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3G Wireless Local Loop

The recent failure of Ionica in the UK underlined the market reality that wireless local loop technology needs to move on from its present voice-centric focus to delivering a mix of voice and non-voice services at equivalent bit rates and bit error rates to wireline at an equivalent (or preferably lower) cost per user bit delivered.

The RF link budget for Ionica was nominally specified at 1 in 10^6. Wireline bit error rates are now being specified at 1 in 10^{10}, 1 in 10^{11} or even 1 in 10^{12}. Teledesic (fixed access from 288 low earth orbit satellites) is specified at 1 in 10^{10}.

These low error rates go hand in hand with high level compression embedded in the (wireline) edge device application layer. You wouldn't want to take video with fractal compression at a compression ratio of 500:1 and put it over a high bit error radio channel.

To achieve low bit error rates in wireless requires a substantial amount of coding gain if uneconomic network density is to be avoided. The use of interleaving and forward error correction is a partial palliative but absorbs bandwidth and introduces interleaving delay. Send again protocols can be used to reduce bit error rates but in turn add to the delay budget (and introduce delay variability). Delay and delay variability are not compatible with the delivery of delay sensitive traffic. Real time video and inter-active services are for example delay sensitive. In other words, to be directly comparable, wireless must deliver **transparent** channel performance (ie a channel not reliant on send again protocol protection) which is at least as good as wireline.

In addition to low bit error rates, wireline is also offering the potential to deliver substantially higher user bit rates. Pair gain techniques such as HDSL (high speed digital subscriber lines) and ADSL (asymmetric digital subscriber lines) offer downlinks of 6 M/bits or more. Wireline modulation techniques such as discrete multi-tone modulation also allow multiple traffic streams to be individually coded on to the (wireline) channel to support the delivery of simultaneous voice and non-voice services, (for example, voice multiplexed in real time with white boarding, image and video streaming).

Third generation wireless local loop technologies can potentially deliver this performance but will need substantial RF bandwidth to be made available to allow for the implementation of high spreading ratios [to deliver the coding gain needed to deliver acceptably low bit error rates **and** acceptable range (economic network density)].

The DSC Airspan product for example (which BT have been benchmarking) uses a 2.56 M/chip spreading code to spread a 160 k/bit traffic channel across a 3.5 MHz radio channel, a spreading ratio which gives a coding gain of 12 – 18 dB. Orthogonal Walsh codes are used to multiplex up to 15 users on to the same channel (ie 15 x 160 kbps), or 56 x 32 kbps users (or traffic streams) or 112 x 16 kbps users (or traffic streams), ie provided the receiver is capable of decorrelating multiple codes, multiple traffic streams per user are theoretically (and practically) supportable.

Granger Telecom's CD2000 uses a similar spreading ratio (and can provide similar code discrimination capability).

In the US, the IS655 W-CDMA proposal is a development of the original Inter-Digital Corporation product which used adaptive modulation techniques (rather like DMT) and a chip rate of up to 24 M/chips. The proposal as it now stands covers user rates from 8 k/bits to 2 M/bits, spreading across 5, 10 or 15 MHz.

Which brings us to the present trend towards harmonising the code structures of wireless local loop with either W-CDMA or cdma2000. Lucent's Airloop product, originally developed for the 3.5 GHz band, now uses a 4.096 M/chip rate in a 5 MHz RF carrier (ie the same as W-CDMA). Using QPSK, the code structure supports up to 128 codes per carrier.

While this may point the way to how wireless local loop will evolve, there is another possibility. Terrestrial digital audio broadcasting and digital TV are now a reality in Europe and the US (though of course the standards are different).

The modulation technique used is OFDM, multiple sub-carriers with overlapping spectra, with orthogonality achieved by making the frequency spacing equal to the inverse of the sub-carrier symbol duration. Time dispersive channel impairments (ie multipath from multiple transmitters) are coded out by using a guard interval equal to the length of the channel impulse response, frequency selective fading is taken out by using forward error correction; (this is termed coded orthogonal frequency division multiplexing or COFDM). OFDM is also of course used in ADSL.

Given that the physical modulation and multiplexing process is common both to wireline and wireless access, there is an obvious benefit in terms of device commonality.

OFDM is already a serious candidate for LMDS/LMCS – it may yet gain favour in more generic (and prosaic) wireless local loop applications.

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