RTT TECHNOLOGY TOPIC
September 2013

Single frequency networks

The RTT August technology topic reviewed the DVB-T to T2 transition and highlighted how the 8K carrier makes it easier to implement single frequency (SFN) broadcast transmission networks.

Single frequency networks are not new and have always existed both in broadcast and two way radio networks, initially served from single base station sites but then increasingly from multiple transmitters. As an example on the RTT web site there is a case study of the first UK FM VHF synchronous multi-site wide area network deployed by Lancashire Police in 1948.

http://www.rttonline.com/documents/History_Archive_01v3.pdf

The radio system operated adequately well until 1953 when it became increasingly hard to ignore problems occurring in areas of equal signal strength where phase cancellation could result in loss of communication. The solution was to introduce a 10 or 20 Hz frequency off set between transmitters.

The network was subsequently upgraded to work at UHF (450 MHz) with significant care being needed to ensure differential path delays between base stations were compensated by introducing variable audio delay on the BT line links.

The transition from analogue to digital radio has changed some of the design and implementation considerations but as with analogue SFN's, digital SFN's if deployed with care can be cost effective and deliver significant gains in spectral utilisation. This applies equally to mobile broadband networks which are now being increasingly deployed with a reuse ratio of one which is another way of describing a single frequency network.

This month's technology topic analyses the design and implementation challenges common to both DVB-T2 broadcast and LTE mobile broadband networks, highlights DVB-T2/LTE coordination opportunities and suggests how these could resolve present coexistence concerns in the UHF band.

Single frequency versus multi frequency broadcast networks

Multi frequency analogue networks were introduced into analogue broadcasting in order to meet geographic and population coverage obligations. Multiple frequencies were needed to avoid the same phase cancellation issues encountered by wide area two way radio networks.

Atmospheric conditions such as temperature inversions can result in UHF signals travelling hundreds of miles. For this reason re use ratios in multi frequency analogue networks need to be conservative. The result is relatively low geographic spectral utilisation.

When digital TV started to be introduced in 1997 there was an opportunity to transition the networks from multi frequency to single frequency.

The use of OFDM doesn't actually solve the differential delay issue between multiple sites on the same frequency but translates the problem from the frequency domain (phase cancellation) to the time domain (inter symbol interference).

The potentially long path delays however required the OFDM physical layer to be an 8K or higher FFT. Increasing the number of sub carriers increases the symbol length which means the time domain guard band can be longer to accommodate long path delays.

However as it was initially hard (expensive) to design 8K demodulators for low cost consumer equipment it was decided to implement DVB-T as a 2K carrier low power MFN. There was less deployment risk and less disruption to users during the analogue to digital switch over process.

15 years on the cost difference between a 2 K demodulator and a more complex FFT (8K and over) is trivial. The current high power DVB-T network is now 8K. DVBT2 supports a 32K FFT making nationwide SFN's (including sparse high power tower SFN's) a practical proposition. The higher FFT's also improve resilience to impulsive interference.

So why don't the broadcasters move from MFN to SFN networks?

Well firstly there are costs in terms of transmitter hardware and software upgrades and no guarantee that the existing transmitter density including repeaters and relay transmitters will deliver the same quality of service. SFN transponders require more accurate frequency standards (GPS and back-ups) and must be line fed with the transport stream data rather than simply rebroadcasting from a parent station.

Secondly user equipment including roof mounted antennas and distribution amplifiers, splitters and combiners might need upgrading.

Nationwide SFN's in Europe would require a substantial renegotiation of existing coexistence agreements and the different combinations of regional and national networks would complicate the re planning process.

It is hard to see why the broadcasters would want to do this.

Coordinated networks as an alternative.

Except that broadcasters do have commercial and technical problems that they would like to solve.
The commercial problem is that young people are increasingly viewing television on mobile broadband devices. For public service broadcasters there is no license fee revenue attached to these devices. For commercial broadcasters there is no guaranteed advertising income from these devices.

Part of the technical answer would be for broadcasters to transmit the T2 multiplex to these devices. However as we pointed out in last month's technology topic the flux density is generally not high enough to support mobile or portable devices used indoor without an external aerial. The answer to this (again as stated last month) is to rebroadcast the T2 multiplex via cellular base stations.

This has the additional benefit of mitigating the hole punching that could potentially happen in fringe TV reception areas in the presence of stronger LTE signals. The T2 multiplex could then be received indoors without an external aerial so upgrading of roof top aerials and distribution amplifiers and filters would be avoided.

Technically it would not be that difficult to add the T2 multiplex to an LTE e Node B. This is similar in concept to adding WiFi. If DVB T2 transmissions and LTE 700 MHz transmissions were collocated, coexistence would be easier to manage. The inter cell interference coordination techniques being implemented in LTE would for example be more effective in an environment in which TVB T2 transmissions and LTE transmissions were coordinated in the time domain. The spectrum released from transitioning to DVB T2 would make it easier to implement wider guard bands between broadcast and LTE networks and would open up opportunities to support other services including dedicated spectrum for public protection and disaster relief and PMSE (wireless microphones).

There are also potential benefits to be gained by overlaying LTE transmissions on to existing broadcast repeater and relay station sites. The repeater protocols being implemented in present LTE Releases make this a more interesting and appropriate option, potentially reducing the cost of providing rural broadband fixed and mobile deep rural coverage. The T2 multiplex comes without IP overheads and the physical layer works in remarkably low carrier to noise conditions. It is good at what it is good at - the spectrally efficient, power efficient, bandwidth efficient delivery of broadcast and multicast content.

The counter argument is that TV can either be delivered via satellite or via the internet accessed by an ADSL or mobile broadband. But satellites get blocked by tree lines or adjacent buildings particularly in more northerly latitudes. Mobile broadband is neither intrinsically spectrally efficient nor power efficient nor cost efficient as a receive path for multicast or broadcast content.

Mobile broadband devices are now being designed to be wirelessly paired to HD displays, for example a smart screen TV. This creates a demand for HD downloads which will be costly to support on an LTE channel with an unknown commercial value and unknown delivery cost. The T2 multiplex would be a more efficient option for delivering at least a percentage of this traffic.

Coordinated networks, coordinated devices, coordinated services and the one remaining problem.

So the argument advanced in this and last month's technology topic is that there are technical benefits and commercial benefits realisable from integrating and coordinating DVB T2 broadcast and LTE mobile broadband networks.

Commentators on last month's technology topic pointed out that even if the technical and commercial benefits were realisable there would be unresolvable arguments about how or whether public service broadcast license fees would be payable by users of mobile devices. I would be happy to have my TV licence fee bundled into my mobile tariff but I may not be typical. Even if this was resolved the content rights management costs might be prohibitive.

But these issues are not impossible to resolve and can intrinsically be included in the incentive auction processes presently being discussed by the FCC. The difficulty here is that the US and Canada have implemented the ATSC standard for digital TV. This is a perfectly good technology but sufficiently different from DVB-T both in terms of the physical layer and band plan to make integrated ATSC/DVB-T consumer devices frustratingly hard to bring to market.

In general it can be stated that coordinated networks would reduce coexistence management costs, reduce delivery costs and improve the user experience. The outcome would be improved spectral utilisation in the UHF band and an improved return on investment for both the broadcasting and mobile broadband community.

LTE can now claim to have a more or less global footprint with a market dominance that should increase over time. The lack of inter-regional band harmonisation remains as a costly frustration but scale benefits are still achievable.

The terrestrial broadcast industry has scale but the scale is not global. Mobile broadband user device vendors prioritise design and development to meet US market needs and the prospect of including ATSC in these products is at present remote. This makes the inclusion of DVB-T2 in LTE smart phones an unlikely prospect.

There are however compelling arguments for a more fundamental review of how the UHF band, one of the most valuable parts of the radio spectrum, should be administered over the longer term. Letting the market decide is presently a favoured regulatory approach but fails to reflect longer term considerations of public and consumer value.

Resources
Lancashire Constabulary Developments in Communications by John Davies
http://www.rttonline.com/documents/History_Archive_01v3.pdf

Three Kings and a Queen – History of Broadcasting
http://www.rttonline.com/documents/History_Archive_02.pdf

If you are interested in the application of past industry experience to help present decision making then have a look at the new Wireless Heritage Group set up within Cambridge Wireless.

http://cambridgewireless.co.uk/sigs/heritage/

Post-holiday reading
The inter relationship of TV broadcast and mobile broadband technology is discussed in RTT's fourth book '**Making Telecoms Work- from technical innovation to commercial success'** available from the **RTT book shop**.

Go and browse and or order via this link
http://www.rttonline.com/bookshop.html

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http://www.rttonline.com/tt/TT1998_008.pdf

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RTT, the Jane Zweig Group and **The Mobile World** are presently working on a number of research and forecasting projects in the mobile broadband, two way radio, satellite and broadcasting industry. If you would like more information on this work then please contact

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