Comparing Static and Statistical Multiplexing in DVB-H

A. López, J. Mas and G. Fernàndez

Abstract— **DVB-H, the standard for mobile TV from the DVB standards family has been validated during the last years by several international projects that have proved the possibilities, maturity and also limits of this technology. One of the most important features to choose when setting up a DVB-H network is whether to use static or statistical multiplexing. This work compares both strategies showing advantages and disadvantages in each scenario. Finally, this work concludes with a numerical comparison in terms of capacity when using static or statistical multiplexing.**

***Index Terms*—DVB-H, statistical multiplexing**

I. Introduction

During the last years, DVB-H [1] has been proved as a mature technology being one if the standards deployed in most mobile TV broadcast networks. This work evaluates and compares both technologies providing some results on the increase of capacity when using Statistical Multiplexing.

In the paper, firstly, VBR and CBR concepts are presented. Variable bitrate (VBR), is a term used in telecommunications that relates to the bitrate used in sound or video encoding. As opposed to constant bitrate (CBR), VBR files vary the amount of output data per time segment while CBR remain the bitrate constant along time. VBR encoded services provide a better quality-to-space ratio compared to a CBR service of the same average bitrate. The bitrate in VBR encoding process is used in an intelligent and flexible way, allocating more bits to difficult-to-encode passages and fewer bits to less demanding passages.

Secondly, the concept of Static Multiplexing in DVB-H is presented. This is the typical and simplest configuration option for multiplexing in DVB-H. The multiplexing process in a DVB-H network is carried out by the IP Encapsulator, it is in this module of the transmission chain where the different parameters that affect to the multiplexing configuration must be tuned to achieve the required performance of the different DVB-H services that are conveyed in the Transport Stream. In few words, the IP Encapsulator must guarantee the encapsulation of the incoming IP flows into the outgoing Transport Stream taking into account the VBR characteristics of the input services. This variability in the input bitrate makes the Static Multiplexing inefficient when many highly variable bitrate services are present in a Transport Stream.

Statistical Multiplexing is the most advanced and complex option for Multiplexing in DVB-H. The aim of Statistical Multiplexing is to increase the capacity of the multiplex taking advantage of the variability of bitrate along time of the different services when a sufficient number of them are combined into a Transport Stream. Statistical Multiplexing has been developed successfully in the past in other DVB networks such as DVB-T or DVB-S. However, due to the time-sliced nature of DVB-H, the application of the classical Statistical Multiplexing is not possible in this case. In the Statistical Multiplexing for DVB-H, the services are allocated into the Time Slicing one after the other without any fixed reserved bitrate, in such a way that each service only consumes the strictly necessary bitrate leaving the rest of the available bitrate for the insertion of other services. In Statistical Multiplexing, different strategies and options are possible; some of them are presented in this work evaluating the advantages and disadvantages.

In this work, a special attention is given to the Statistical Multiplexing strategy used in a real IP Encapsulator [2], [3], presenting concrete examples of encapsulation of a number of TV/Radio services. This strategy offers the possibility to accept highly variable bitrate services by the insertion of additional bursts of the same service into the Time Slicer before the end of the cycle, which allows the encapsulation of services with double VBR variation than in other Statistical Multiplexing implementations.

Finally, a comparison between the different multiplexing strategies, advantages and disadvantages of each of them are presented as well as the suitability of each strategy for different situations and contexts. Finally, this work also provides numerical results regarding the increase in capacity obtained by the use of Statistical Multiplexing.

II. CBR and VBR Concepts

CBR is a term used when media contents encoding

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processes produce flows of data at a constant rate. This means that complex and simple parts of the media are encoded in the same way producing the same amount of data per time segment which produces variable quality of the received media.

VBR encoding as opposed to CBR, varies the amount of information per time segment. This means that complex parts of the encoded source are allocated with more capacity while the less complex parts are allocated with less capacity and so the perceived quality remains constant. This variation in bitrate normally fluctuates around an average bitrate which refers to the average amount of data transferred per unit of time.

The advantage of VBR is that it produces a better quality-to-space ratio compared to CBR for the same data. The disadvantage is that it may take more time to encode, since the process is more complex, which can be critical in real time source encoding.

When multiplexing VBR data into a typical multiplexing scheme of DVB-T/-C/-S based on MPEG-2 the constraint comes from the total bitrate of the output and the maximum deviation in time between the position of an incoming packet at the output and its position at the input. However, when sending data in bursts as in DVB-H/-SH, a new constraint appears which is the maximum size of the burst, which is limited and defined in the time slice configuration set by the network operator.

Multiplexing in DVB-H is performed by the IP Encapsulator, this equipment can be configured by different input parameters depending on the implementation, but in summary, the following parameters must be set for each service: Number of Rows, Maximum Number of Columns, FEC Code Rate, Burst Bitrate and Time Slice Period. The first two parameters (Number of Rows and Maximum Number of Columns) determine the maximum capacity of each burst which is the new constraint when multiplexing in bursts. The problem when having VBR IP flows at the input of the IP Encapsulator is that high variations of the incoming data rate may not be absorbed by the current burst, leading to a delay in the transmission of some packets until the next burst is sent. Figure 1 shows how a peak of bitrate in a VBR media source is absorbed by two bursts filled up to its maximum capacity and sent within the minimum burst repetition.

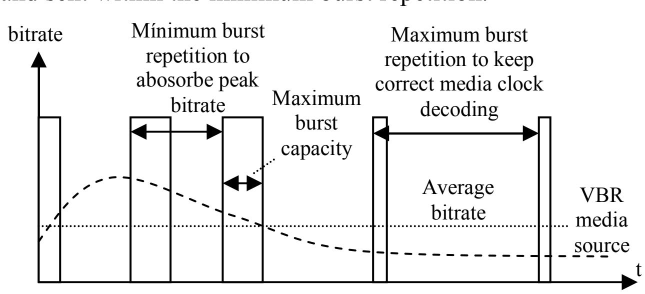

Fig. 1. Burst multiplexing absorbing a peak bitrate in VBR media source.

The delay in the transmission may lead to artifacts in the image/audio since each packet must be sent within a time margin. This complication makes multiplexing in bursts more difficult than normal 'continuous' multiplexing, since it introduces a new constraint which must be taken into account.

III. Static Multiplexing

Static Multiplexing allocates services into the Time Slicing with a fixed reserved bitrate, so a fixed bandwidth is assigned to each service (Fig. 2). In the configuration process of the IP Encapsulator, apart from the parameters associated to each service, a constant bitrate must be set for each service. This value must absorb the variations of the incoming data rate to avoid delays in packet transmission. The Time Slicing pattern obtained in Static Multiplexing is constant. Bursts are allocated at the same time position in every Time Slicing. Due to the margin of bitrate allocated to each service, and in order to assure the absorption of incoming data rate, the dedicated bandwidth is not always fully used. A disadvantage of Static Multiplexing versus Statistical strategies is the dynamic waste of bitrate in every service Time Slicing allocation.

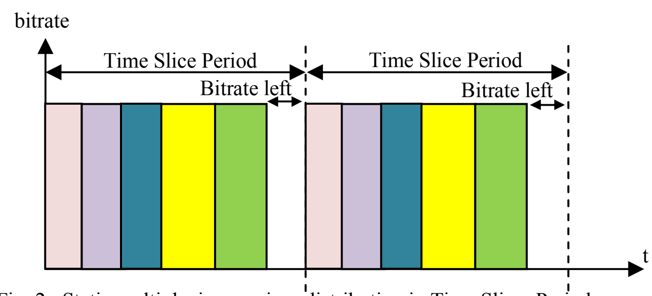

Fig. 2. Static multiplexing services distribution in Time Slicer Period.

The Static Multiplexing bursts allocation process requires a complex and tedious parameter configuration to distribute all services along the Time Slicing Period. For this reason, an algorithm has been developed in order to automatically allocate a set of services in a desired Time Slicing Period. The strategies of this automatic algorithm are explained in the following: the first consideration is that service with lower bitrate establishes the upper limit of the Time Slicing Period. The first strategy step consists of setting a main Time Slicing Period (corresponding to the most restrictive service – lowest bitrate), and, at the same time, the closest (equal or greater) to the desired Time Slicing Period. In the case this is not possible, due to bitrate restrictions, the closest multiple period to the desired Time Slicing Period is set. For the rest of services, the allocation a specific Time Slicing Period as similar process must be established, but only submultiples of the Time Slicing Period previously set are considered.

In summary, the input parameters of the algorithm are: the desired Time Slicing Period and, for each service, the bitrate and FEC code rate. The algorithm calculates for each service the number of rows and the number of columns ADT and RSDT (according to FEC code rate) in order to fit its bitrate and find its specific Time Slicing Period, which must be equal or submultiple of the main Time Slicing Period and closest to the desired Time Slicing Period. As a result, a main Time Slicing Period is obtained where bursts of different services are allocated. One service may have one or more bursts along the main Time Slicing Period depending on whether its particular Time Slicing Period is a submultiple of the main one, as seen in Fig. 3. Due to the restriction of working with submultiple periods of the main Time Slicing Period, the bitrate allocated to services (according to the number of rows and ADT columns assigned) may be slightly larger than strictly necessary.

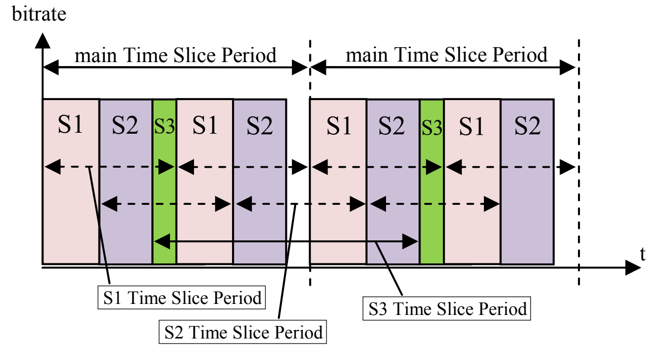

Fig. 3. Automatic algorithm service allocation example for Static multiplexing.

IV. Statistical Multiplexing

Statistical Multiplexing in DVB-H is performed by the IP Encapsulator when multiplexing a high number of services (IP Flows) into a Transport Stream. Due to the statistically distribution of bitrate among different services, the total capacity needed to encapsulate N IP Flows decreases with higher values of N compared with Static Multiplexing.

This work presents a real implementation of a Statistical Multiplexing scheme. The first feature of a Statistical Multiplexing scheme is that services do not have any fixed reserved bitrate, so services tend to be allocated as close as possible into the Time Slicer as shown in figure 4.

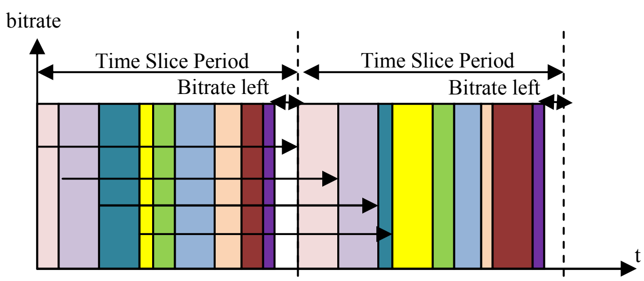

Fig. 4. Statistical multiplexing setting services close to each other in Time Slicer.

One feature of DVB-H, and also DVB-SH in some modes, is the signaling of the time of next burst by means of a delta-T value included in every section carrying an IP packet or FEC section. If each service is set close to the next one in the Time Slicer, the delta-T value is time varying since it depends on the allocation of the previous bursts into the Time Slicer except for the first one which will always start at the beginning of the Time Slice Period. This means that the encapsulation can not finish the processing of one Time Slice Period until the allocation of all the services into the next Time Slice Period has been done (as the delta-T values of the first Time Slice Period depend on the allocation of the second Time Slice Period).

In this multiplexing scheme, the services are allocated into the Time Slicer in order according to a previously established priority. This priority becomes critical for the lowest priority services in the TimeSlicer in the situation when no bitrate left is available in the Time Slice Period and still some services need to be inserted. In this situation, the adopted solution is to discard packets from the incoming buffer since they will be discarded anyway by the player when being received beyond the time margin when they are expected. However, if this situation occurs is due to an incorrect configuration of the IP Encapsulator where the measure of needed bitrate has not been correctly made. In a more advanced scenario, a loop between the IP Encapsulator and the video encoders may solve this situation but this is not always possible due the nature of some networks where the input source is out of the scope of the mobile TV network.

Another considered aspect to improve the behavior of the Statistical Multiplexing scheme has been the increase of the peak bitrate absorption capacity by the insertion of an additional burst. The decision to insert an additional burst is made according to the state of the buffer of incoming IP flows for that service. The decision considers two aspects: the size of the buffer in IP packets after the encapsulation process and the control of RTP clock of the packets in the buffer to avoid RTP clock break and thus image/audio artifacts. If the size of the buffer in IP packets after the encapsulation process is bigger than the number of IP packets just encapsulated, then a new burst is inserted. Regarding the second control, if the packets remaining in the buffer contain an RTP time stamp so close taht may make that an encapsulation in the next Time Slice Period to break the RTP clock, then an additional burst is inserted in the current Time Slice Period at a position around Time Slice Period divided by two.

The insertion of this new burst implies that time collision between additional bursts and 'normal' bursts may occur into the Time Slicer and so bursts reallocation must be controlled.

The figure 5 shows a Time Slicer with one service with an additional burst after service reallocation due to time collision into the Time Slicer.

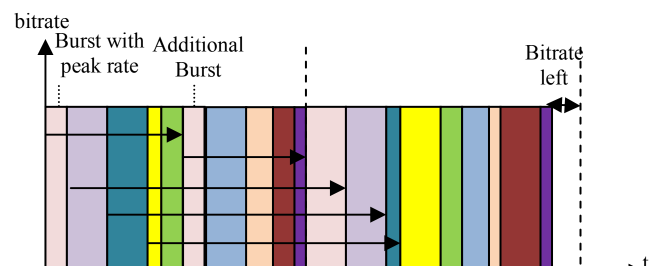

Fig. 5. Statistical multiplexing with additional burst insertion.

V. Static VS Statistical Multiplexing in DVB-H

This section compares both multiplexing schemes to show the benefits of Statistical Multiplexing. The test compares the increase in the number of services allocated when using statistical multiplexing when the number of combined services increases. In all the tests, the services have been configured in the same way with the same bitrate and configuration parameters; the only difference is the content of the videos.

For each point in the figure, the IP Encapsulator has been configured in static multiplexing with the maximum number of services allowed for certain combination of modulation, code rate and guard interval. For that combination of modulation, code rate and guard interval the IP Encapsulator is configured in Statistical Multiplexing measuring the maximum number of services that allocable within the bitrate available.

Figure 6 shows how the difference on the number of services allocable between statistical and static multiplexing increases with the number of services combined. The increase of capacity when using statistical multiplexing goes from 20% when combining 5 services up to 45% when combining more than 20 services.

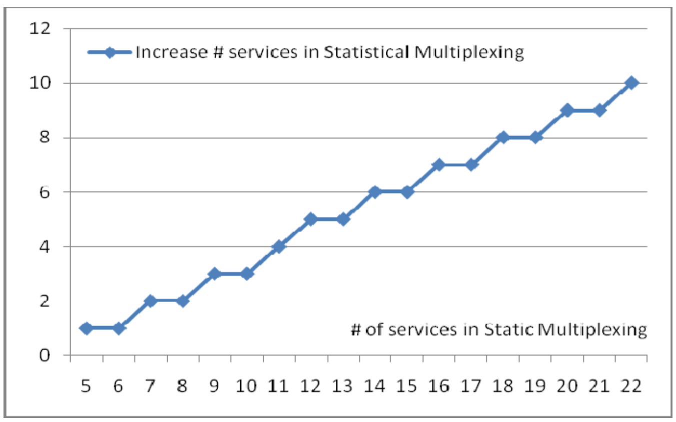

Fig. 6. Increase on the number of services when using statistical multiplexing compared to static multiplexing.

The tests have been developed using an open loop between the IP Encapsulator and the video encoders, thus the increase on capacity has considered strictly only the services without packet discarding.

VI. Conclusion

This work has presented the differences from Variable Bitrate and Constant Bitrate encoding for DVB-H and has focused on two possible multiplexing schemes based on Static Multiplexing or Statistical Multiplexing. The differences between Static and Statistical Multiplexing have also been presented by comparing similar configurations running at the same time with the same source, leading to the conclusion of an increase in capacity in terms of services allocated per multiplex. If a closed loop between the IP Encapsulator and the video encoders is possible, then Statistical Multiplexing offers a clear advantage especially when the number of services is high. When this loop is not possible, Statistical Multiplexing is still the better option since considerable capacity increase is possible with very low probability of packet discard in low priority services. Static Multiplexing is only the best option when having CBR sources, which is very unlikely, and/or when reserved bandwidth, is required for each service to guarantee independent service capacity transmission.

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