A New Switching Scheme for DVB-RCS+M Return Link in a Land based Scenario

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Abstract—**An important suggestion of the standard for DVB-RCS+M is the possibility of using a continuous carrier operation mode in the return channel beyond the classical MF-TDMA mode. In order to realize it a mechanism for switching between these two modalities has to be used. In this paper, after showing the typologies of applications considered in the simulation, a proposal of a novel switching mechanism is presented and the simulation results are reported in order to provide some guidelines to the satellite operators that want to adopt in their satellite system this hybrid mode. The simulation results provide good indications and this study is the base for more depth researches.**

Keywords: DVB-RCS, Return Link, MF-TDMA, SCPC, Switching Mechanism.

I. INTRODUCTION

The DVB-RCS+M standard includes guidelines for mobile user in the market of aircraft, maritime and terrestrial [1],[2],[3]. These studies have also shown one of the most important characteristics of the satellite terminals installed in airplanes, ships and trains, that is they have to manage aggregate and dynamic traffic pattern generated from a relatively high number of end-users that represent the passengers of the transportation vector. This requires a very dynamic capacity allocation mechanism in order to optimize the satellite capacity by using Single Channel Per Carrier (SCPC) with high aggregate traffic volume and Multi Frequency – Time Division Multiple Access (MF-TDMA) for bursty traffic pattern. The design of scalable and multimedia satellite systems integrated with terrestrial networks is an important issue to realize the convergence and the ubiquity of communication. Such as shown in previous works, scalable architecture [4][5], QoS mechanisms in multicast routing [6][7] and admission control and interworking functions [8] become essentials for a convergence among broadband satellite networks and IP backbone. At this purpose a switching mechanism is an important feature to be considered in satellite communications. In this work, the return link of DVB-RCS+M has been analyzed and, in particular, the attention has been focused on the dual uplink management suggested by the standard. The railway environment has been chosen as reference scenario, therefore mobile terminals are considered to be mounted on trains where the end-users are the passengers accessing to applications like HTTP, FTP and Video Conference. The model used for traffic representation are shown in order to highlight the impact of the traffic on the resource management. An algorithm to perform the switching between the two modalities (MF-TDMA and continuous carrier –SCPC) has been proposed which is able to guarantee the required constraints (latency, data rate…) to these applications. The proposed algorithm, called Threshold Basic Switching Algorithm (TBSA), is based on a threshold-crossing behavior. This modality allows the mobile terminal to send the information either in MF-TDMA or SCPC depending on the traffic demand. The TBSA controls the switching from MF-TDMA to SCPC mode based on the capacity request operated by the mobile terminal. Therefore, the switching from the SCPC to the MF-TDMA is done on the basis of the mobile terminal throughput (aggregate traffic volume). Section II presents the DVB-RCS+M architecture; the return link structure is explained in section III; the considered traffic models are presented in section IV; the proposed algorithm is presented in section V; and last, the performance evaluation and conclusions are summarized respectively in section VI and section VII.

II. DVB-RCS+M ARCHITECTURE

The DVB-RCS+M system architecture (see Figure 1) is based on the standard for fixed terminals composed of a DVB-RCS satellite, Return Channel Satellite Terminals (RCSTs), the Gateway (GTW) and the Network Control Centre (NCC). NCC and GTW can be the same object called HUB. The forward channel (from GTW to the terminals) is compliant with DVB-S2 standard, while, the return channel (from the terminals to the GTW) uses the DVB-RCS standard with the extension for mobile scenarios [1],[2].

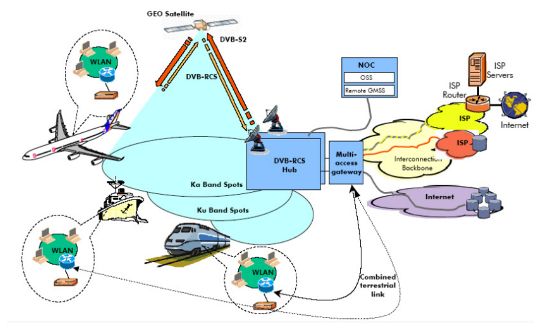

Figure 1. DVB-RCS+M Architecture.

The NCC is responsible of managing the resource allocation for the terminals and the GTW of managing the traffic queues. The NCC has the responsibility of processing the Capacity Requests (CRs) that come from RCST and, on the basis of these requests, it assigns resources through the Terminal Burst Time Plan (TBTP) table. In some case NCC and GTW are in the same device called HUB. The RCST are transportation vectors represented in the considered scenario by trains whose passengers using applications generate traffic on return channel.

III. RETURN CHANNEL STRUCTURE

In this paper, the considered return link is divided in two portions, one managed in a classical MF-TDMA mode with a frame as reported in the standard and the other in Single Channel Per Carrier (SCPC) also called continuous carrier operation that use a very short frame size (4kbit). In DVB-RCS systems, the resource allocation policy is based on the so-called Bandwidth on Demand (BoD). In the SCPC case, the use of continuous carriers in the return link has been adopted in order to exploit a simple and robust access mechanism for mobile DVB-RCS networks, in particular, for RCS Terminals with substantial traffic aggregation, like terminals represented by transportation vectors such as trains, ships and airplanes. In particular, the standard proposes two modalities in which a RCST terminal can work: one is called Basic RCST mode and the other one is called Enhanced RCST mode [1][2]. In the reference mobile scenario the traffic pattern is dynamic depending on the number of users accessing the network. The provisions in the standard are therefore designed to support a hybrid architecture that retains all the characteristics of a DVB-RCS network, while adding continuous carrier operation in the return link as an overlay.

IV. SWITCHING MECHANISM FOR THE RETURN LINK

In this work a simple algorithm for switching the terminal from MF-TDMA to SCPC and vice versa is proposed. It is a simple mechanism based on a threshold that states when a RCST terminal can move from the MF-TDMA modality to the SCPC one and vice versa. The proposed algorithm is composed of two parts. In the first part, if the RCST terminal is in a MF-TDMA mode, the proposed mechanism controls the capacity request performed by the terminal for the Rate Based Dynamic Capacity (RBDC) queue in order to decide if it is better to switch the RCST to a SCPC mode. The choice of performing the control only on RBDC queue has been done in order to better satisfy the QoS in the considered applications. In this work the Video Conference traffic has been mapped in the RBDC category and the HTTP and FTP traffics have been mapped in the Volume Based Dynamic Capacity (VBDC) category. This in order to give more priority to the video traffic that has more stringent constraints (end-to-end delay, jitter, etc.). In a given time window *wnd*, the mechanism verifies if the capacity request is higher than a certain threshold *thr*, previously empirically estimated through a specific campaign of simulations: in order to choose right values of *thr* and *wnd*, many observations of end-to-end delays and queue lengths have been made. After the preliminary simulations we stated that a value of *thr* equals to two times the value of maximum RBDC request and a value of *wnd* equals to 4 seconds lead the system to best results. If the capacity request is greater than *thr* for the overall time window *wnd*, then the NCC sends a Terminal Information Message (TIM) toward the RCST allowing it to the continuous carrier mode.

The second part previews that, if the terminal is in a SCPC mode, the mechanism controls, on periodical basis, the throughput of the specific terminal in order to state if there is a waste of bandwidth that would make more efficient the MF-TDMA mode in order to exploit the dynamic capacity request. The NCC performs a control now based on the throughput of the mobile terminal. If the throughput is lower than a threshold, evaluated through simulations, for a fixed time interval, the NCC sends a TIM message toward the RCST that it will switch from SCPC to MF-TDMA modality. For more details see [9]. In this work no Adaptive Coding and Modulation (ACM) mechanism has been considered.

V. TRAFFIC MODELS

In order to simulate a more realistic scenario and to get realistic and valid results, a set of real traffics (shaped realistically) have been considered in this work. For the simulations two different kinds of non-RT traffic (HTTP, FTP) and one kind of RT traffic (video conference) have been modeled on IP layer. Next subsections show the traffic considered in this work, such as HTTP, FTP and Video Conference.

A. HTTP Traffic Model

Web traffic is nowadays the most important application used by the internet community. The term web traffic comprises all HTTP traffic generated during a session with a typical web browser like Netscape Navigator or the Internet Explorer. A session is considered to be the time between start and exit of the browser (session level). Typically, HTTP traffic is modeled as an ON/OFF source with the ON state corresponding to the request and download of the objects and the OFF state corresponding to the inactive time. In this work the implementation is based on a work of the Communications Technology Laboratory of Intel Corporation of the 2007 [10]. The model used in this work follows the basic ON/OFF model. In this model the traffic was modeled as a series of user generated Web-Request. It has been considered an HTTP session that consists of a series of Web-Request. A Web-Request consists of one HTML object and zero or more embedded objects that arrive before the next HTML object. The first interval between the web-request and the first embedded object is called Parsing Time, the next intervals that follow a different distribution, are called Inter-Arrival-Time (IAT). At last, the time between the download of the last embedded object to the arrive of another page request is called Reading Time. The arrival process of a Web server can be considered as superimposing individual user requests to the server. A user who is browsing a page on the Web server usually initiated a request to an HTML document. Then, it possible to have separate requests that can be automatically or by user generated during the page downloading. After all the user's requests are completed, the page is said to be completely downloaded. The user, usually, takes some time to go through the page before browsing another page on the server. The delay introduced by the user is called Think Time or Reading Time. A user session may be ended if the user stops accessing the server or may be continued if the user accesses another page in the server after the reading time. The following figures show the impact of the HTTP capacity request on the system, in order to highlight that the HTTP traffic is a light traffic that requires low capacity to the system.

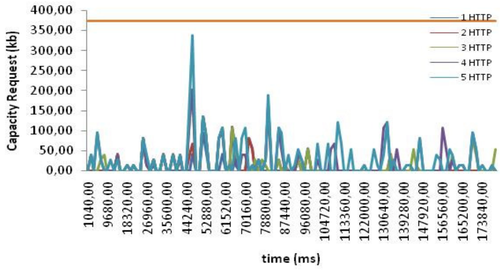

Figure 2. HTTP capacity request for a small number of users.

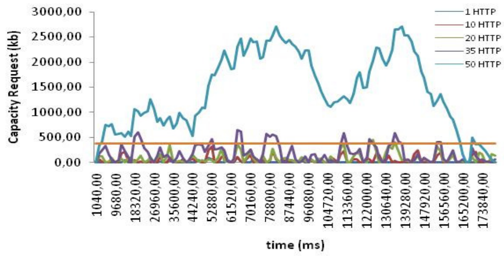

Figure 3. HTTP capacity request for a high number of users.

In fact it is possible to view that only a number of users equal to 50 puts the system in a heavy condition that requires the move towards the SCPC modality (see Figure 3). The line in Figure 2 and Figure 3 represents the considered capacity request threshold.

B. *FTP Traffic Model*

The importance of FTP is steadily decreasing with the upcoming of HTTP downloads. According to [11], an ESA project concerning on Broadband on Train, an FTP file transfer can be modeled like a web session with only one web request. The implementation in this work has been done creating a software model for the generation of a single HTML document, that is a HTTP page with the main object and a certain number of embedded object that have a size bigger from the HTTP case. The following figures show the impact of the FTP capacity request on the system, in order to highlight that the FTP traffic is a heavier traffic than the previous one. FTP requires more capacity to the system.

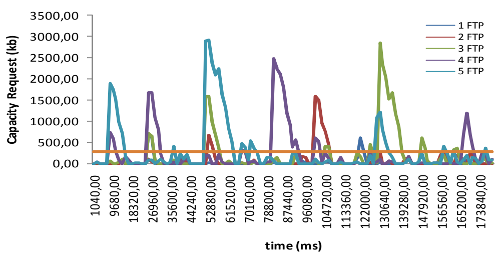

Figure 4. FTP capacity request for a small number of users.

In Figure 4 the graphic for a low number of users is shown, instead in Figure 5 the graphic for a higher number of users is presented.

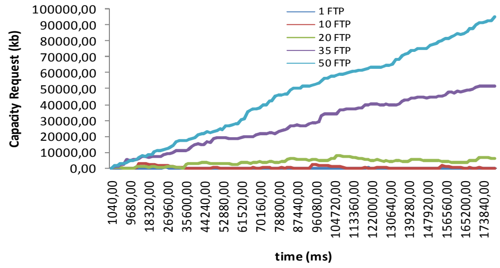

Figure 5. FTP capacity request for a great number of users.

C. *Video Conference Traffic Model*

The traffic generation for the Video Conference consists of two parts. First the arrival of a video session and second the behavior of the video source itself. The arrival of the Video Conference sessions is modeled with a Poisson distribution, the duration of a session as an exponential distributed random variable. The video source itself is modeled as a discrete time Markovian arrival Process [12],[13]. The bit-rate that is produced by a video-conferencing terminal has been considered as the aggregated output of M independent mini-sources (see Figure 3). Each of the mini-sources switches its state from ON to OFF and vice versa. A mini-source in the ON state produces traffic at a constant rate of *A* bits/sec - in the OFF state no traffic is generated. The time intervals that the mini-source is in the ON or OFF state are modeled by a geometric distribution. To prevent sudden variations in the generated traffic, it is considered, that only one ON-OFF or OFF-ON transition per generation time slot is allowed.

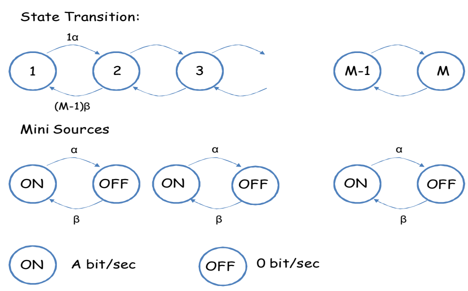

Figure 6. Video Conference Traffic Model.

A video traffic source based on the modulating process as in Figure 6 can be implemented as follows: as soon as the source enters the state *i* with leaving probabilities $i\alpha$ and $(M-1)\beta$ it is possible to generate two samples t_{incr}, t_{decr} from geometrically distributed random variables with mean values $1/i\alpha$ and $1/[(M-1)\beta]$ respectively. Hence, the sojourn time for state *i* in T_S units can be determined as $t_{sog} = \min\{t_{incr}, t_{decr}\}$; correspondingly, the transition accomplished at the end of interval t_{sog} is towards state *i -1*, if otherwise, the transition is towards state *i +1*. During t_{sog}

we have a source generating traffic at a constant bit-rate equal to *iA*. The following figures show the impact of the Video Conference CR on the system, in order to highlight that the Video traffic is the heaviest traffic considered in the system. Video Conference requires more capacity to the system than the other two considered traffics.

In Figure 7 the graphic for a low number of users is shown; instead in Figure 8 the graphic for a higher number of users is presented. It is possible to view how heavy this type of traffic and, then, how it is important to manage in a better way the return link resource.

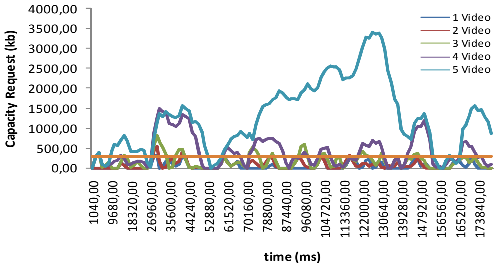

Figure 7. Video Conference capacity request for a small number of users.

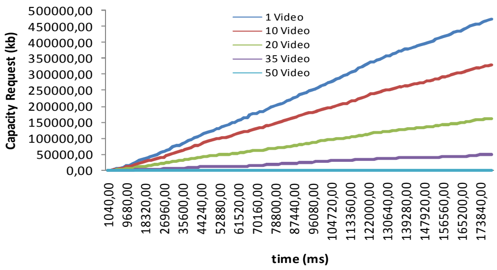

Figure 8. Video Conference capacity request for a great number of users.

VI. Performance Evaluation

In this implementation, the three types of applications previously presented are considered. In this section it will be shown how the traffic can affect the system resources and then what limits are used for the three typology of traffic in order to use the satellite capacity in a better way. The parameters considered for the simulations are reported in the table I. In order to make a fair comparison between the two modalities SCPC and MF-TDMA the correct parameters have been chosen. The guidelines on DVB-RCS standard [1] have a section on Turbo Code Performance where are presented the performance of the system for a PER of 10^{-5} and 10^{-7}. In this work a PER of 10^{-7} has been chosen. The value corresponding to DVB-RCS MF-TDMA scenario has been compared with the value in the case of SCPC, in order to have the same Es/N0 ratio. It is important that the obtained E_s/N_0 is the same for the two modalities because the satellite terminals have to be able to get the signal with their antenna system.

The considerations reported in this paper are qualitative analysis; impact of QoS is not investigated, it will be done in future works. The results show a comparison between a classical MF-TDMA operation scheme with a system that dedicates a part of the total return capacity to MF-TDMA and another one to SCPC and in which the proposed switching algorithm (TBSA) works.

TABLE I. Simulation Parameters

Total Capacity	10 MHz		
MF-TDMA Capacity (%)	100, 90, 85, 80, 75		
SCPC Capacity (%)	0, 10, 15, 20, 25		
Carrier MF-TDMA	500 kHz		
Carrier SCPC	500 kHz		
E_S/N_0	5.2 dB		
FEC MF-TDMA	2/3		
FEC SCPC	¾		
Continuous Carrier frame size	4kbit		
Modulation	QPSK		
# Mobile Terminal (RCST)	20, 22, 24, 26, 28, 30		
# User	1,2,3,4,5,10,20,35,50		
	HTTP	FTP	Video
Traffic percentage	60%	25%	15%

In order to make a fair comparison between the MF-TDMA and the SCPC modality the same bandwidth granularity has been chosen for both. A 500 kHz carrier has been considered for the simulations. This choice has been performed in order to make comparison on same channel capacity in the two modalities. In the system a total capacity of 10 MHz for the return link has been considered and different distribution of this capacity between MF-TDMA and SCPC mode are used in order to find the better distribution that guarantees the better performance in a system using the proposed algorithm. Moreover, different number of mobile terminals has been considered, from 20 to 30 in order to load the system from 100% to 150%. A scenario with a small number of Video Conference applications (that represents the most demanding application in terms of traffic) has been considered, that is, in this paper the results related to a scenario with 65% of HTTP traffic, 25% of FTP traffic and 15% of Video Conference traffic are reported.

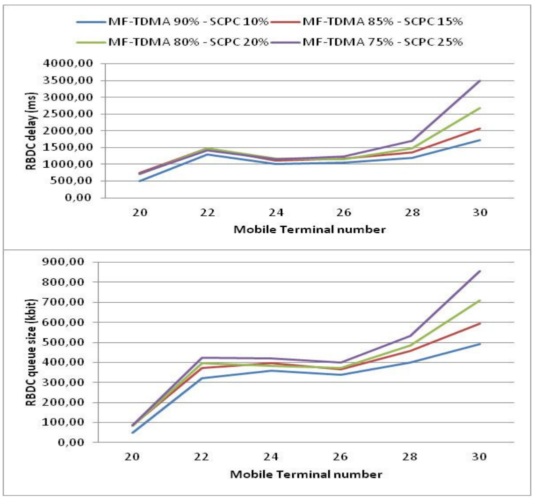

Figure 9. RBDC delay and queue size varying the capacity repartition between MF-TDMA and SCPC

In order to find the better capacity reparation between MF-TDMA and SCPC some simulations are performed. The results show that the repartition that allows to the system the better performance in terms of delay and queue size is a 90% of MF-TDMA and a 10% of SCPC. It is possible to note observing Figure 9 that this repartition guarantees lesser delay and lesser queue size for both capacity category considered in the work (VBDC results are not shown for space issues).

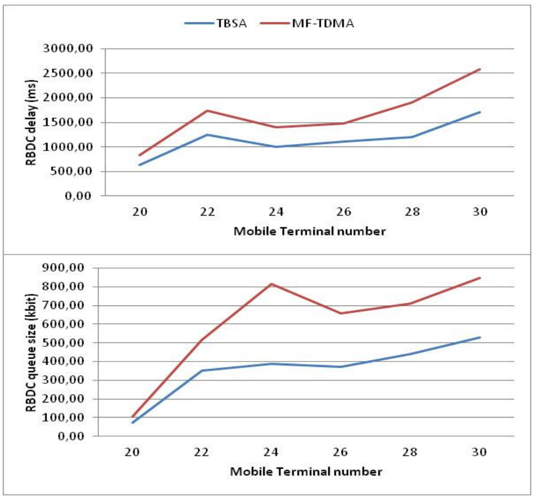

Figure 10. RBDC delay and queue size comparison between classical MF-TDMA system and a system with a 90% of MF-TDMA and 10% of SCPC and the TBSA algorithm.

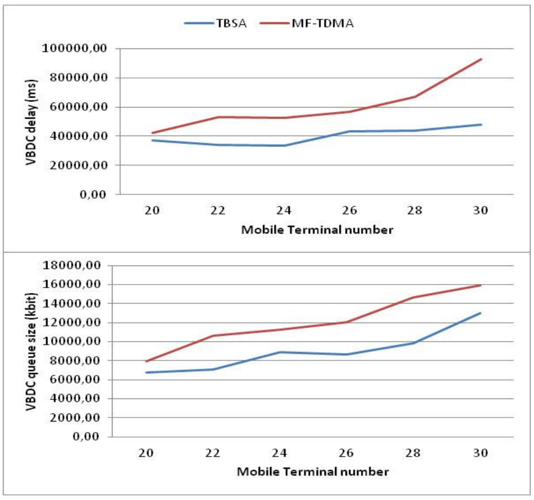

Figure 11. VBDC delay and queue size comparison between classical MF-TDMA system and a system with a 90% of MF-TDMA and 10% of SCPC and the TBSA algorithm.

In order to make a fair comparison between the two modalities SCPC and MF-TDMA the correct E_s/N_0 parameters have been chosen in this work. It is important that the obtained E_s/N_0 is the same for the two modalities because the satellite terminal has to be able to get the signal with its antenna system. It has been calculated that with a code rate of 2/3 for MF-TDMA mode for MPEG packets and a code rate of 3/4 for SCPC mode both with a modulation of QPSK the E_s/N_0 value is enough similar and then it is possible to make these choices for the system implementation. Figures 10 and 11 show the results of the comparison between the classical MF-TDMA and a system with a repartition of return link capacity of 90% MF-TDMA and 10% of SCPC in terms of delay. These results show that with the system and assumption analyzed and with the introduction of the TBSA algorithm the observed delay and the queue size are lower than a system that works only with a classical MF-TDMA scheme.

VII. CONCLUSIONS

In this work an algorithm to perform the switching between the two modalities MF-TDMA and SCPC has been proposed. Three types of applications have been considered and the work shows how the traffic can affect the system resources in order to use the satellite capacity in a better way. The proposed algorithm, called Threshold Basic Switching Algorithm (TBSA), meets the requirements imposed by the applications considered in the analysis. The TBSA provides a switching mode capable of better exploiting the system resource. Lower delay means better QoS provided by the network to the end users, queue size means better resource management. Thanks to these techniques, the network is able to save capacity and serve a greater number of mobile terminals while maintaining the QoS required by the users. Results show the performance of a system equipped with the TBSA algorithm compared with a classical MF-TDMA scheme.

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