RTT TECHNOLOGY TOPIC
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Standard Bearers? The role of OFDM

The cost of standardisation and the relationship with measurement science

In Europe, we measure and weigh at a cost equivalent to 2% and 7% of gross domestic product, one of the statistics to emerge from a **presentation** given at **a recent meeting** at the National Physical laboratory.

Metrology, the science of measurement, has been an integral part of civilisation since the earliest days of organised agriculture, several thousand years ago.

Today metrology is an essential part of every industrial and economic process. Food, transport, medicine, health and safety are all dependent on measurements that have been agreed and are enforced on an international basis. Standards provide the reference for this global enforcement process.

Measurement and associated regulation and enforcement introduce direct and indirect cost. For example in the pharmaceutical industry, drug testing introduces the direct cost of laboratory time and the indirect cost of delayed time to market.

This relationship introduces tension to the regulatory process but is a necessary mechanism for ensuring that market forces drive invention and innovation in a well ordered way.

Metrology in Wireless Communications

The regulation of communications is no different. Enforcement agencies have tended to be born out of market and political necessity. For instance the **Federal Communications Commission** was founded in 1934 to impose order on an increasingly chaotic US broadcasting industry. The broadcasters had been transmitting at ever higher powers in order to reach more customers and interference was becoming intolerable. This required enforced management of power outputs and spectral masks – mandated metrology.

The principles of interference management still underpin today's regulatory process but have been made more complex by a need to support system to system and user to user interoperability.

Five billion mobile phones are theoretically capable of producing five thousand megawatts of RF power, fortunately not all at the same time or place. None the less the RF flux density proximate to a one watt mobile phone is usually higher than that from a distant 50 kilowatt broadcast transmitter.

So it is self evident that mobile phone RF outputs need to be measured and managed.

Unfortunately multiple bands and multiple standards have expanded conformance standards and conformance test time and cost to a point where the industry increasingly needs to consider how efficiency and cost savings can be made.

Pragmatically this often comes down to knowing which parts of a standard are important and which can be safely ignored and **which parts of the radio are important where compromise**

should be avoided.

There may also be a case to be made for a move towards more standard standards.

The politics of wireless metrology
In mobile phone standardisation this is a political rather than technical challenge. The emergence of Asia as a dominant market has resulted understandably in a desire by countries in Asia, China in particular, to develop their own standards.

This is problematic for more or less all involved parties.

Economic common sense has to be coupled with economic common interest in order to provide sufficient motivation to head off nationally or regionally specific standardisation initiatives.

Unfortunately the full costs and risks of pursuing national or regionally specific wireless standards are not always apparent when political decisions are made. A degree of dysfunction is therefore something we probably just have to accept.

Efficiency and cost savings may therefore have to be realised in some other way.

Standard bearers? OFDM as a common denominator? Technical common interest.
One option might be to explore how the developing commonalities between wireless and other physical media could be better exploited. **Given that traffic across all physical media at the application layer is migrating towards an all IP environment would it not make sense to more closely integrate physical media at the physical layer?**

The thesis goes as follows

Wireless, copper, cable and fibre all suffer from propagation loss and impairments. Wireless has unique characteristics, multi path for example, but all communication systems suffer signal dispersion.

OFDM is either already used or proposed as a mechanism for mitigating these impairments coupled with the use of adaptive modulation schemes that match throughput to channel quality.

The addition of OFDM allows the signal to be processed in the time and frequency domain using an FFT and inverse FFT. This delivers processing gain and provides a potentially efficient way of using symbol orthogonality to help separate wanted from unwanted signal energy.

For mobile and portable devices the problem historically has been that the FFT transform introduces significant processing overhead and requires a large **dynamic range from the ADC**. Additionally the high peak to average ratio of the transmitted modulated waveform requires an increase in linearity which reduces RF power amplification efficiency. These factors increase DC power drain even when, as in LTE, OFDM is only used on the downlink.

Fixed devices connected through cable and ADSL modems do not have the power budget constraints of a portable or mobile device. OFDM has therefore been implemented successfully and aggressively in the copper network and potentially can deliver similar benefits in cable networks.

OFDM deployment in fibre is presently **still being discussed** rather than implemented but the theoretical benefits should be capable of being realised once the linearity of optical components has improved.

OFDM is also used very successfully in **terrestrial broadcasting**. **In satellite systems, OFDM techniques are used for secure encryption.**

In wireless we are just reaching the point where OFDM can be shown to deliver spectral and power efficiency gains in a broad cross section of channel conditions.

However the standards making process for wireless OFDM, copper OFDM, cable OFDM and fibre OFDM comes under different specialist groups reporting to different standards making bodies and are represented by separate trade organisations.

This is neither efficient nor effective and fails to exploit potential technical common interest.

Neither does it reflect the commercial common interest touch points that exist between all four delivery options.

Fibre Commercial Common Interest
Most cellular phone calls, almost all landline calls and some satellite phone calls travel down **optical fibre** at some point in their journey.

However fibre is expensive to install when compared to competitive access options that have either been fully amortized (copper) or written down (cable). One solution for terrestrial connectivity may be to deliver fibre over existing utility poles. Coupled with optical routing and optical storage, this could transform the cost and energy economics of broadband delivery.

Similarly **a closer coupling between fibre and wireless could be potentially beneficial**. Low powered transmitters on utility poles would significantly decrease the clutter of cabling that link utility poles to adjacent buildings and would of course also provide greatly improved outdoor coverage for mobile and portable devices. Indoor coverage on the upper storeys of buildings adjacent to utility pole transceivers would often be better than coverage provided by wireless from an indoor ground floor femtocell.

Cable Commercial Common Interest
In common with fibre, **cable** is benefiting from higher order modulation schemes and includes OFDM in **DOCSIS 3.0** but these higher order schemes are noise sensitive if high data rates have to be supported.

This suggests that present cable networks may need substantial additional investment to ensure that sufficient bandwidth is available to support a competitive high definition TV proposition and acceptable down load times for high definition content.

This of course strengthens the business case for competitive or preferably complementary fibre investment but also implies **a substantial engineering common interest between cable and fibre in final mile access platforms but arguably also with wireless.**

Copper Commercial Common Interest
Higher order modulation schemes over **copper** combined with adaptive channel coding schemes deliver data rates that are presently competitive for internet access but marginal for high definition TV.

ADSL and VDSL modems add in an OFDM multiplex to deliver additional bandwidth gain but are severely distance limited. The 100 M/bit high profile service for example needs to be within 350 meters of a fibre node.

As with cable this suggests that present copper networks may need substantial additional investment to ensure that sufficient bandwidth is available to support a competitive high definition TV proposition and acceptable down load times for high definition content.

This strengthens the business case for competitive or preferably complementary fibre investment but also implies **a substantial engineering common interest between copper and fibre in final mile access platforms. Arguably this common interest could/should include wireless delivery over the final drop**.

The economics of integrated access
The theoretical benefits of adopting a more integrated approach to broadband access standardisation and broadband access implementation are however likely to be frustrated unless the political and regulatory regimes presently in place change to reflect and encourage the opportunity.

Essentially the delivery of broadband access both in terms of standards making and implementation is likely to be more efficient if approached in a unified way.

This reality is partly reflected by the fact that most major telecom vendors have competence in all four delivery options. Unfortunately they also have standardisation and conformance costs across all four options which arguably should and could be reduced.

Summary
There is no such thing as a universal device that can access a universal network and access policy inevitably has to be conditioned by composite cost factors that have to be factored into access pricing.

There is an underlying assumption that wireless can deliver broadband connectivity more cost efficiently than other delivery options. It has the apparently obvious advantage of not needing to be buried in the ground.

However the industry has managed to introduce substantial additional costs that have needed to be amortized as part of the overall cost of delivery including spectral cost and standardisation cost. Spectral cost is now largely a sunk investment though in practice still needs to be recovered. Standardisation costs could be reduced if we could find a way of improving the standardisation process and potential resource re-use across multiple platforms and standards not only in the wireless domain but across all physical layer options.

An opportunity to debate this topic at the Standards and the New Economy meeting

The Kaetsu Centre Murray Edwards College Cambridge Thursday 25th March

The topic of standard standards will be discussed and debated at the next Future Wide Area Special Interest Group **Standards and the New Economy** meeting in Cambridge on the 25th March.

There will be presentations from David Barker of **Quintel,** Ian Vance of **Amazing Communications**, John Haine of **Cognovo** (a case study of **Ionica**), Alan Howell, Director of

BGAN at Inmarsat, Ollie Haffenden, **DVB T2 subject expert at BBC Research** and Tim Masson of **Agilent Technologies.**

These events are free to attend if you are a Cambridge Wireless or DCKTN member (and joining the DCKTN is free). The cost (nothing for the two groups above) includes lunch and post meeting networking drinks. These events are popular so register now if you are interested in attending

Event description

Full agenda

Registration

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We aim to introduce new terminology and new ideas to clarify present and future technology, engineering, market and business issues.

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Contact RTT

RTT, the **Shosteck Group** and **The Mobile World** are presently working on a number of research and forecasting projects in the cellular, two way radio, satellite and broadcasting industry.

If you would like more information on this work then please contact

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