A Novel MF-TDMA/SCPC Switching Algorithm for DVB-RCS/RCS2 Return Link in Railway Scenario

M. Tropea, P. Fazio, F. De Rango, A.F. Santamaria
DIMES Department, University of Calabria
Rende 87036 Cosenza, Italy

***Abstract*- This work focuses on the return channel resource allocation in the DVB-RCS/RCS2 system for mobile terminals. A Continuous Carrier operation mode based on DVB-S2/S2X is considered and investigated. The paper focuses on the possibility of transmitting simultaneously in MF-TDMA or SCPC medium access techniques, as suggested by a previous DVB-RCS+M standard. The introduction of this capability has also been analyzed for a new DVB-RCS2 standard that gives the possibility of using both return link modalities. Moreover, we propose a detailed study of the return link channel in a satellite platform in order to understand the operative range of SCPC and MF-TDMA techniques. The contribution seeks to provide some threshold indications to network operators for dynamically managing satellite resources. We considered the railway market, which is characterized by an N-LOS condition due to blockage caused by tunnels, vegetation, and buildings, as the reference scenario. Furthermore, we introduced a transparent gap filler solution to overcome this issue. Simulation campaigns are shown, in order to give to satellite operators some guidelines, when they want to make use of this hybrid channel modality.**

***Keywords* – Satellite, MF-TDMA, SCPC, Return Link, DVB-RCS/RCS2, DVB-S2/S2X**

I. INTRODUCTION

The Digital Video Broadcasting – Return Channel Satellite for Mobile (DVB-RCS+M) [1],[2],[3],[4],[5] and the successive DVB-RCS2 [6],[7] standards include guidelines for mobile users in the aircraft, maritime and terrestrial markets [3],[4],[8],[9]. One of the most important characteristics of the Satellite Terminals (STs) installed in airplanes, ships and trains, is their capability of managing aggregate and dynamic traffic patterns generated from a relatively high number of end-users. This requires a very dynamic capacity allocation mechanism in order to optimize satellite resources [10],[11],[12]. The dynamic capacity allocation mechanism is obtained by using the Single Channel Per Carrier (SCPC) access [13], with high aggregates of traffic volume and Multi Frequency–Time Division Multiple Access (MF-TDMA) for a bursty traffic pattern. The new DVB-RCS2 standard, enhancing the previous standard, suggests the possibility of using Continuous Carrier (CC) operation [6],[7] based on DVB-S2 [14] on the return channel. The design of scalable and multimedia satellite systems integrated with terrestrial [15],[16],[17],[18] and other wireless networks (e.g. sensor networks [19], HAP [20],[21]) is an important issue in realizing convergence and ubiquity of communications. Moreover, mobile services on satellite platforms are of great interest [22]. QoS multicast mechanisms, admission control and interworking functions [23],[24],[25] are essential for convergence among broadband satellite networks and an IP backbone. For this purpose, a switching mechanism is an important feature to consider in satellite communications. The main goal of the paper is the proposal of a new algorithm to perform switching between the two modalities (MF-TDMA and SCPC) in the Return Link (RL) of DVB-RCS/RCS2. It can guarantee the required constraints (delay, queue length, etc.) to the applications, both for "basic" and "enhanced" techniques. Moreover, we propose a new study on DVB-RCS2 performance in a railway scenario with a transparent (GF) solution. The two proposed ideas: one called Threshold Basic Switching Algorithm (TBSA) [26], and the other named Threshold Enhanced Switching Algorithm (TESA), are based on a *traffic threshold-aware resource management*. Both TBSA and TESA perform the switching from MF-TDMA to SCPC mode based on the MT Capacity Request (CR). Switching from the SCPC to the MF-TDMA mode is based on the MT throughput (aggregate traffic volume). We chose the railway environment as the reference scenario based on some studies initiated by ESA through a series of projects, such as [27]. It is classified as an N-LOS scenario that is a strong-fading environment, characterized by frequent/deep/long signal blockages and shadowing. A 3-state Markov channel model [9] was implemented; it considers the three main conditions in which a train can be: LOS, shadowing, and blockage states. We chose a transparent Gap Filler (GF) solution to take the issue introduced by tunnels in the trains' path into account. The considered GF solution considers the time values obtained in [28], which shows handover time values, due to the switch from satellite to GF on the tunnel entrance and from GF to satellite on the tunnel exit. On the basis of a detailed study on the lower link layers for the railway scenario, we implemented the Mobile Terminals (MTs) mounted on trains in our simulator, where the end-users are the passengers accessing HTTP, FTP and Video Conference applications. This work is organized as follows: Section II presents the main existing works in the literature; in section III the DVB-RCS/RSC2 architecture is described, while the mobility scenario is presented in section IV; section V describes the proposed algorithms; section VI describes the simulation environment. Performance evaluation and conclusions are summarized respectively in section VII and section VIII.

II. RELATED WORK AND CONTRIBUTION

DVB-RCS/RCS2 covers both physical and Media Access Control layer (MAC) protocols for downlink and uplink. In particular, the DVB-S/S2/S2X standard [14],[29] defines a high capacity broadcast channel that can be received by a large set of terminals; while the DVB-RCS2 standard [6],[7] defines the characteristics of the return channel, also in mobile conditions [30]. The DVB-RCS working group introduced some specific features to improve the performance of broadband services offered to mobile users in different mobile scenarios, leading first to DVB-RCS Mobile (DVB-RCS+M) [3],[4],[5] and then to DVB-RCS2. The most promising markets for DVB-RCS2 mobile applications are those related to public transportation. Three main market domains can be identified: aeronautical, maritime and railway [8],[27]. Due to the limitation of the available radio resources, one of the most important issues is to minimize the scheduling time and maximize the radio link throughput [31],[32],[33],[34],[35],[36]. For the RL in DVB-RCS2 systems, since there is neither a broadcasting effect as in the Forward Link (FL) nor a high reuse efficiency, much effort is invested in investigating how to achieve high capacity with limited available radio resources. Many works have been proposed in order to find an optimal timeslot schedule for each super-frame in a fixed MF-TDMA RL, so that the RL throughput is maximized [37],[38]. Regarding this issue, in [37] the authors separated the original optimization problem into two sub-problems. The optimal assignment amount vector was determined in a first phase and a Terminal Burst Time Plan (TBTP) was determined in a second phase. Experimental results have shown that good results can be reached in an efficient way. The design of scalable and multimedia satellite systems, integrated with terrestrial networks, is an important issue to realize the convergence and the ubiquity of communications. As shown in previous works, scalable architectures [39],[40], QoS mechanisms in multicast routing, admission control policies and interworking functions become essentials for a convergence among broadband satellite networks and IP backbone. With this aim, a switching mechanism is an important feature to consider in satellite communications. In [26] and [41] the authors provide another contribution regarding the possibility of using a CC operation mode in the return channel beyond the classical MF-TDMA mode. The authors present a novel switching mechanism and the obtained simulation results provide some guidelines to the satellite operators that wish to adopt the proposed idea in their satellite systems. In [42] the authors indicate TDM/TDMA and SCPC as the main alternative technologies for satellite networking, explaining the related important trends and trade-offs. Numerous studies exist on STs and FL, such as [43],[44],[45], where the authors analyze interferences for small aperture STs [43], giving indications on how to calculate the transponder power [44] and how to increase the throughput on FL [45]. The underlying idea of this paper is to design an RL resource utilization in DVB-RCS/RCS2 mobile platform, that needs to manage aggregate traffic generated from a relatively high number of end-users, representing transportation vector passengers. In this paper we propose a mechanism for using MF-TDMA with the SCPC approach to cope with the request increase due to aggregate users. We tested the mechanism with a network simulator written in Java language, based on the concurrent/agents programming paradigm. In particular, we consider the performance evaluation of a DVB-RCS satellite with simultaneous modalities in the return link and the performance of a DVB-RCS2 system under a railway scenario We implemented a transparent GF solution in the considered scenario to verify the effectiveness of our proposal in a more realistic case.

III. DVB-RCS/RCS2 Scenario Description

The considered space segment includes one GEO-satellite with a single beam configuration in Ku-band with an FL in DVB-S2/S2X [14],[29]. In order to perform a comparison between DVB-RCS [3],[4] and DVB-RCS2 [6],[7], we supposed that a satellite system can operate in both standards. We considered a regional case service coverage scenario (coverage of one country or part of a continent). We did not consider any handover mechanism.

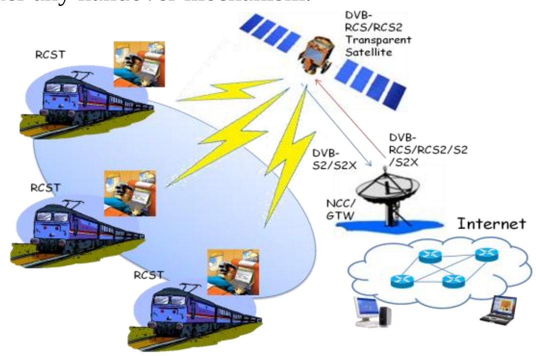


Figure 1. DVB-RCS/RCS2 System Scenario.

The ground segment sub-system consists of the Network Operator Centre (NOC), the Network Control Centers (NCCs), which are compatible with the definition of the NCC and the gateways, providing access to the terrestrial networks. The main NOC functionalities are: sharing the satellite resource among network operators; bandwidth allocation and centralized management of satellite handover if relevant. We suppose a certain number of RCSTs compliant with the DVB-RCS standard and others compliant with DVB-RCS2, that are managed by one single NCC within the satellite coverage area (as shown in Fig.1). In this scenario, the NCC manages the resource allocation for the terminals while the gateway (GTW) manages the traffic queues. The NCC has the responsibility of processing the CRs that come from RCSTs [3],[4].

A. *Changes introduced in DVB-RCS2*

While DVB-RCS2 retained the basic MF-TDMA nature of the return link from DVB-RCS, there were some incompatible changes. In particular they were made in the following areas: encapsulation variable-payload RLE (Return Link Encapsulation) vs. fixed-payload ATM/MPEG); FEC coding (16-state vs. 8-state turbo code); burst formatting (distributed pilots vs. preamble-only); modulation (extension to 8PSK and 16QAM) and dynamic operation (rapid changes to the time slot parameters). The support of "Adaptive Coding and Modulation (ACM) per burst" on TDMA carriers previewed in this new standard can produce a 2x to 2.5x increase in the average efficiency and throughput of those carriers in Ku or Ka band networks, while also greatly increasing link-level reliability. Moreover, the enhancement includes improvements in link availability for low Signal-to-Noise Ratio (SNR) environments; improved bandwidth efficiency and improvements in the encapsulation method for IP packets. Consequently, the recommended resource sharing method in the return link during migration from DVB-RCS to DVB-RCS2 is to exploit the multi-carrier nature of the transmission scheme, configuring separate sets of carriers with appropriate characteristics and capacity for the two terminals' populations. These characteristics make the new standard power/bandwidth efficiency better compared to the previous one.

B. Changes Introduced in DVB-S2X

The new standard DVB-S2X introduces a series of innovative technological improvements that aim to enhance satellite links up to 50% in many professional applications compared with the previous DVB-S2 standard. Applications like video on-demand now require many platform resources; thus the extensions introduced in this new standard seek to gain a higher system transmission rate in order to support Ultra High Definition Television (UHDTV). The main improvements suggested by the standard are: a smaller Roll-Off (RO) percentage than currently used in the DVB-S2 standard resulting in a better efficiency gain; Advanced Filtering Technologies for Improved Carrier Spacing whose results have an immediate effect on bandwidth savings; Increased Granularity in MODCODs; Higher Modulation Schemes up to 256 APSK; Very Low SNR for Mobile Applications; Different Classes for linear and non-linear MODCODs; Bonding of TV streams; Wideband Support; and Additional Standard Scrambling Sequences. Although there are gains in terms of increasing DVB-S2X, the capacity is lower than that obtained with the move from DVB-S to DVB-S2; it is attractive for satellite operators interested in new services.

C. Rate Based Dynamic Capacity (RBDC)

This capacity category is used for high priority variable rate traffic that can tolerate the MAC Scheduler dynamic response time latency. A maximum rate limit (MaxRBDC) can be set. The RBDC capacity is said to be guaranteed if the sum of CRA and MaxRBDC values configured in the MAC scheduler for each ST are constrained to the terminal physical transmission limit, and if the total (CRA + MaxRBDC) values for all STs in the segment/area are within the segment/area capacity. If these conditions are met, the RBDC is appropriate for traffic that requires bandwidth guarantees. In the case of overbooking, the latter condition is not met and, therefore, no absolute guarantees can be provided. Various strategies can be used concerning the requests in excess of MaxRBDC [46]. Some network operators may use overbooking in order to increase capacity utilization. It relies on the fact that, due to traffic variability, not all STs using RBDC transmit packets at the maximum rate (i.e. MaxRBDC). In this case, the capacity is guaranteed on a statistical base. Each request overrides all previous requests from the same terminal, and is subject to a configurable time-out period, to prevent a terminal anomaly resulting in a hanging capacity. In the considered architecture, CRs are sent by using SYNC slot. The request of a single capacity such as RBDC or VBDC can occur on periodical base k, where k is normally chosen as equal to a 32 superframe period (see standard [3],[4]). The calculation of the RBDC request is performed using the following equation (eq. 1), that consists of a term associated with the incoming traffic rate and another term associated with the RBDC queue length:

$$CR\_RBDC[k] = \left\lceil r_{IN} + \max\left\{0, p \cdot \left[queue\_length - (k \cdot T_{SF}) \cdot r_{IN}\right]\right\}\right\rceil \quad (1)$$

where r_{IN} is the current incoming rate, *queue_length* is the current MPEG queue length in bits, T_{SF} is the superframe period and p is a constant value that indicates in which measure the request takes queue occupancy into account. The algorithm then checks if it is possible to send the CR. It limits the CR request to maxRBDC request (eq. 2):

$$if\ (CR\_RBDC[k] > \max RBDC)\ CR\_RBDC[k] = \max RBDC \quad (2)$$

and it sets the RBDC timer to *timeout_RBDC*. The controller mechanism on NCC takes this request. Moreover, it performs a control on the timeout_RBDC. In fact, if it does not receive a request and the timeout_RBDC has not expired, it considers the current request as the previous one; otherwise if the timer is expired it sets the request to 0.

D. Volume Based Dynamic Capacity (VBDC)

This capacity category is used for applications that can tolerate delay jitter such as Internet Best Effort class. VBDC is provided in response to dynamic volume requests from the ST to the MAC Scheduler (a volume request is for a given number of slots with no time constraint). VBDC is not guaranteed and it is managed after satisfying the total CRA and RBDC capacity components. The amount of VBDC assigned to a terminal can be limited to a MaxVBDC value, based on rules set by the network administrator or by traffic measurements [46]. As for the RBDC CR, also for VBDC the RCST sends the request on the SYNC burst with k granularity, where k is an integer number that represents the superframe period. We performed the calculation of the VBDC request using the following equation (eq. 3), consisting of a term associated with the incoming volume of data, measured in bits that arrive at RCST and the second term associated with the VBDC queue occupancy:

$$CR\_VBDC[k] = \left\lceil volume_{IN} + \max\left\{0, p \cdot \left[queue\_length - volume_{IN}\right]\right\}\right\rceil \quad (3)$$

where: $volume_{IN}$ is the current incoming bits that have entered the queue, *queue_length* is the current MPEG queue length in bits and p is a constant value that indicates in which measure the request takes into account of the queue occupancy. Then, the algorithm checks if it is possible to send the CR. It can limit the CR to maxVBDC request (eq. 4):

$$if\ (CR\_VBDC[k] > \max VBDC)\ CR\_VBDC[k] = \max VBDC \quad (4)$$

it sets the VBDC timer to *timeout_VBDC*. The controller mechanism on NCC takes this request. It performs also a control on the *timeout_VBDC*. In fact, it does not receive a request and the *timeout_VBDC* has not expired it considers the current request as the previous one, otherwise if the timer is expired it sets the request to 0.

IV. Mobility Scenario

The main reference markets for mobile satellite scenarios comprise aeronautical, maritime and terrestrial segments. For the aeronautical and maritime segments a purely AWGN channel [5] can assume and approximate a LOS channel, where the latter is classified as an N-LOS scenario. It is a strong-fading scenario characterized by frequent/deep/long signal blockages and shadowing. The mobility effects, such as multipath, shadowing and blockage, encountered due to the local environment in the vicinity of the mobile RCST, such as adjacent buildings, vegetation, bridges, and tunnels, result in severe fading N-LOS conditions. We performed several measurements of propagation in Ku and Ka band, based on statistical channel models proposed in literature. For Ku-band, the behavior of the land mobile satellite channel can be modeled using a 3-state (namely LOS, shadowing and blockage) Markov chain, where each state is further characterized by a Rice distribution. The railroad satellite channel is in LOS state for most of the time. However, short blockages due to power arches as well as long blockages due to obstacles, such as buildings, vegetation, bridges, and tunnels, are also possible leading to N-LOS effects. In this study, the referenced scenario is the Rome-Naples railway path (see Fig.2) with the following characteristics: total length 205 km with 168 km in LOS and 37 km in tunnels and a max speed of 300 km/h. In this work, two assumptions were made for the N-LOS condition. The shadow case due to power arches and vegetation was addressed with the FEC. Instead, we adopted a transparent GF [28] solution in order to manage the blockage case during the train's path. We addressed the GF issue taking into account paper [28].

Figure 2. Rome-Naples railway path

We have used the FEC technique by making the assumption of considering only small fading, but other interesting approaches exist that face with these issues. In particular, in order to face with long scale fading an upper layer technique that considers packet elements and not just bits it possible to use [47]. This approach can be more efficient in the case of a long scale fading thanks to the longer codeword duration whereas physical layer FEC can be more suitable for small scale fading. For what concerns blockage case another suitable approach consists in DTN based technique [48]. DTN exploits a new packet called bundle that is transmitted in a "custody and transfer" manner to adjacent nodes. This permits of transmitting information also in the so called channel disruption due to tunnels on railways or highways induced by mobility. The simulations performed in this work assume a handover time due to the switch from satellite to GF at the tunnel entrance and from GF to satellite at the tunnel exit. The work takes into account the time values obtained in [28] which shows handover time values varying train speed. We did not consider a handover, in this paper, we supposed that trains are inside a regional beam that, as can be read in the standard, can cover a country or a part of a continent.

V. Proposed Algorithms: TBSA and TESA

In this contribution, we propose two algorithms for switching terminals from MF-TDMA to SCPC access techniques and vice versa. Moreover, "basic" and "enhanced" modalities provided in the previous DVB-RCS+M standard are evaluated. The algorithms are based on a simple threshold mechanism that states when an RCST terminal can move from MF-TDMA modality to SCPC and vice-versa. Both proposed algorithms consist of two parts: one related to the CR control (in order to switch from MF-TDMA to SCPC) and the other one related to the throughput control of the MT. In particular, the latter one enables the NCC to send an appropriate Terminal Information Message (TIM) towards the RCST, in order to switch from SCPC to MF-TDMA mode). The new DVB-RCS2 standard also suggests the possibility of using both modalities, so we conducted a performance analysis of the return channel in DVB-RCS2 technology. Before explaining how the MF-TDMA<->SCPC transitions take place, we provide a brief explanation of the CC operation in RL.

A. *Continuous Carrier (CC) Operation in Return Link*

We adopted the use of CC in the RL in order to exploit a simple and robust access mechanism for mobile DVB-RCS/RCS2 networks, especially for RCSTs with substantial traffic aggregation, such as those serving trains, cruise ships and commercial aircraft. Such RCSTs may have a sufficient number of users behind them. In this way, the efficiency gains of CC operation outweigh the inherently incurred losses when using a highly responsive Demand Assignment mechanism such as that in the DVB-RCS/RCS2 MF-TDMA scheme. We can consider the CC mode as an add-on to the classical DVB-RCS/RCS2 system. In any given network, it is unlikely that all terminals will operate in CC mode all the time. The provisions in the standard are therefore designed to support a hybrid architecture that retains all the characteristics of a DVB-RCS/RCS2 network, while adding CC operation in the RL as an overlay. Note that the FL is unchanged, except for the addition of some signaling elements needed to control the CC system itself. In order to ensure maximum flexibility for operation of an RCST while retaining backwards compatibility, we define CC operation in terms of a number of functional states that complement the existing RCST state diagram defined in clause 7 of the standard [3],[4] and [6],[7]. An RCST declaring support for "basic" CC operation is capable of transmitting either a CC or an MF-TDMA signal, but will normally not be able to transmit both carriers simultaneously. An RCST declaring support for "enhanced" CC operation is able to transmit both types of signal simultaneously (only in DVB-RCS). A way of using CC is that each terminal can be

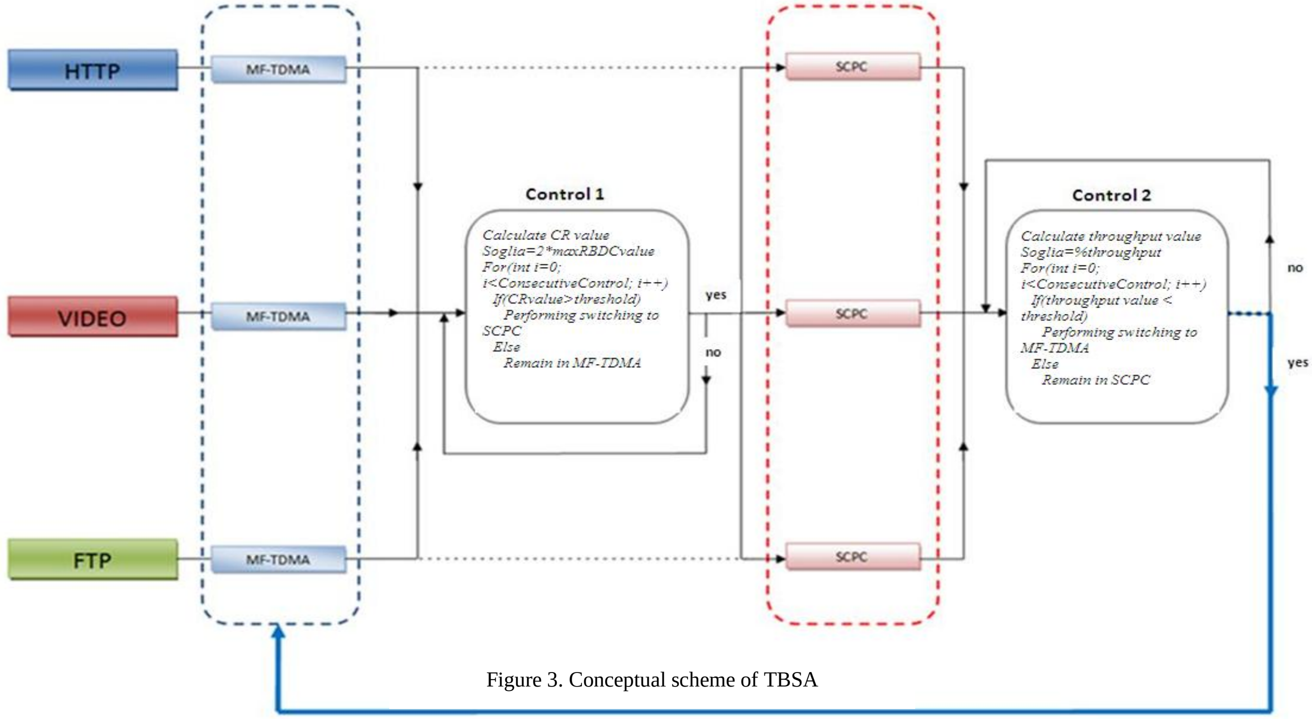


Figure 3. Conceptual scheme of TBSA

permanently assigned to a carrier. This is obviously the simplest in terms of management, but it is wasteful of bandwidth if the terminal is inactive for extended periods. System control is implemented by the exchange of signaling messages between the RCST and NCC. Due to the nature of the chosen architecture, an FL signaling path always exists. The definition of the characteristics of the available CC and the assignment/revocation process are handled within the existing signaling framework, i.e., TBTP2 in DVB-RCS2 [3],[4],[5]. In this work, we suppose that a portion of uplink bandwidth is dedicated to CC modality. In the CC, IP datagrams are encapsulated over DVB-S2/S2X, and called BBFRAME (in information bits) or FECFRAME (in coded bits).

B. TBSA - Moving from MF-TDMA to SCPC

If the RCST terminal is operating in the MF-TDMA mode, the proposed mechanism controls its RBDC CR request. Then, the RCST can decide if it is better to switch to the SCPC mode, in order to receive a static carrier [14].

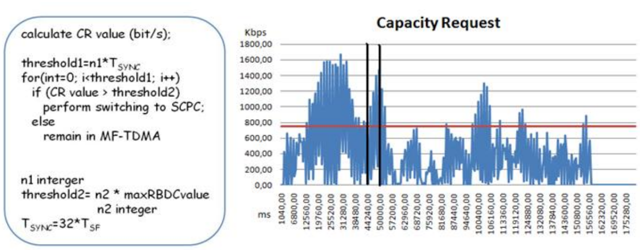


Figure 4. Pseudo-code and example of CR control on TBSA algorithm.

This choice can be made to better satisfy the guarantee of more constrained traffic, such as audio and video applications. Fig.3 shows a conceptual scheme and a pseudo-code of the proposed control mechanism performed in the NCC satellite terminal. The mechanism checks if the CR is greater than a threshold (*threshold2*) in a time window, as shown in Fig.4. If the CR is greater than the *threshold2* for an amount of time equal to *threshold1*, then the NCC sends a TIM message toward the RCST in order to switch from MF-TDMA to SCPC. In order to set the threshold values used in the algorithm, we conducted numerous simulation campaigns. For details, see [26].

C. TBSA - Moving from SCPC to MF-TDMA

If the terminal is operating in the SCPC modality, the mechanism checks the throughput of the specific terminal on a periodical basis, in order to state if there is a waste of bandwidth. If so, then it is better to move the RCST to the MF-TDMA mode, in order to exploit the dynamic CR.

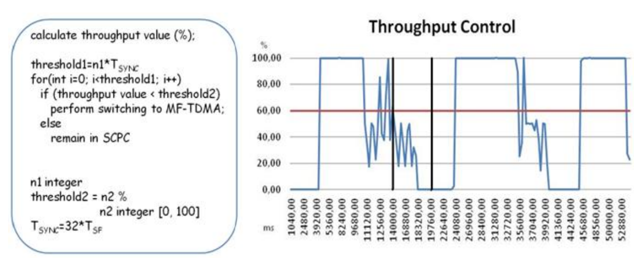


Figure 5. Pseudo-code and example of throughput control on NCC.

Fig.5 shows the pseudo-code that describes the behavior of the control mechanism. As in the previous case, the NCC performs a control that is now based on the MT throughput also for switching from SCPC to MF-TDMA modes. If it is lower than a threshold (*threshold1*) for a certain amount of time, the NCC sends a TIM message towards the RCST that

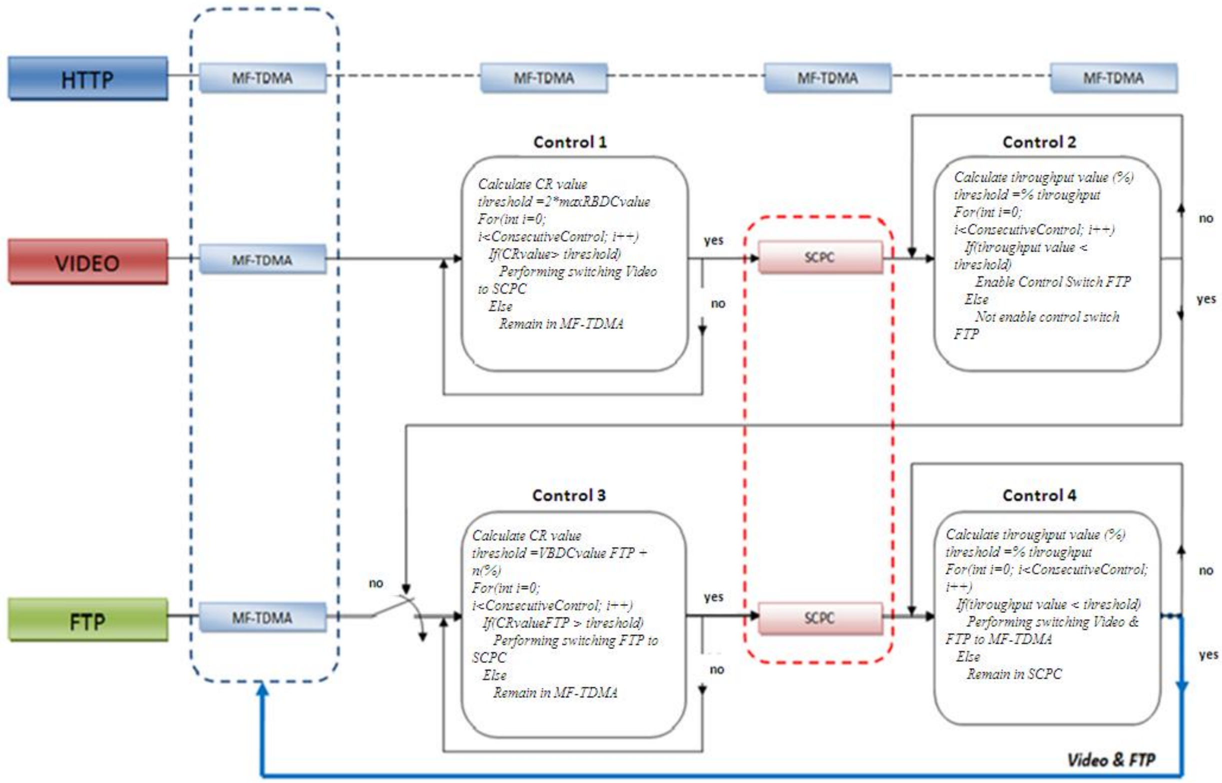


Figure 6. The TESA conceptual scheme and pseudo-code.

will switch from SCPC to MF-TDMA modality. Moreover, in Fig.5 it is possible to view the throughput check operated by NCC. For details, see [26].

D. TESA – Threshold Enhanced Switching Algorithm

Based on the TSBA, in this section we propose a new algorithm for the "enhanced mode". It is also a threshold-based mechanism for the switching between MF-TDMA and SCPC, called TESA. It works starting from the MF-TDMA modality and the idea is to transmit HTTP applications in MF-TDMA mode only, allowing Video and FTP applications to switch between the two modalities, on the basis of two threshold mechanisms. Fig.6, shows a simple schema of the algorithm and, in the following, the used mechanisms are illustrated.

E. Control 1: Switch Video from MF-TDMA to SCPC

This control is performed to decide whether it is better to switch RCST Video applications from MF-TDMA to SCPC mode. The core of the mechanism is similar to the previous algorithm. It checks if CR is over the threshold in a specific time window (represented in the algorithm by a number of consecutive controls). In this case, like TBSA, NCC sends a TIM message towards the terminal, in order to exploit the benefit of an SCPC transmission. Fig.6 shows a simple pseudo-code of the proposed mechanism.

F. Control 2: Enable control mechanism for the FTP switching

Once Video traffic for a terminal is sent along the network in SCPC mode, it is necessary to check if its throughput is not below a prefixed threshold. After several simulation campaigns, we identified the threshold to be 90%. If throughput is lesser than this value, it means that there is a waste of bandwidth. In order to use the bandwidth in a better way, a new mechanism for switching the FTP applications is enabled and, then, the control is performed on FTP traffic. Fig.6 shows the pseudo-code of the proposed mechanism.

G. Control 3: Switch FTP from MF-TDMA to SCPC

Once the control of FTP traffic is enabled, the proposed mechanism controls the FTP CR for the VBDC queue. If CR is greater than the fixed threshold (fixed as the CR value augmented by 50% of its value based on a specific simulation campaign), the system will enable switching to SCPC modality. Naturally, the control has to be applied in a time window. In Fig.6 the pseudo-code is also shown.

H. Control 4: Switch Video and FTP from SCPC to MF-TDMA

Finally, once the FTP traffic is switched to SCPC mode, the control has to verify that the throughput is sufficiently high in order to avoid bandwidth waste. Subsequently, it can release the bandwidth for other terminals that have requested it. The mechanism is very simple and also very similar to TBSA control, where the NCC checks the throughput and decides if it is better to operate the switching, through the use of TIM message towards the RCST. The main difference with the TBSA algorithm is that the HTTP traffic is always transmitted in MF-TDMA mode, while Video and FTP applications are subject to switching, allowing RCST to operate simultaneously in MF-TDMA and SCPC. Obviously, this is possible only if the RCST makes use of two transmission circuits. Fig.6 shows the pseudo-code of the proposed mechanism.

VI. Simulator Environment Description

In this paragraph, we introduce the description of the simulation environment to illustrate the software used for the implementation and the assumptions made in order to simplify the realization of the simulation software. The realized software allows the detailed modeling of the uplink channel of a DVB-RCS/RCS2 satellite architecture for the MT. The tool is programmed in Java language and runs on a Windows platform. The final result is a platform able to simulate the uplink of both standards, capable of using the MF-TDMA or the SCPC modality in order to better handle system resources. To make simulator implementation easier and to focus our attention on the goal of this work, we assume that the considered satellite system has a fixed MF-TDMA frame structure where bandwidth and slot duration are fixed in RCSTs. Moreover, we also assume that frame and superframe durations are the same. An RL continuous transmission can use a very short frame size (4096 bits or 4k bits). This very short frame is an extension of the DVB-S2 format and applies the recommendation described in [14]. We chose a superframe period of 45 ms (as suggested by the standard [3],[4]). We considered the propagation delay for the satellite link to be 125 ms. Moreover, we assumed that the satellite channel is "Quasi Error Free (QEF)". In order to simplify the test scenario, we considered a zero Bit Error Rate (BER) during the simulation campaigns. The considered value of the RO factor, as suggested by [3],[4], is 0.35. A superframe period of 45 ms and an allocation granularity of 32 kbps were assumed. The reference design is based on a symbol rate of 270 ksps. We chose 270 ksps as basic rate due to its simple relationship with the clock of the system (27 MHz). It is, of course, possible to use other symbol rates [27].

A. *Physical Parameters*

In order to make a fair comparison between the SCPC and MF-TDMA modalities, we identified the correct parameters. It is important to notice that the obtained E_s/N_0 is the same for the two modalities, as the satellite terminal has to be able to obtain the signal with its antenna system. Then we chose the physical parameters by taking into account that the E_s/N_0 value has to be almost equal both in MF-TDMA and SCPC cases. The guidelines on the DVB-RCS standard [5] have a section on Turbo Code Performance where the performance of the system for a PER of 10^{-5} and a PER of 10^{-7} in terms of E_b/N_0 are presented. In this work, we chose a PER of 10^{-7} (it is then simple to convert E_b/N_0 in E_s/N_0). In this work, we chose the MPEG encapsulation with the assumption that only one MPEG packet can be mapped in one slot. A table with the association between FEC and E_b/N_0 values for the MF-TDMA mode is shown in the standard [4]. Another table is presented in [46], [49] where it is possible to view the value of the code rate associated with the E_b/N_0 value in the case of SCPC mode. 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 the SCPC mode both with a modulation of QPSK, the E_s/N_0 value is similar enough. It is possible to make these choices for system implementation. Both tables report the E_b/N_0 value, based on Annex D.2 of guidelines [4]. Furthermore, it is possible to calculate the E_s/N_0 in dB based on the following relation (this coding scheme is still valid for DVB-RCS2 [6]):

$$\frac{E_b}{N_0}=\frac{1}{Coderate}\cdot\frac{Symbol}{Bit}\cdot\frac{E_s}{N_0}\Rightarrow\frac{E_s}{N_0}=Coderate\cdot\frac{Bit}{Symbol}\cdot\frac{E_b}{N_0} \quad (5)$$

In the following the Es/N_0 value for MF-TDMA and SCPC 4k mode: $\frac{E_s}{N_0}=\frac{2}{3}\cdot 2\cdot 4.0=5.33dB$ – $\frac{E_s}{N_0}=\frac{3}{4}\cdot 2\cdot 3.3=4.95dB$

VII. Simulation Results

In this section, simulation results will be presented. We compared a classical MF-TDMA operation scheme with a system where the proposed switching algorithms (TBSA and TESA) are implemented. In this system, the available capacity of the return link is divided between MF-TDMA and SCPC operational mode. The work focuses first on both the "basic" and "enhanced" RCST operational mode as suggested by the previous DVB-RCS standard. It then focused on performance in a DVB-RCS2 system where enhancement was introduced in the platform. In order to make a fair comparison between the MF-TDMA and the SCPC modalities, we chose the same bandwidth frequency granularity for both. We considered a carrier of 500 kHz to carry out the simulation results. Table I reports the main parameters considered in the simulation that are valid for both satellite platforms.

TABLE I
SIMULATION PARAMETERS

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		3/4	
# Mobile Terminals (RCSTs/Trains)		20,22,24,26,28,30	
# User		35	
	HTTP	FTP	Video
Scenario 1	70%	20%	10%
Scenario 2	60%	25%	15%
Scenario 3	50%	30%	20%

In the system, we considered a total bandwidth of 10 MHz for the RL and used different distributions of this capacity between MF-TDMA and SCPC mode in order to find the right distribution that guarantees the better performance in a system, using the proposed algorithm. Moreover, we considered different numbers of MT that correspond to a different number of trains inside the selected regional area, from 20 to 30, in order to load the system from 100% to 150%. Furthermore, we consider three different types of scenarios for the simulations. The first has a small number of Video Conference applications that represents the heaviest traffic of those considered in the system. The second presents an intermediate number of terminals with Video traffic such as referred in table I. The latter has a greater number of Video applications, in order to analyze the system behavior in these different conditions. As shown in [26], first of all we conducted a simulation campaign to find better capacity repartition, that allows better system performance in terms of delay and queue size. The values found and used in the next simulations are 90% of MF-TDMA and 10% of SCPC. We used these values in both the proposed and compared algorithms. As described in section IV we considered a transparent GF solution consisting of a simple frequency conversion and signal amplification. Due to space limitation, we provide only simulations for scenario 1 and 2, but the same considerations can be made for scenario 3

A. *Simulation results for TBSA and TESA Algorithms Comparison in DVB-RCS system*

In this work, as in [26], we also performed different simulation campaigns considering the parameters shown in table I. The aim of this section is to perform a comparison between the new proposed algorithm and the TBSA [26]. Both algorithms are based on the two suggested modalities of previous European Telecommunication Standards Institute (ETSI) standard [4], [5]. Use of an SCPC for the return channel in the DVB-RCS mobile is suggested. In particular, it proposes an “enhanced mode” (ST can work simultaneously in MF-TDMA and SCPC modalities) and a “basic mode” (contemporary modalities are not allowed). After the proposal of a new threshold based algorithm called TESA, this section shows a comparison with the previous TBSA, in order to demonstrate how the new one is the best trade-off in achieving a better utilization of the satellite resources. In our previous work, see [26], we showed that, based on a specific simulation campaign, the better repartition of RL capacity is 90% of MF-TDMA and 10% of SCPC. The obtained results prove that the observed delay and queue size with TBSA algorithm are lower than a system with a classical MF-TDMA scheme. In this section, we conduct a comparison between TBSA and TESA algorithms, for the same scenarios considered in [26]. The considered mobility scenario is a railway environment assumed to be in a LOS condition on the basis of the consideration that, for most of the time, trains are in direct visibility with the satellite. Fig.7 shows a comparison between the delay of RBDC for the TBSA and TESA mechanisms in scenario 1 and 2. It is possible to observe the trend of the curves compared with the curve of the classical MF-TDMA approach, typical of satellite platforms. In both scenarios, the TESA algorithm curve shows better performance values due to better satellite resources management. This is due to the “enhanced mode” approach. Both scenarios show that the TESA approach allows a lower delay for RBDC, if compared to TBSA. This permits the QoS satisfaction for a real time class of traffic, such as video applications. Fig.8 shows a comparison between the delay of VBDC category for TBSA and TESA approaches. For this capacity category, it is also possible to make the same considerations of RBDC. Figs.9 and 10 show the queue size comparison, for both capacity categories, RBDC and VBDC. The TESA mechanism allows a major saving in terms of queue size, guaranteeing a better respect of the QoS parameters of the traffic flow. The double modality allows a better queue management for those applications that use a lot of bandwidth, separating traffic queues and guaranteeing a better tradeoff for queues dedicated to real time applications. In the last considered scenario, a greater number of videos were considered, in order to understand the system behavior when a lot of users request a large amount of traffic. The same simulation campaigns were performed and the same considerations can be made. When compared with the TBSA, the system with the TESA approach has an enhanced performance in terms of delay and queue size.

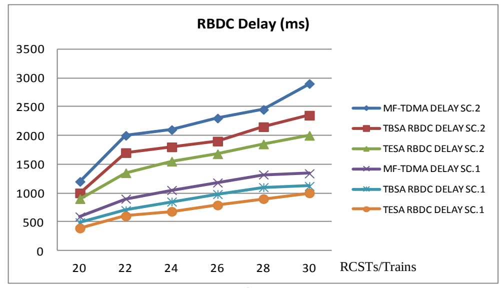


Figure 7. RBDC delay comparison for TBSA and TESA in scenario 1 and 2.

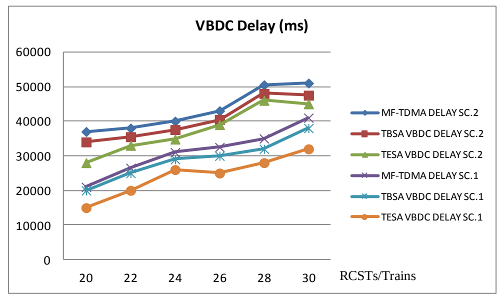


Figure 8. VBDC delay comparison for TBSA and TESA in scenario 1 and 2.

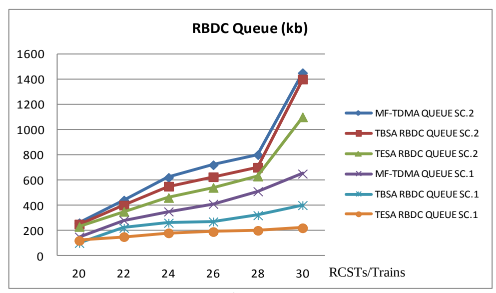


Figure 9. RBDC queue comparison for TBSA and TESA in scenario 1 and 2.

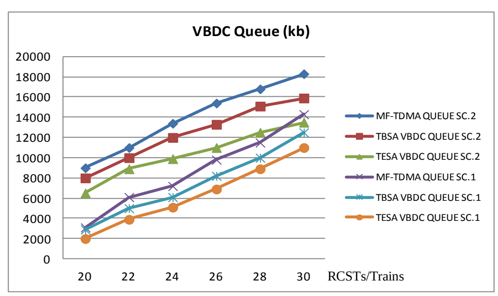


Figure 10. VBDC queue comparison for TBSA and TESA in scenario 1 and 2.

B. *Simulation results for RL performance in DVB-RCS2 system with Transparent Gap Filler solution*

In this section we conduct the performance analysis of a DVB-RCS2 railway scenario. In order to make the considered scenario more realistic, we implemented a 3 state Markov channel model that considers a LOS, Shadow and Blockage state. We then implemented a transparent GF solution that considers only a simple frequency conversion and signal amplification. The considered simulation parameters are equal to the previous one. In the system equipped with a DVB-RCS2 satellite, we took only the TBSA algorithm into account due to the suggestion in the new standard. In this scenario, with the introduction of the new standard, we also considered a GF issue faced with a transparent solution that previews the use of device at the entrance of tunnels.

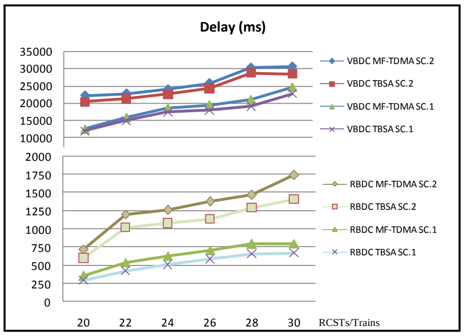


Figure 11. Delay comparison MF-TDMA vs. TBSA in DVB-RCS2 system

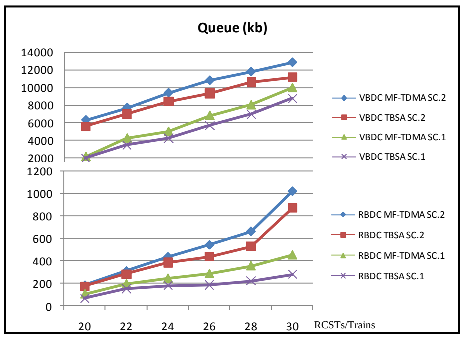


Figure 12. Queue comparison MF-TDMA vs. TBSA in DVB-RCS2 system

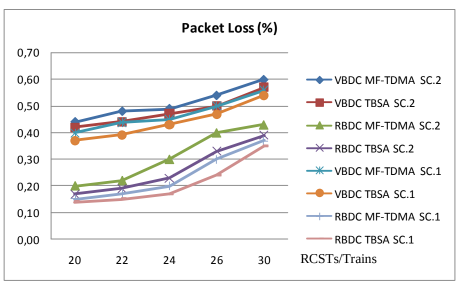


Figure 13. PL % comparison MF-TDMA vs. TBSA in DVB-RCS2 system

The performance analysis has shown the trends of delay and queue length varying the number of trains in the system in order to exploit the satellite resources. Fig.11 shows a comparison between MF-TDMA and TBSA for both RBDC and VBDC traffic classes. For the proposed algorithm it is possible to observe a better performance result, in terms of packet loss and delay, for both traffic classes and considered scenarios. It is possible to conclude that there is a better management of the return link with the possibility of using a CC operation. Fig.12 shows the trend for the queue size for both classes of traffic in both considered scenarios. Also in this case it is possible to draw same considerations made for the delay case. Fig.13 shows the Packet Loss (PL) percentage. It indicates how the packet loss degrades due to the handover time in the switching between satellite and GF device when the train is entering into the tunnel. It is also possible to notice that the packets loss is quite low and thus it does not create a problem for the QoS requirements. Finally, Fig.14 shows the throughput comparison between classical MF-TDMA, SCPC and the two proposed algorithms. It is possible to note how the performance of our proposals are similar to that of the MF-TDMA. This is due to the prefixed capacity repartition of the total satellite resources. The proposed algorithms then are able to guarantee QoS requirements with high throughput values. For space limitations problems we have shown only the curves for scenario 3 but the trend is respected also in the other ones.

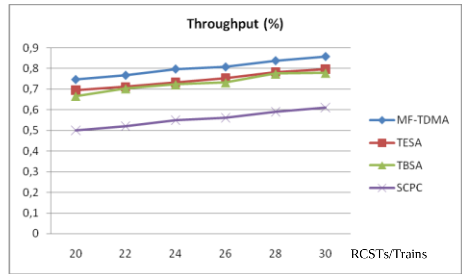


Figure 14. Throughput % comparison in DVB-RCS2 system in the scenario 3

VIII. Conclusions

In this work, we analyzed the RL of DVB-RCS/RCS2 standard for MTs in a railway scenario characterized by an N-LOS condition due to tunnels in the railway. This work has focused on the dual mode operation of the RCST suggested by the standard: it allows the terminal to switch from the classical MF-TDMA assign-on-demand mode to a SCPC mode. The use of a CC scheme is very useful for MTs that, managing an aggregate of users, would need to perform many CRs to the satellite. In such scenarios, the signaling overhead associated to the on-demand capacity assignment would make the system less efficient. In this work, we proposed the TESA algorithm, in order to perform a switching between the two modalities, MF-TDMA and SCPC, as well as a comparison with a previous proposal, TBSA. Moreover, we studied the introduction of the new DVB-RCS2 standard in the railway scenario (characterized by a GF issue due to tunnels on the path) and showed its performance. The results, shown in this paper, highlight lower delay, which means a better QoS provided by the network to end users and a reduced queue size, which, consequently, means better resource management. These results show satellite operators a possible capacity saving and then to be able to handle a greater number of MTs, while satisfying the QoS required by users.

Acknowledgment

This work was made possible thanks the contribution of the ESA group, in particular thanks to Ana Bolea Alamanac and Domenico Mignolo for their precious contribution.

References

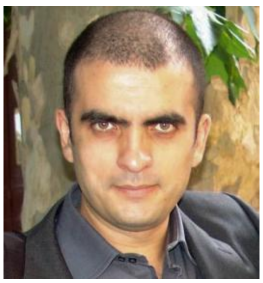
[1] Skinnemoen, H., & Thompson, P. T. *Overview of DVB-RCS+ M and its development*. Inter. J. of Sat. Comm. and Net., 28(3-4), 119-135, 2010.

[2] Bolea Alamanac A., Chan P.M., Duquerroy L., Hu Y F., Gallinaro G., Guo W., & Mignolo D. *DVB-RCS goes mobile: Challenges and technical solutions*. Int. J. of Sat. Comm. and Networking, 28(3-4), 137-155, 2010.

[3] ETSI, *Digital Video Broadcasting (DVB); Interaction channel for Satellite Distribution Systems*, ETSI EN 301 790 V1.5.1 – 2009-05.

[4] ETSI, "*Guidelines for the Implementation and Usage of the DVB Interaction Channel for Satellite Distribution Systems*" TR 101 790 V.1.4.1, 2009-07.
[5] ETSI, *Digital Video Broadcasting (DVB); Interaction channel for Satellite Distribution Systems, Guidelines for the use of EN 301 790 in Mobile scenarios*, ETSI TR 102 768 v1.1.1 (2009-04).
[6] ETSI, *Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard*, ETSI EN 301 545-2 v1.2.1 (2014-04).
[7] ETSI, *Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 1: Overview and System Level specification*, ETSI TS 101 545-1 v1.1.1 (2012-05).
[8] Skinnemoen H., *DVB-RCS: Revitalizing the Open Standard for Mobile Applications*, Ka and Broadband Comm. Conf. Turin, Italy, Sept. 2007.
[9] Tropea M., De Rango F., Marano S., *"Current Issues and Future Trend: DVB-RCS Satellite Systems"*, in IEEE AESM vol. 24, issue 9, Sept. 2009.
[10] Bisio I., Marchese M.,"*Power saving bandwidth allocation over geo satellite networks.*", Comm. Letters, IEEE 16.5: 596-599, 2012.
[11] Sacchi C., Jamalipour A., Ruggieri M., *Aerospace Communications and Networking in the Next Two Decades: Current Trends and Future Perspectives (Scanning the Issue)* in proc. of the IEEE, v.99, n.11, p. 1835-1839, 2011.
[12] Chini P.,Giambene G., Kota S., *A survey on mobile satellite systems.*, Int. J. Satell. Commun. Network., 28:29–57, 2010.
[13] Saleh, N. *Optimum Design of Single Channel per Carrier Satellite Systems*. Aeros. and Electr. Syst., IEEE Trans. on, (6), 858-859, 1980.
[14] ETSI, *Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)*, ETSI EN 302 307 V1.3.1 (2012-11).
[15] Taleb T.,Hadjadj Aoul Y.,Ahmed T.: *Challenges, opportunities, and solutions for converged satellite and terrestrial networks*, IEEE Wireless Communications 18(1): 46-52, 2011.
[16] Kota, S.L., *Hybrid/integrated networking for NGN services*, Wireless Communication, Vehicular Technology, Information Theory and Aerospace & Electronic Systems Technology (Wireless VITAE), 2011 2nd International Conference on, pp.1,6, Chennai, Feb.28-March 3 2011.
[17] Skinnemoen, H., *Creating the next generation DVB-RCS satellite communication & applications: The largest standards initiative for satellite communication inspires new oppurtunities*, Advanced sat. multimedia systems conf. (asma) and the 11th signal proc. for space comm. workshop (spsc), 5th pp.147,154, Cagliari, Italy,13-15 Sept. 2010.
[18] Bisio I., De Gaudenzi R., Nguyen H., Pavlidou F.N., Yamazato T., *Recent advances in satellite and space communications*, Communications and Networks, Journal of,12(6), 523-528, 2010.
[19] Celandroni N., Ferro F., Gotta A., Oligeri G., Roseti C., Luglio M., Bisio I., Cello M., Davoli F.,Panagopoulos A.D.,Poulakis M.,Vassaki S.,De Cola T., Marchitti M.A., Hu Y-F., Pillai P., Verma S., Xu K.J., Açar G., *A survey of architectures and scenarios in satellite-based wireless sensor networks: system design aspects.* Int. J. Sat. Comm. Net. 31.1,1-38, 2013.
[20] De Rango F., Tropea M., Provato A., Santamaria A.F., Marano S., *Multiple metrics aware ant routing over HAP mesh networks*, Electrical and Computer Engineering, CCECE Canadian Conference on, pp.1675,1678, 4-7 May 2008
[21] De Rango, F.; Tropea, M.; Provato, A.; Santamaria, A.F.; Marano, S., *Minimum Hop Count and Load Balancing Metrics Based on Ant Behavior over HAP Mesh*, Global Telecommunications Conference, IEEE GLOBECOM, pp.1,6, Nov. 30-Dec. 4 2008
[22] Wyatt-Millington, R. A., Sheriff, R. E., & Hu, Y. F. *Performance analysis of satellite payload architectures for mobile services*. Aerospace and Electronic Systems, IEEE Transactions on, 43(1), 197-213, 2007.
[23] De Rango F., Tropea M., Fazio P., Marano S., *Call Admission Control for Aggregate MPEG-2 Traffic over Multimedia Geo-Satellite Networks*, IEEE Transaction on Broadcasting, vol. 54, Sept. 2008.
[24] De Rango F., Tropea M., Santamaria A., Marano S., *An Enhanced QoS CBT Multicast Routing Protocol based on Genetic Algorithm in a Hybrid HAP-Satellite System*. Comp. Comp. J. (Elsevier), pp. 1-21, Dec.2007.
[25] De Rango F., Tropea M., Santamaria A.F, Marano S., *Multicast QoS Core-Based Tree Routing Protocol and Genetic Algorithm Over an HAP-Satellite Architecture*, in IEEE Transaction on Vehicular Technology, Vol.58, Issue 8, pp.4447 – 4461, 2009.
[26] Tropea M., Bolea-Alamanac A., Mignolo D., De Rango F., Marano S., *Mac scheme For Hybrid Return Link in a DVB-RCS+M Railway Scenario*, 27th IET and AIAA Intern. Comm. Satellite Syst. Conf. (ICSSC), Edinburgh, UK, 1-4 June 2009.
[27] ESA Project, *Preparation for Internet to Trains Initiative: Broadband on Trains, Analysis of the opportunity and Development Roadmap*, 2006. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=24283
[28] Iubatti M.; Corazza, G.E.; Vanelli-Coralli, A.; Villanti, M., *DVB-S2 in Railway Environments: An Exploratory Study for Tunnel Coverage*, Sat. and Space Comm., Int. Workshop on, pp.71,75, 14-15 Sept. 2006.
[29] ETSI, *Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part2: DVB-S2 Extensions (DVB-S2X);* ETSI EN 302 307-2 V1.1.1 (2015-02).
[30] Combes S., Goegebeur L., Sannier N., Fitch M., Hernandez G., Iuoras A., Pirio S., *Integrated resources and QoS management in DVB-RCS networks*", AIAA, Monterey, California, 9-12 May 2004.
[31] Heyung Sub Lee, Un Gi Joo, Hyeong Ho Lee, and Whan Woo Kim, *Optimal Time Slot Assignment Algorithm for Combined Unicast and Multicast Packets*, ETRI J., vol. 24, no. 2, pp. 172-175, Apr. 2002.
[32] Lee K.-D., Lee H.-J., Cho Y.-H., Oh D., "Throughput-maximizing timeslot scheduling for interactive satellite multiclass services, Communications Letters, IEEE, vol.7, no.6, pp.263,265, June 2003.
[33] Lee K.-D., Cho Y.-H., Lee S.J., and Lee H.-J., *Optimal Design of Superframe Pattern for DVB-RCS Return Link*, ETRI Journal., vol. 24, no. 3, pp. 251-254, June 2002.
[34] Suresh, S., Run, C., Kim, H. J., Robertazzi, T. G., & Kim, Y. I., *Scheduling second-order computational load in master-slave paradigm*. Aerospace and Electronic Systems, IEEE Trans. on,48(1), 780-793, 2012.
[35] Fenech, H., Amos, S., Tomatis, A., & Soumpholphakdy, V., *High throughput satellite systems: An analytical approach*. Aerospace and Electronic Systems, IEEE Transactions on, 51(1), 192-202, 2015.
[36] Sun, Y., Ji, Z., & Wang, H., *TFRC-satellite: a TFRC variant with a loss differentiation algorithm for satellite networks*. Aerospace and Electronic Systems, IEEE Transactions on, 49(2), 716-725, 2013.
[37] Wang G. and Ansari N., *Searching for Optimal Frame Patterns in an Integrated TDMA Communication System Using Mean Field Annealing*, IEEE Trans. Neural Net., vol. 9, no. 6, pp.1292-1300, 1998.
[38] Lee K.-D., Cho Y.-H., Lee H.-J., Oh D., *Improving Efficiency of Timeslot Assignment for Non-realtime Data in a DVB-RCS Return Link: Modeling and Algorithm*, ETRI J., vol.25, no.4, Aug. 2003.
[39] Molinaro A., De Rango F., Marano S., Tropea M., *A Scalable Framework for End-to-End QoS Assurance in IP-Oriented Terrestrial-GEO Satellite Networks*", IEEE Comm. Mag., pp.130-137, Apr.2005.
[40] De Rango F., Tropea M., Marano S., *Integrated Services on High Altitude Platform: Receiver Driven Smart Selection of HAP-Geo Satellite Wireless Access Segment and Performance Evaluation*, Intern. Journal on Wireless Information Networks, vol.13, n.1, pp.77-94, Jan.2006.
[41] Tropea M., Fazio P., Marano S., *A New Switching Scheme for DVB-RCS+M Return Link in a Land based Scenario*, VTC 2012, Yokohama, Japan, May 2012.
[42] SatLink System Technical Note *TDMA vs. SCPC*, Emerging Markets Communications, 2014. http://www.emc-corp.net/satlink/tecSpec/
[43] Weerackody, V. *Interference Analysis for a Network of Time-Multiplexed Small Aperture Satellite Terminals*. Aerospace and Electronic Systems, IEEE Transactions on,49(3), 1950-1967, 2013.
[44] Knab, J.J. *Optimization of Commercial Satellite Transponders and Terminals*. Aer. and El. Syst., IEEE Trans. on, 49(1), 617-622, 2013.
[45] Serrano-Velarde, D.; Lance, E.; Fenech, H.; Rodriguez-guisantes, G., *Novel dimensioning method for high-throughput satellites: forward link*, Aerospace and Electronic Systems, IEEE Transactions on, vol.50, no.3, pp.2146-2163, July 2014.
[46] ESA Project Application Layer QoS in DVB-RCS System, Nov. 2007. http://telecom.esa.int/telecom/www/object/index.cfm?fobjectid=28729
[47] Papaleo, M.; Firrincieli, R.; Corazza, G.E.; Vanelli-Coralli, A., *Packet Coding Performance with Correlated Fading and Shadowing*, GLOBECOM, pp.1,8, Honolulu , Nov. 30 2009-Dec. 4 2009.
[48] Caini, C.; Cornice, P.; Firrincieli, R.; Livini, M.; Lacamera, D., *TCP, PEP and DTN performance on disruptive satellite channels*, Satellite and Space Communications,. IWSSC 2009. International Workshop on , vol., no., pp.371,375, Tuscany, 9-11 Sept. 2009
[49] Liva G., Papaleo M., Parraga Niebla C., Cioni S., Scalise S., Vanelli-Coralli A., Corazza G.E., Kim P. and Lee H.-J., *The very short frame of mobile DVB-RCS: Code designand QoS Performance*, International Journal of Satellite Comm. and Networking, 28.3-4, pp209-231, 2010.

Mauro Tropea graduated in computer engineering at the University of Calabria, Italy, in 2003. Since 2003 he has been with the telecommunications research group of D.E.I.S. in the University of Calabria. In 2004 he won a regional scholarship on Satellite and Terrestrial broadband digital telecommunication systems. From May 2008 to October 2008 he was visiting researcher at the European Space Agency (ESA). In November 2009 he received Ph.D in Electronics and Communications Engineering at University of Calabria. His research interests include satellite communication networks, QoS architectures and interworking wireless and wired networks, mobility model.



Peppino Fazio received the master's degree in computer science engineering and telecommunications in May 2004 and Ph.D. in Electronics and Communications Engineering in 2008. He is an assistant professor at DIMES Department of University of Calabria, after many collaborations with the UPV of Valencia and the VSB-Technical University of Ostrava. His research interests include mobile communication networks, QoS architectures and interworking wireless and wired networks, mobility modeling for WLAN environments and mobility analysis for prediction purposes.

Floriano De Rango graduated in Computer Science in October 2000, and a Ph.D. in electronics and telecommunications engineering in January 2005, both at the University of Calabria, Italy. From January 2000 to October 2000 he worked in the Telecom Research LAB C.S.E.L.T. in Turin with a scholarship. From March 2004 to November 2004 he was visiting researcher at the University of California at Los Angeles (UCLA). He is now Assistant Professor at D.E.I.S. Department, University of Calabria. He was recipient of the Young Researcher Award in 2007 and is reviewer TPC member for many International Conferences and reviewer for many journals such as IEEE Communication Letters, JSAC, IEEE Trans.on Vehicular Technology, Computer Communication, Eurasip JWCN, WINET etc. His interests include Satellite networks, IP QoS architectures, Adaptive Wireless Networks, Ad Hoc Networks and Pervasive Computing. In 2009 he founded a spin-off company (Spintel s.r.l.) in the smart control tools design field for energy efficiency for Smart Building and Cities and Internet of Things (IoT) that won some awards in International Competitions such as the Intel Business Challenge award. His company has been ranked in the first 20 innovative start-up in Europe (IBCE 2013)

Amilcare Francesco Santamaria received the master's degree in computer science engineering in October 2005. Since November 2005 he was employed in the Department of Computer Science at the University of Calabria. Since January 2007 he was Ph.D student at the University of Calabria and he has got the Ph.D in computer science in April 2012. Since November 2008 to March 2013 he was employed in the "NEXT Ingegneria dei Sistemi" in Rome as senior Software Architect. Since April 2013 he has got a PostDoc position at DIMES Department. His research interest are Multicasting, Satellite communications, QoS routing and VANETs.