

Optimizing the DVB-SH FEC Scheme for Efficient Erasure Recovery

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Abstract—DVB-SH is a new broadcasting standard offering a mobile TV service for handheld devices using hybrid satellite/terrestrial-repeaters solution. A new link layer protection algorithm called Multi-Burst Sliding Encoding (MBSE) has been recently adopted to cope with the long fading time introduced by the direct satellite link. This paper presents a method to optimize the MBSE parameters and an analysis of the performance gain. Various sets of parameters are studied and optimized with respect to the link performance. Furthermore, an algorithm was provided to compute the optimum values of the MBSE parameters according to some constraints. We have implemented MBSE in two UDCast DVB-SH equipments and we have validated our optimization method using intensive experiments with typical usage scenarios under a hardware-emulated wireless link.

I. INTRODUCTION

The recent developments and improvements of the broadcasting techniques and video compression had a big impact on the television market. Beside classical TV, people are willing to watch their favorite program on their mobile devices anytime, anywhere. In the last few years, several standards broadcast mobile TV have emerged. DVB-H [1], [2], Digital Video Broadcasting-Handheld, one of the most prevalent mobile TV formats, is based on DVB-T [3] (T for Terrestrial) but takes into account the limited battery capacity of handheld devices. To solve the problem of power consumption, a time division multiplex transmission is introduced at the link layer level. This technique is called Time-Slicing [4]. The Time-Slicing is one of the innovations of DVB-H. The key idea is to transmit data in “bursts” exclusively carrying a single service. The data rate of bursts is much higher compared to the average data rate of the service itself; typically a burst uses the whole channel rate during its transmission. This enables a time selective reception of the desired service by switching to a power-save mode during the transmission of other services.

DVB-SH [5] (SH for Satellite services to Handhelds) is an independent derivative of DVB-H. It was designed for frequencies below 3 GHz, supporting UHF band, L-Band or S-band. Like its predecessor specification (DVB-H), it is based on DVB IP Datacast (IPDC) [6] delivery and electronic service guides (ESG) [7]. The DVB-SH standard defines the way to deliver “IP based media content and data” to handheld terminals using hybrid satellite/terrestrial solution. It employs a high-power geo-stationary satellite for cost-effective nationwide coverage and a network of low-power repeaters

to provide urban and indoor coverage. The satellite ensures nationwide direct reception of up to nine channels at 256 kbits/s. Repeaters in urban areas retransmit the received data at the frequency of the satellite carrier and therefore are able to offer indoor coverage. Synchronization between the terrestrial repeaters and the satellite allows the receiver to see the satellite signal as a simple echo of the terrestrial repeater signal¹[8]. To increase the system capacity in urban areas, adjacent carrier transmitters complement the satellite signal, allowing the transmission of additional channels.

DVB-H key technologies such as Orthogonal Frequency Division Multiplexing (OFDM) modulation, time slicing and IP data casting are maintained while an improved link budget is achieved by employing turbo-codes. Furthermore, significant improvements are made within the terminals (higher antenna gain and reception diversity).

One of the major challenging issue addressed by DVB-SH is the protection of data against the impairments of the direct satellite link which is often modeled using a Land Mobile Satellite [9] (LMS) model². This kind of channel is characterized by long fading time where the signal can be interrupted for several seconds due to physical obstacles like tree, tunnel or weather conditions. To cope with this problem, a new encoding algorithm called Multi Burst Sliding Encoding (MBSE) has been adopted. This algorithm is able of generating an outer FEC to recover several consecutive lost bursts. It extends the DVB-H intra-burst MPE-FEC (MultiProtocol Encapsulation-Forward Error Correction)[4] protection to an inter-burst protection so that complete burst losses could be recovered while taking into account the specificity of mobile handheld devices.

There are four main parameters that regulate the operation of MBSE: The encoding parallelization factor (B), The FEC spreading factor (S), the number of computed outer FEC columns from an encoding matrix (F_o) and the number of

¹Single Frequency Network (SFN) operation comes from the robustness of the transmission system against echos. In fact echos can be passively generated by the environment (reflection, refraction, etc. in short, multipath propagations) or be artificially produced by active transmitters radiating on the same frequency, at the same time, the same bits.

²In satellite to mobile communications, there is generally a strong line-of-sight component in addition to the diffuse multipath component. The spectral and statistical properties of both components are influenced by shadowing caused by obstacles such as trees, houses or small buildings.

rows of an encoding matrix (N_R). However according to the maximum end-to-end delay tolerated by the application layer, constraints on the memory usage and the service bitrate, many combinations of these parameters, resulting in a very different performance, can be used. The DVB-SH standard does not give a method to determine the best set of these parameters to be used. In this paper we first evaluate theoretically the performance of MBSE, then we derivate a linear problem allowing the computation of the optimum values of B and S and N_R according to the FEC ratio and the end-to-end delay. Finally we evaluate the performance of MBSE under an LMS and TU6 (Terrestrial Urban-6 paths) ³[10] channels while varying B , S , N_R , F_o and the end-to-end delay, and we demonstrate that our method for the parameters computation provides the optimum values. To our knowledge, this is the first work focusing on the optimization of the DVB-SH MBSE parameters. A similar work [11] has been performed for the DVB-H FEC scheme. In [11] results are only obtained by simulations using a very simple channel estimation while in our work, the results are obtained theoretically and then by experiments using a real implementation of the standard and a hardware channel emulator. Furthermore the DVB-H and DVB-SH FEC schemes are quite different.

The rest of the paper is organized as follows: section II describes the Multi-burst Sliding Encoding Algorithm. Then a theoretical analysis of its recovering capacity is presented in section III and an algorithm is provided to compute the optimum values of B , S and N_R . In section IV we evaluate the performance of MBSE applied to the RS (191,255) under an LMS and TU6 channel model while varying the parameters that regulate the operation of the algorithm and we demonstrate by experiments the correctness of our analysis given in section III. Finally section V presents our conclusion and future work.

II. THE MULTI BURST SLIDING ENCODING

The Multi Burst Sliding Encoding mechanism is a link layer solution for extending the duration of the protection while still using small size blocks. It extends the existing DVB-H MPE-FEC intra-burst protection scheme to an inter-burst protection so that complete burst losses may be recovered by producing an “outer/inter FEC” in a regular basis (a fraction of the protection is created every burst). In order to achieve this protection, data coming from several bursts are interleaved inside parallel matrices before FEC protection is applied, even if original data are not sent interleaved eventually. On the reception side, received data are also interleaved before being placed in decoding matrices. In order to achieve this extension the following parameters are needed:

- B : The encoding parallelization factor expressed in encoding matrix units. Each burst is split into B parts distributed over B encoding matrices.
- S : The depth of the FEC spreading factor: The generated FEC is spread over S bursts.

³TU6 models the terrestrial propagation in an urban area. It uses 6 resolvable paths, each one characterized by a delay, a power, and fading model.

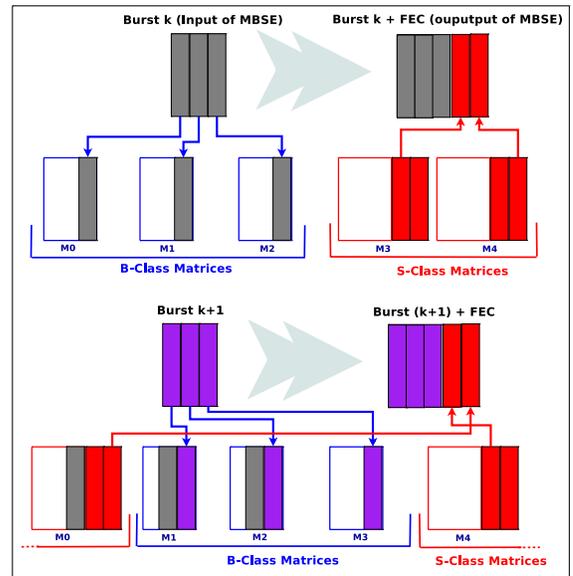


Figure 1. MBSE Encoder

- F_o : Number of computed outer-FEC columns from an encoding matrix.

The algorithm works as follows: The encoder allocates a set of $(B + S)$ encoding matrices divided into two classes : B -class made of B matrices and S -class made of S matrices. At each iteration a sliding window (hence the name of the algorithm) is applied to the $(B + S)$ matrices and thus one matrix from the B -class goes to the S -class and vice versa.

Each data burst (several IP datagrams) is mapped ⁴ in an Application Data Table (ADT) (matrix of bytes) made of C columns and N_R rows. Each ADT is divided into B parts made of a number of non contiguous columns taken in a particular way. Each part is placed in a specific encoding matrix from the B -class. At each iteration, only one specific encoding matrix - from the S -class - containing columns coming from several bursts is encoded and thus, F_o FEC columns are generated. Each IP datagram from the burst is encapsulated in an MPE section⁵ and sent without additional delay. At the end of the burst, some FEC columns⁶, chosen in a specific way from the S -class matrices, are encapsulated in an MPE-FEC sections⁷ and sent.

Figure 1 shows a simple example of an encoder with $B = 3$, $S = 2$ and $F_o = 2$. We suppose that each burst can be mapped on an ADT with 3 columns.

With MBSE, in order to perform the decoding operation, the mobile device has to wait until the reception of all the IP datagrams and the parity symbols of each encoding matrix. Parity symbols generated from one encoding matrix are sent

⁴The ADT is filled with the bytes of the IP datagrams

⁵An MPE section consists in a header followed by an IP datagram and a CRC32

⁶The number of FEC columns per burst depends on the FEC ratio and the burst size

⁷An MPE-FEC section consists in a header followed by several FEC bytes and a CRC32

into S time-sliced bursts. The terminal has first to receive the B bursts necessary to retrieve all the IP datagrams, and then the S bursts necessary to retrieve the FEC. Because of this, the mobile device has to wait a total of $(B + S)$ bursts to be able to fill one encoding matrix and achieve full protection. As the mobile device has to buffer $(B + S)$ bursts, the size of the required required buffer is equal to $(BurstSize * (B + S))$.

A. Encoder algorithm

Initialization

The encoder allocates $(B + S)$ encoding matrices $\{M_0, \dots, M_{(B+S-1)}\}$ with C columns and T rows each. Each encoding matrix M_i is composed of two parts: The application data table $MADT_i$ and FEC data table $MFDT_i$.

The following process is applied for each burst of data numbered k .

Step 1: Processing and transmission of the k^{th} data burst.

- Map the data burst in an ADT noted ADT_k .
- Send the data burst as is.
- Create a FEC burst containing F_o FEC columns $\{F_0, \dots, F_{F_o-1}\}$ extracted from S interleaved $MFDT$ $\{MFDT_{f(0,k)}, \dots, MFDT_{f(F_o-1,k)}\}$ among $B + S$. F_i is the i^{th} FEC column of the $MFDT_{f(i,k)}$. The f function is defined as:

$$f(j, k) = (k - 1 - (j \bmod S)) \bmod (B + S) \quad (1)$$

Step 2: Interleaving of the ADT_k (the k^{th} data burst) and outer FEC computation.

- Interleave the ADT_k inside B $MADT$ $\{MADT_{g(0,k)}, \dots, MADT_{g(C,k)}\}$ among $B + S$ such as the i^{th} column of the ADT_k ($C_{i,k}$) is copied into the $p(i)^{th}$ column of the $MADT_{g(i,k)}$. The g and p functions are defined as:

$$g(i, k) = (k + (i \bmod B)) \bmod (B + S) \quad (2)$$

$$p(i) = (B - 1 - (i \bmod B)) \times \lfloor \frac{C}{B} \rfloor + \max(0; (C \bmod B) - (i \bmod B) - 1) + \lfloor \frac{i}{B} \rfloor \quad (3)$$

- Encode the Matrix $M_{h(k)}$. The FEC encoding function generates the $MFDT_{h(k)}$ from the $MADT_{h(k)}$. The h function is defined as:

$$h(k) = k \bmod (B + S) \quad (4)$$

B. Decoder algorithm

The decoding operation is basically the reverse of the encoding one. When a data burst k is received, it is interleaved inside B matrices and the outer FEC carried by this burst is inserted in the corresponding matrices. The encoding matrix $M_{u(k)}$ is decoded, then de-interleaved and finally the burst $l(k)$ can be retrieved and passed to the upper layer. The u and l functions are defined as follows:

$$u(k) = (k + B) \bmod (B + S) \quad (5)$$

$$l(k) = (k - B - S + 1) \bmod (B + S) \quad (6)$$

III. PERFORMANCE ANALYSIS

In this section, we derive an expression of the burst recovery capacity of the MBSE scheme.

A burst k is made of C data columns mapped into an ADT , and F_o outer FEC columns. In order to recover a lost burst k , all the encoding matrices containing a portion of that burst must be successfully decoded (all erasure recovered). At the encoder, ADT_k is interleaved with the $(B - 1)$ previous ADT $\{ADT_{k-(B-1)}, ADT_{k-(B-2)}, \dots, ADT_{k-1}\}$ and with the $(B - 1)$ following ADT $\{ADT_{k+1}, ADT_{k+2}, \dots, ADT_{k+(B-1)}\}$ inside B encoding matrices $\{M_{h(k)}, M_{h(k+1)}, \dots, M_{h(k+B-1)}\}$. Each matrix contains $\frac{C}{B}$ data columns coming from ADT_k . In the case of a "perfect FEC code", the decoder needs to receive $\frac{C}{B}$ FEC columns for each encoding matrix $M_{h(k)}$. This makes sense only if $\frac{C}{B} \leq F_o$. On the other hand, the FEC columns produced by the encoding of the matrix $M_{h(k)}$ are spread over the S following bursts $\{Burst_{k+1}, Burst_{k+2}, \dots, Burst_{k+S}\}$. $Burst_{k+i}$ contains $\frac{F_o}{S}$ FEC columns coming from the encoding matrix $M_{h(k)}$. Therefore, to retrieve the burst k , the decoder needs to receive the $(B - 1)$ previous bursts and the $\lceil B - 1 + \frac{C \cdot S}{B \cdot F_o} \rceil$ following bursts.

In a more general case, when n successive bursts $\{ADT_k, ADT_{k+1}, \dots, ADT_{k+n-1}\}$ are lost, the set χ of the involved encoding matrices is defined as:

$$\chi = \{M_{h(k)}, M_{h(k+1)}, \dots, M_{h(k+\min(B;n)-1)}, M_{h(k+\min(B;n))}, \dots, M_{h(k+\min(B;n)-1)}, M_{h(k+\max(B;n))}, \dots, M_{h(k+n+B-2)}\} \quad (7)$$

To show more clearly the calculations, we divide the set χ into three subsets χ_1 , χ_2 and χ_3 such that:

$$\begin{aligned} \chi_1 &= \{M_{h(k)}, M_{h(k+1)}, \dots, M_{h(k+\min(B;n)-1)}\} \\ \chi_2 &= \{M_{h(k+\min(B;n))}, \dots, M_{h(k+\max(B;n)-1)}\} \\ \chi_3 &= \{M_{h(k+\max(B;n))}, \dots, M_{h(k+n+B-2)}\} \\ \chi &= \chi_1 \cup \chi_2 \cup \chi_3 \end{aligned} \quad (8)$$

To decode the matrices of χ_1 , the set of bursts ψ_1 must be received by the decoder and the constraint C_1 must be satisfied. ψ_1 and C_1 are defined as:

$$\psi_1 = \{Burst_{k+n}, \dots, Burst_{k+m_1}\} \quad (9)$$

$$C_1 : \lceil n + (j+1) \frac{C.S}{B.F_o} - 1 \rceil \leq j + S \quad (10)$$

$$\forall j \mid 0 \leq j \leq \min(B; n) - 1$$

$$m_1 = \lceil n + \min(B; n) \times \frac{C.S}{B.F_o} - 1 \rceil \quad (11)$$

To decode the matrices of χ_2 , the set of the bursts ψ_2 must be received by the decoder and the constraint C_2 must be satisfied. ψ_2 and C_2 are defined as:

$$\psi_2 = \{Burst_{k+n}, \dots, Burst_{k+m_2}\} \quad (12)$$

$$C_2 : \lceil n - \min(B + j + 1; n) + \min(B; n) \frac{C.S}{B.F_o} - 1 \rceil \leq S \quad (13)$$

$$\forall j \mid 0 \leq j \leq |n - B| - 1$$

$$m_2 = \lceil \max(B; n) + \min(B; n) \times \frac{C.S}{B.F_o} - 1 \rceil \quad (14)$$

To decode the matrices of χ_3 , the set of the bursts ψ_3 must be received by the decoder and the constraint C_3 must be satisfied. ψ_3 and C_3 are defined by:

$$\psi_3 = \{Burst_{k+\max(B;n)+1}, \dots, Burst_{k+m_3}\} \quad (15)$$

$$C_3 : \lceil (\min(n; B) - 1) \frac{C}{B.F_o} \rceil \leq 1 \quad (16)$$

$$m_3 = \lceil \max(B; n) + (\min(B; n) - 1) \times \frac{C.S}{B.F_o} + (\min(B; n) - 2) \times (1 - \frac{C.S}{B.F_o}) \rceil \quad (17)$$

Therefore, to decode all matrices of χ , the set of the bursts $\psi = \psi_1 \cup \psi_2 \cup \psi_3$ must be received by the decoder and the constraint C (satisfying C_1 , C_2 and C_3) must be satisfied. ψ and C are defined by:

$$\psi = \{Burst_{k+n}, \dots, Burst_{k+m}\} \quad (18)$$

$$C : \lceil n - \min(B; n) \times (1 - \max(\frac{C.S}{B.F_o}; 1)) \rceil \leq S \quad (19)$$

$$m = \lceil \max(B; n) + \frac{C.S}{B.F_o} - 1 + \max(\frac{C.S}{B.F_o}; 1) \times (\min(B; n) - 1) \rceil \quad (20)$$

From (19), we can see that when $\frac{C.S}{B.F_o} \leq 1$, the maximum recovery capacity of the MBSE algorithm becomes S successive bursts. On the other hand, when $\frac{C.S}{B.F_o} > 1$ then $C.S \leq B.F_o$. since B is equal to $M - S$, $S \leq \frac{M}{(\frac{C}{F_o} + 1)}$. This means that MBSE is able to recover up to $\frac{M}{(\frac{C}{F_o} + 1)}$ consecutive lost bursts. For large enough FEC percentage ($F_p = \frac{F_o}{C}$), This expression (bounded by M), can reach $(M - 1)$.

To recover the n successive lost bursts, the decoder needs to receive the bursts from $k + n$ to $k + m$. When condition C is satisfied, we obtain $m - n \leq B + S$. Therefore the optimum values of B and S for a given FEC percentage ($F_p = \frac{F_o}{C}$) and

Algorithm 1 MBSE parameters selection

INPUT:

ServiceBitrate, *RepetitionInterval*, C_{max} , F_p , M
01: if (*RepetitionInterval* > $\frac{1024 \cdot C_{max}}{ServiceBitrate}$) then
02: *RepetitionInterval* = $\frac{1024 \cdot C_{max}}{ServiceBitrate}$
03: endif
04: *BurstSize* = *ServiceBitrate* \times *RepetitionInterval*
05: $N_R = 256$
06: while (*BurstSize* > ($N_R \times C_{max}$)) do
07: $N_R = N_R + 256$
08: end while
09: $C = \lceil \frac{BurstSize}{N_R} \rceil$
10: $F_o = F_p \times C$
11: $S = \lfloor F_p \times \frac{M}{1+F_p} \rfloor$
12: $B = M - S$

a fixed value of $B + S$ are computed by solving the following linear program:

$$\begin{aligned} & \text{Maximize} && S \\ & \text{Subject to} && \begin{cases} \frac{C.S}{B.F_o} \leq 1 \\ B + S = M \end{cases} \end{aligned} \quad (21)$$

Problem 21 has the following closed-form solution:

$$\begin{aligned} S &= \lfloor F_p \times \frac{M}{1+F_p} \rfloor \\ B &= \lceil \frac{M}{1+F_p} \rceil \end{aligned} \quad (22)$$

On the other hand, the number of rows has an impact on the performance of MBSE. In fact, even if the size of an IP datagram is independent from the value of N_R , the payload of a FEC section consists in a column of bytes taken from an $MFDT_i$. Thus its size is equal to the value of N_R . So what is the impact of the section size on the packet loss rate? Let p the byte error probability, and T the section size, then the section error probability is:

$$\sum_{n=1}^T \binom{T}{n} \cdot p^n = 1 - (1-p)^T \approx T \cdot p, \quad (23)$$

approximation being valid whenever $p \ll 1$. From equation 23 we can see that the section error probability grows linearly with the section size. the higher the section size the higher the probability to have at least one erroneous byte.

As shown previously, the performance of MBSE depends on several parameters which are interdependent. Different combinations of these parameters may result in a deviation of the recovery performance. Algorithm 1 can be used to compute the optimum values for the number of rows N_R , B and S according to a service bitrate (*ServiceBitrate*), repetition interval (*RepetitionInterval* derived from the power saving ratio), the maximum number of columns per ADT (C_{max}), the FEC percentage (F_p) and M (derived from the end-to-end delay or the memory size of the receiver device).

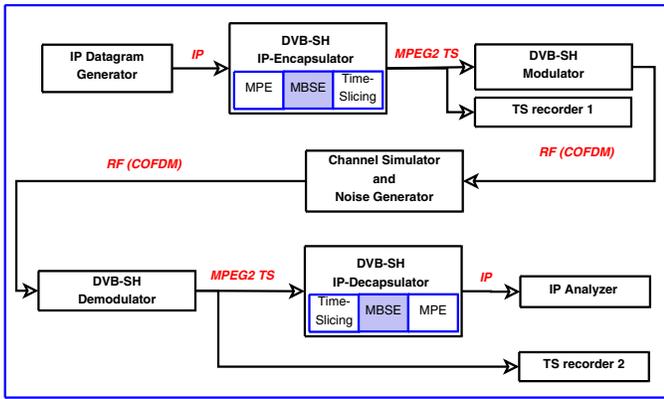


Figure 2. DVB-SH Test bed

IV. EXPERIMENTAL PERFORMANCE OF THE SLIDING ENCODING SCHEME

In the following we applied the RS(191,255) MBSE algorithm to a live stream while varying the values of B , S , N_R , and F_o . The aim is to find the best combination of these parameters that maximizes the recovering capacity of the algorithm.

1) *Test bed description:* We have implemented the encoding and decoding algorithms of the MBSE in two standard UCast [12] equipments: the DVB-SH IP-Encapsulator and the DVB-SH Navigator.

For experimental purpose the test bed described in Figure 2 is set up. The MPE and MPE-FEC sections are generated so that an IP datagram forms the payload of an MPE section and an outer-FEC column forms the payload of an MPE-FEC section [13]. The MPE and MPE-FEC sections are then fragmented into MPEG2 [14] packets carried through an ASI cable to a DVB-SH OFDM modulator. The modulated signal is passed through a hardware channel emulator [15] implementing the TU6 and the LMS models. The Noisy signal is demodulated by the DVB-SH signal demodulator and the generated MPEG2 packets are passed to the MBSE decoder to retrieve the IP datagrams. An IP analyzer then provides statistics on the packet loss rate (PLR) and the Erroneous Second Ratio (ESR)⁸. The following parameters are used in the experiments :

- Repetition interval: 1s
- Physical layer FEC ratio: 50%
- Physical layer interleaving: 100ms
- Physical modulation: QPSK
- Mobile speed: 3Km/h

2) *Experiments Results:* In the first experiment we examine the effect of different values of number of rows (N_R) against erroneous second ratio over a TU6 and LMS channels while keeping the service bitrate and the repetition interval constant. Figures 3 and 4 report the error free second ratio ($EFSR = 1 - ESR$) after applying MBSE to a noisy signal under a TU6

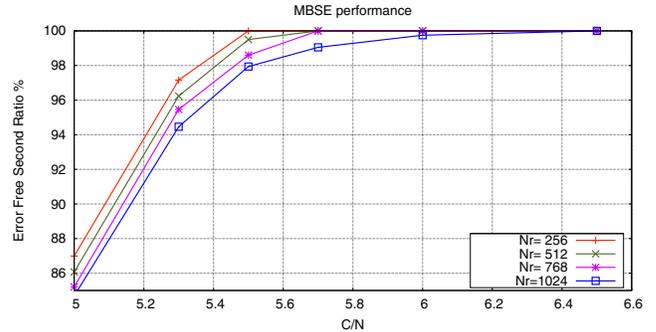


Figure 3. Error Free Second Ratio in TU6 channel while varying the C/N for different values of number of rows

and LMS channels respectively, while taking different values of N_R . From these set of curves we can clearly see that the lower the value of N_R parameter the better the performance of MBSE for both channel models. For example, in a TU6 channel an EFSR of 100% is reached at 5.5db by using a value of N_R equal to 256, while the same EFSR is only reached at 6.5db if we use 1024 rows per matrix.

The second experiment consists in finding the optimum combination of B and S that gives the best performance of MBSE according to a given FEC ratio and the maximum end-to-end delay ($M = B + S$). the values of N_R and C have been fixed to 1024 rows and 100 columns respectively. The carrier to noise ratio (C/N) has been fixed to 5.4db. Figures 5, 6 and 7 report the packet loss rate (PLR) under an LMS channel while varying B and S for different values of FEC ratio and end-to-end delay (M). From these set of curves, we can observe that for each couple of (B, S) we obtain a different value of PLR even if we keep the FEC ratio, $M = (B + S)$ and the the C/N constant. For the nine curves, the gap between the worst and the best PLR is higher than 5%. For example for $M=16$ and a FEC ratio of 33%, the worst PLR is about ~12% (for $B = 1$) and the best one is about ~4% (for $B = 11$). We can also check that the minimum PLR is always obtained for the values of B and S that verify the eq. 21. For example: for $M=10$ and FEC ratio of 33% the optimum value of (B, S) is (7,3).

As demonstrated by experiments, the parameters regulating the operation of MBSE have an impact on the quality of service in term of packet loss rate. Indeed, comparing to the worst case, we can achieve a gain of ~1db by setting the appropriate combination of these parameters. This gain or optimization in term of C/N can be used by the broadcasters to increase the coverage area of the transmitters or to reduce the transmission power of the base stations while maintaining the same coverage and the same quality of service.

V. CONCLUSION

The DVB-SH standard defines an error correction scheme called Multi-Burst Sliding Encoding (or MBSE) for the link layer to combat effects of the LMS channel model. However, the parameters configuration of MBSE is left open. In this paper, The burst interleaving scheme of MBSE has been

⁸ESR represents the ratio between the number of seconds containing a least one erroneous IP datagram and the duration of the experiment

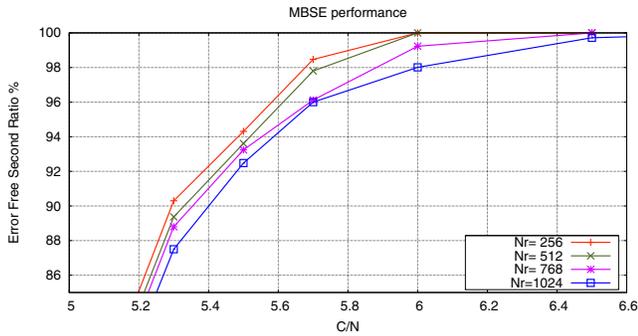


Figure 4. Error Free Second Ratio in LMS channel while varying the C/N for different values of number of rows

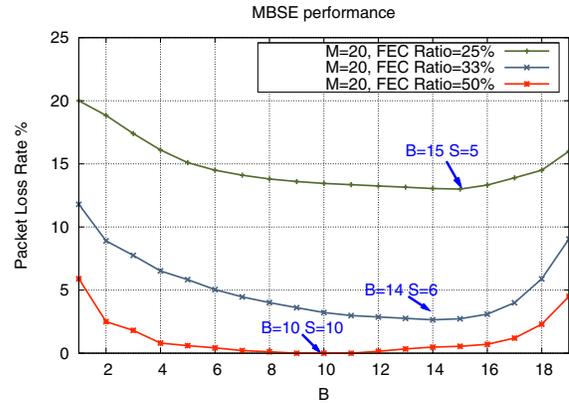


Figure 7. Packet Loss Rate in LMS channel while varying B and S subject to $B + S = 20$ for a FEC ratio of 25%, 33% and 50%

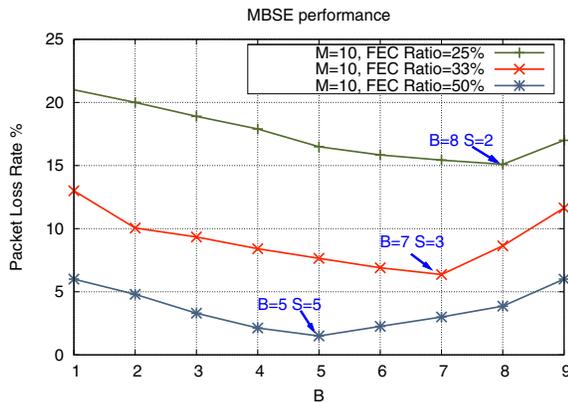


Figure 5. Packet Loss Rate in LMS channel while varying B and S subject to $B + S = 10$ for a FEC ratio of 25%, 33% and 50%

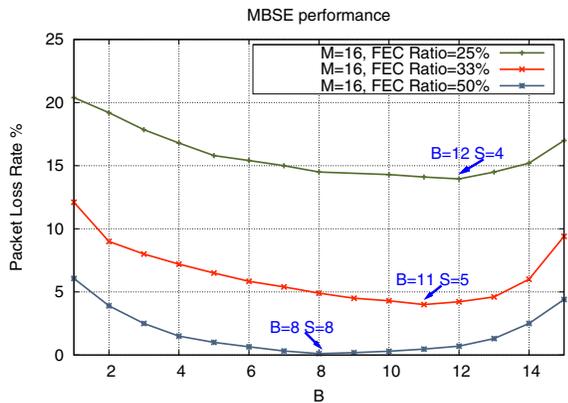


Figure 6. Packet Loss Rate in LMS channel while varying B and S subject to $B + S = 16$ for a FEC ratio of 25%, 33% and 50%

analyzed. We have demonstrated that there is a relationship between the FEC ratio and the interleaving parameters. As a result, an analytic method to calculate the optimum parameters of MBSE was derived, furthermore an algorithm was provided. To validate our analytic method, several experiments have been performed for different usage scenarios. Experiments have been done using a real implementation of MBSE in two UCast standard equipments and a hardware channel emulator implementing two typical mobile channels (TU6 and LMS). Results show that, comparing to the worst case, our recom-

mendations for the burst interleaver setup can optimize the recovering capacity by more than 5% in term of PLR and provide a gain of ~1db in term of C/N.

In a future work, we intend to examine the effects of the repetition interval and the encoding matrix size against the packet loss rate in a DVB-SH transmission. We will also study the performance of a two-dimensional FEC scheme (MPE-FEC and Multi-burst Sliding Encoding) using a recursive decoding.

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