4 (1710-1755, 2110-2155 MHz), a second requirement to couple Band 17 to the US PCS band (1850-1910, 1930-1990 MHz), a third requirement to couple Band 5, the US 850 band (824-849, 869-894 MHz) to Band 4 and a fourth requirement to couple Band 17 and Band 5 (LTE 700/LTE 850).

Verizon are asking for a Band 13 (reverse duplex 746-756, 777-787 MHz) and Band 4 option.

US Cellular and Sprint have a completely separate set of requirements.

And that's just one country.

Why US band plans get RF design priority

Our October 2010 technology topic http://www.rttonline.com/tt/TT2012_010.pdf pointed out that US vendors give development priority to RF front ends optimised for the US market.

This might seem surprising given that the US market is declining year on year in terms of relative volume to other markets. Our colleagues at The Mobile World <http://www.themobileworld.com/> point out that the US market in 2006 was equivalent to 9% of the global subscriber base. By Q4 2012 this had reduced to 5%. Allocating design effort to a market of this size with limited band plan commonality with other parts of the world seems close to foolhardy.

However the US market is effectively a duopoly. AT and T and Verizon have a combined market share of more than 60% and are blessed with competitors who have either invested in unusable spectrum or sub scale technologies or both.

As a result the US market share of global market value is about 15 %, remarkably similar to 2006 despite the relative loss of volume.

As any economist will tell you this means that US ARPU is higher than many other markets and US operators have relatively deep pockets which at least partially explains why they have been able to deploy LTE rather faster than operators in other parts of the world and why they have an apparently disproportionate influence over how RF design effort is deployed.

This is inconvenient for operators servicing markets outside the US. The example given in the October Technology Topic was the unavailability of an iPhone with Band 20 support for Europe.

Why bother with carrier aggregation

So you might wonder why operators want to bother with yet another physical layer change. The answer is that at system level it is potentially possible to realise multiplexing and scheduling gain which can be translated into additional throughput and capacity. Marketing teams can also claim a higher per user peak data rate.

At network level, one option is for a user device to be camped on a macro cell at 700, 800 or 900 MHz with a simultaneous connection to a micro cell or pico cell. As no hand off is needed between the macro cell and other cells the signalling load is lower. Potentially a voice channel could be supported on the macro cell or data could be multiplexed across both carriers. A throughput gain and reduced latency should be achievable. Together these should translate into improved service quality.

The impact on the supply chain

However the potential system gain opportunities are offset by the impact carrier aggregation will have on user device RF front end complexity (design risk), cost and performance. Additionally it is questionable whether the supply chain will be willing or able to respond to these multiple requirements.

For example suppliers wishing to meet the carrier aggregation requirements of operators other than those in the US are being asked to deliver a completely different set of carrier aggregation options including coupling LTE 1800 (Band 3) with Band 7 (LTE at 2.6 GHz), Band 20 (LTE 800 for Europe), with Band 8 (LTE900), Band 4 and Band 7 for Canada and Band 38 intra band for China – and that's a highly edited list.

And operators with HSPA are asking for dual carrier HSPA (Release 8), dual band dual carrier HSPA (Release 9), four carrier HSPA (Release 10) and eight carrier HSPA (Release 11).

Each of these options determines where the multiple carriers are combined, for example at digital baseband, in analogue waveforms before the RF mixer, after the RF mixer but before the power amplifier or after the PA. This implies a requirement for multiple front end architectures.

Each option needs to be noise matched on the receive path and power matched on the transmit path

And designed to minimize inter modulation which effectively means more linearity.

It is hard to see how this can be achieved without introducing additional insertion loss and noise. The linearity on the transmit path can potentially be achieved by a combination of clipping, adaptive pre distortion and envelope tracking but these are not noiseless processes.

Release 12 LTE introduces 256 QAM on the downlink and the option of OFDM on the uplink. This implies a need for a lower noise floor and more linearity on the TX and RX path.

The Supply Chain Smith Chart

So once again we find ourselves describing a mismatch between regulatory policy, spectrum allocation policy, standards evolution, marketing ambition (high per user peak data rates) and practical RF plumbing, a mismatch which threatens to leave operators in markets other than the US with spectrum

and network investments that cannot be recovered due to RF supply chain constraints.

These constraints are a form of commercial impedance. What would be really useful is a nice circular chart on which we could plot technology choice, band plan choice and supply chain resistance – a Supply Chain Smith chart.

Ends

Supply chain constraints in the telecoms industry are discussed in RTT's fourth book '[Making Telecoms Work- from technical innovation to commercial success](#)' available from the [RTT book shop](#).

Also in the Book shop is the new and very excellent (second) edition of [LTE and the Evolution to 4G Wireless](#) published by John Wiley and Agilent Technologies and edited by Moray Rumney.

This takes you through the practicalities of Release10 (which is what baseband vendors were showing at the MWC show last week) and Release 11 through 15 and includes useful insights on the test and measurement implications of each Release for conformance testing and manufacturing test – ideal reading for that Easter break that you are promising yourself.

Order via this link

<http://www.rttonline.com/bookshop.html>

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