MULTI RESOLUTION CODING (MRC)

SATELLITE RETURN WAVEFORM

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In a Satellite Return Link (RTN), a single up to thousands of terminals (e.g. cruise ships, fishing boats, broadband users, towers or airplanes) access a single gateway through a single satellite transponder, thereby sharing a common bandwidth. The specifications per terminal may vary greatly, from low (fishing boat) to high throughput (cruise ship), from low (IoT or downloading) to high (audio call) jitter sensitivity, from low-cost (broadband users) to high-end (cruise ships) terminals.
Thousands of terminals should potentially be able to log on in a few seconds, e.g. due to mobility or when the network recovers from an outage. For a profitable business, the required number of Multi-Carrier Demodulators (MCDs) needed at the gateway to demodulate up to thousands of terminals should be limited and as low as possible, without compromising the efficiency of transmission (number of bits per Hz that can be transmitted). In order to address this, we have designed and productized a single return technology that captures all the above requirements and which represents a significant improvement on our previous 3 return (RTN) link technologies SCPC, Mx-DMA and CPM. This new RTN link technology is referred to as MRC Mx-DMA.
Multi-Resolution coding (MRC) can demodulate, on a single MCD, any combination of terminal transmissions (from high demanding (high throughput, no jitter) to low cost (low throughput, no jitter sensitive transmissions) terminals). Keep-alive traffic does not cost any noticeable bandwidth. Guard bands are minimized. Jitter is as low as a single FEC word duration, even though a burst from a terminal spans up to 100 FEC words. Automatic in-band regrowth detection without any calibration prevents terminals from saturating BUCs while maximizing power transmission. This results in a single RTN link transmission that is as efficient as SCPC for high throughput terminals while achieving CPM like scalabilities, overbooking ratios and efficiencies for services with high overbooking. There is no need for mode switching between CPM and SCPC, as it is all done within a single time-frequency frame using a single technology on a single MCD. All terminals share a single bandwidth pool and can log on in an unsolicited way (thousands at the same time in a few seconds). In this paper, we will present the waveform and compare it with our previous award winning, patented and market-leading RTN link technologies, Mx-DMA and CPM. We are confident that this significant performance improvement will enable us to maintain our dominant position in terms of efficiency. We also believe that this very cost-effective and highly scalable solution will open up a lot of new opportunities, especially in vertical markets.

The proposed multi-resolution coding (MRC) satellite return channel waveform solves the problem of finding a balance between TDMA flexibility and SCPC efficiency in a unified waveform. The waveform is highly parametrizable allowing to cope with very different user scenarios. The MRC waveform optimizes spectral efficiency in all traffic conditions and minimizes system jitter. The waveform needs to allow nearly continuous carriers minimizing time guards, frequency guard bands and synchronisation overheads. Next, the waveform keeps the possibility to allocate very small time/frequency chunks to serve terminals with low traffic demand.

The efficiency of the proposed waveform varies a lot with the terminal traffic demand. For low bit rates, efficiency is lower because of the smaller FEC codewords, but also, and mainly because the proportionally higher guard times, frequency guard bands and synchronization overheads. Figure 1 gives the efficiency in function of traffic demand for different signal to noise ratios (assuming one scheduled burst per frame).

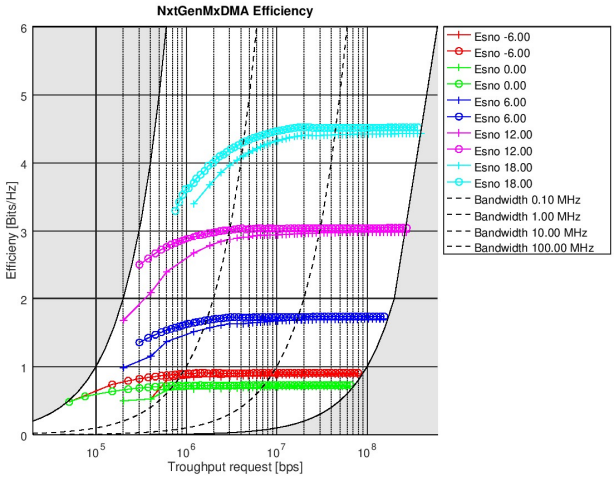

Figure 1 : MRC spectral efficiency in function of traffic demand

The waveform efficiency is shown in capacity plot on Figure 2. The new waveform outperforms CPM for small packets (low traffic) and is on par with HRC for larger payload sizes. A nearly continuous list of payload sizes is available allowing to match any terminal demand.

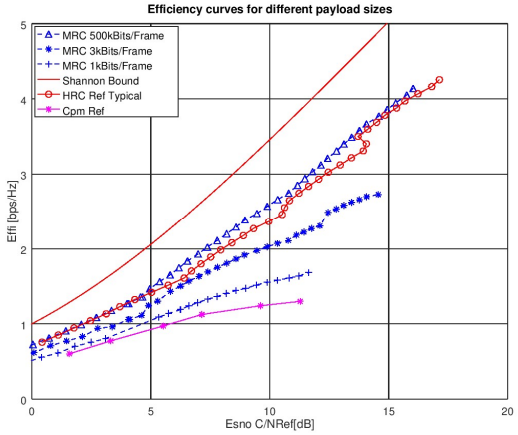

Figure 2 : MRC efficiency compared to HRC and CPM

The presented MRC waveform supports transmit modes from 100kBaud to 100MBaud, allowing terminal bit rate ranges from 1kbps to 100Mbps. The MCD is such that the whole aggregated bandwidth can be allocated at will by the MRC controller in order to optimize the spectral usage. There is no limitation in MRC on the allocation complexity. The MCD design is such that high and low bandwidth carriers can co-exist, and the allocation is bounded only by the aggregated bandwidth and not by the allocation complexity.

A new MF-TDMA waveform is proposed. The new MRC waveform complies with HRC and CPM performances and with a large variety of end user needs (high and low traffic demands). A time multiplexed hardware architecture has been presented based on a time multiplexed demodulator, allowing cost effective implementation and low processing jitter.

[1] Daniel Delaruelle, 'Robust Logon Waveform Deployed in Large Mobile Satellite Access Networks', Ka Conference (2019)