DIstribution Of Multi-view Entertainment using content aware DElivery Systems

DIOMEDES

Grant Agreement Number: 247996

D5.5

Report on DVB-T Proof of Concept Work

Document description	
Name of document	Report on DVB-T Proof of Concept Work
Abstract	Initial work and studies for DVB-T broadcast of multi-view video will be described. Performance results will be provided, showing that broadcast of high quality content can be achieved. Video quality will be measured using the QoE metric, developed in Task 3.2.
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1 INTRODUCTION

1.1 Purpose of the document

This deliverable is the final deliverable for the Task 5.5 - 3D Multi-view DVB-T Broadcast. It shows the progress and results from this task.

1.2 Scope of the work

The components described in this document are part of the media transmission chain of the DIOMEDES proof of concept demonstrator. Over the DVB-T transmission chain the basic stereoscopic view is transmitted that also includes the timing information for real-time playback on the client side.

1.3 Objectives

The main objective of this document is to describe the system components that are part of the DVB transmission chain.

1.4 Structure of the document

The document starts with a short overview over DVB-T and DVB-T2, followed by the DIOMEDES related descriptions of the technology regarding the modules and their performance, all in chapter 2. The document closes with a conclusion in chapter 3.

2 DVB BROADCAST OF 3D CONTENT

This chapter gives an overview over DVB-T and DVB-T2 and describes the requirements for the DVB broadcast chain for the DIOMEDES system as well as the relevant system components. All next descriptions written in *italic* are quoted from the related standards.

2.1 DVB broadcast concept

The Digital Video Broadcasting Project (DVB) is an industry-led consortium of around 250 broadcasters, manufacturers, network operators, software developers, regulatory bodies and others in over 35 countries committed to designing open technical standards for the global delivery of digital television and data services. Services using DVB standards are available on every continent with more than 500 million DVB receivers deployed.[2]

The DVB-T (or DVB-T2) broadcast will be used for the transmission of the conventional delivery of television signals within the DIOMEDES project. But the satellite (DVB-S or DVB-S2) or the cable (DVB-C or DVB-C2) can be used, too. All transmission systems are independent from the coding scheme used within the video or audio elements.

2.1.1 Basic facts of DVB-T

In 1997 the first standard for digital terrestrial television was published (actual version: ETSI EN 300 744, v1.6.1, 2009-1 [1]). It specifies the framing structure, channel coding and modulation of the broadcasted signals.

DVB-T uses OFDM (orthogonal frequency division multiplex) modulation. A large number of sub-carriers are used within this modulation and it delivers a robust signal that is able to deal with a lot of severe channel conditions. The main characteristics of the DVB-T system are [3]:

- *modulation options (QPSK, 16QAM, 64QAM)*
- *5 different FEC (forward error correction) rates*
- *4 Guard interval options*
- *Choice of 2k or 8k carriers*
- *Can operate in 6, 7 or 8 MHz channel bandwidths (with video at 50Hz or 60Hz)*

All these options can be combined in different ways to meet the requirements of different conditions / network operators to find the best balance between capacity and robustness.

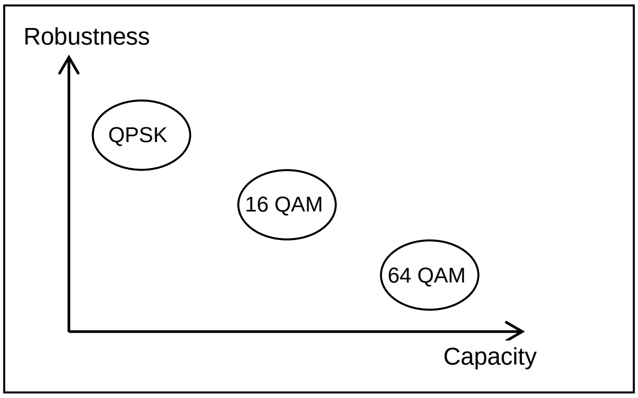

Figure 1: Balance between robustness and capacity in DVB-T

Typical and useful bit-rates (Mbit/s) for all combinations of guard interval, constellation and code rate for non-hierarchical systems for 8 MHz channels are listed in Table 1 (irrespective of the transmission modes).

Modulation	Code rate	Guard interval			
		1/4	1/8	1/16	1/32
QPSK	1/2	4,98	5,53	5,85	6,03
	2/3	6,64	7,37	7,81	8,04
	3/4	7,46	8,29	8,78	9,05
	5/6	8,29	9,22	9,76	10,05
	7/8	8,71	9,68	10,25	10,56
16 QAM	1/2	9,95	11,06	11,71	10,06
	2/3	13,27	14,75	15,61	16,09
	3/4	14,93	16,59	17,56	18,10
	5/6	16,59	18,43	19,52	20,11
	7/8	17,42	19,35	20,49	21,11
64 QAM	1/2	14,93	16,59	17,56	18,10
	2/3	19,91	22,12	23,42	24,13
	3/4	22,39	24,88	26,35	27,14
	5/6	24,88	27,65	29,27	30,16
	7/8	26,13	29,03	30,74	31,67
NOTE: Figures in italics are approximate values for 8 MHz channels. Values for 6 MHz and 7 MHz channels are given in annex E. Values for 5 MHz channels are given in annex G. For the hierarchical schemes the useful bit rates can be obtained from table 17 as follows: - HP stream: figures from QPSK columns; - LP stream, 16-QAM: figures from QPSK columns; - LP stream, 64-QAM: figures from 16-QAM columns.					

Table 1: Useful Bit-rates for DVB-T (ETSI EN 300 744, Table 17) [1]

2.1.2 DVB-T2 – successor of DVB-T

The first standard of DVB-T2 was published in 2009 (ETSI EN 302 755, actual version v1.3.1, 2011-11 [4]). The actual version of this standard includes beside higher efficiency, robustness and flexibility also a subset of DVB-T2 for mobile and portable receiption (T2-Lite).

DVB-T2 is also based on OFDM-modulation but with a larger number of sub-carriers to deliver a more robust signal. Furthermore an improved error correction coding is used (the same as for DVB-S2 and DVB-C2): LDPC (Low Density Parity Check) coding combined with BCH (Bose-Chaudhuri-Hocquenham). The key-technologies of DVB-T2 are [5]:

- *Multiple Physical Layer Pipes allow separate adjustment of the robustness of each delivered service within a channel to meet the required reception conditions (e.g. in-door or roof-top antenna). It also allows transmissions to be tailored such that a receiver can save power by decoding only a single service rather than the whole multiplex of services.*
- *Alamouti coding, a transmitter diversity method, improves coverage in small-scale single-frequency networks.*

- *Rotated Constellations provide additional robustness for low order constellations.*
- *Extended interleaving, including bit, cell, time and frequency interleaving.*
- *Future Extension Frames (FEF) allow the standard to be compatibly enhanced in the future.*

As a result, DVB-T2 can offer a much higher data rate than DVB-T ***or*** *a much more robust signal. For comparison, the last two rows of the table show the maximum data rate at a fixed C/N ratio and the required C/N ratio at a fixed useful data rate.*

	DVB-T	***DVB-T2*** *(new/improved options in red)*
FEC	*Convolutional Coding+Reed Solomon 1/2, 2/3, 3/4, 5/6, 7/8*	*LDPC + BCH* *1/2, 3/5, 2/3, 3/4, 4/5, 5/6*
Modes	*QPSK, 16 QAM, 64 QAM*	*QPSK, 16 QAM, 64 QAM, 256 QAM*
Guard Interval	*1/4, 1/8, 1/16, 1/32*	*1/4, 19/128, 1/8, 19/256, 1/16, 1/32, 1/128*
FFT Size	*2k, 8k*	*1k, 2k, 4k, 8k, 16k, 32k*
Scattered Pilots	*8% of total*	*1%, 2%, 4%, 8% of total*
Continual Pilots	*2.6% of total*	*0.35% of total*
Typical data rate *(UK)*	*24 Mbit/s*	*40 Mbit/s*
Max. data rate *(@20dB C/N)*	*29 Mbit/s*	*47.8 Mbit/s*
Required C/N ratio *(@22 Mbit/s)*	*16.7dB*	*8.9 dB*

Table 2: Comparison of DVB-T and DVB-T2 [5]

2.2 System components

As described in chapter 2.1 there are several combinations of parameters for DVB-T and DVB-T2. The widely spread DVB-T broadcast mechanism is selected to deliver the basic stereoscopic view within the DIOMEDES project.

The modules forming the DVB-T broadcasting and receptionchain within the DIOMEDES architecture are described in the following sections. The relevant modules are the DVB-Tx transmission module on the server side and the DVB-Rx reception module on the client side.

2.2.1 Server side

2.2.1.1 Playout module

The DVB-Tx module on the server side has the following characteristics:

- Constant[1] bitrate DVB conformant MPEG2 transport streams are supported
- The output bitrate is derived from the timing information (Program Clock Reference (PCR)) within the transport stream
- Optionally, it is possible to embed the reference ID[2] of the content

Implementation

The DVB-Tx module is running on a PC with Windows 7 64 bit. For the proof of concept system it is using a Dektec [6] modulator (or other) to create the modulated DVB-T signal.

Operation

Since there is no real-time encoder within the DIOMEDES project, the DVB-Tx module is operating in file mode, meaning that the transport streams which are played out in real-time are fully prepared and available from hard disc drive.

2.2.1.2 Multiplexing module

Before sending the content over the DVB transmission chain and also over the P2P chain the different audio and video streams, including coding layers, have to be multiplexed according to the requirements defined in the DIOMEDES system architecture.

The streams produced by the encoders are encapsulated into the single transport streams. Every such stream carries an audio or video elementary stream.

Depending on the 2 scenarios (described in D2.1/ D2.2, section Use Cases):

a. Single 2D view over DVB and second view over P2P for stereoscopic rendering
b. Stereoscopic 3D view over DVB and additional views over P2P for multiview rendering

the streams for DVB transmission are differently multiplexed, either

a. One base layer video view, 2.0 and 5.1 audio or
b. Two base layer video views (stereoscopic 3D pair) and audio in 2.0 and 5.1.

The multiplexes distributed through the P2P system contain the same elementary streams as the DVB multiplexes, but also include the WFS audio, additional views (base layer), depth maps of the views, and enhancement layers for the base layer streams (including also the base layer streams transmitted through DVB). The reason why the content transmitted through DVB is also included is found in the IP-only reference scenario (please refer to D2.1/ D2.2, section Use Cases).

The software multiplexer has the following characteristics:

[1] Constant refers to the overall bitrate of the transport stream, including stuffing packets. Elementary stream can have variable bitrate

[2] GUID which the P2P system uses to identify content

- Real-time multiplexing of constant[1] bitrate transport streams
- (Re)Generation of Service Information (SI)
- Insertion of additional signalling, e.g. the content reference as described above
- Timing information (PCR) is not changed

Implementation

The multiplexer is running on a PC on Windows 7 64 bit.

Operation

The multiplexer is operating in file mode like the DVB-Tx module.

2.2.2 Client side

The DVB-Rx module on the client side has the following characteristics:

- Constant[1] bitrate DVB conformant MPEG2 transport streams are supported
- The modulated stream is demodulated and then passed to AVSync module using UDP/IP. The output stream is also constant bitrate. It does not modify the stream contained in the modulated signal in any way.
- The input bitrate is derived from the timing information (PCR) within the received transport stream
- The input stream is parsed and checked for the available streams.
- Optionally, it is possible to retrieve the reference ID[2] of the content
- The received signal is monitored and in case of failure in DVB reception a notification is generated and sent to the system.

Implementation

The DVB-Rx module is running on a PC on Windows 7 64 bit. For the proof of concept system it is using a Dektec [6] demodulator (or other) to demodulate the DVB-T signal.

Operation

The module supports two operation modes:

- The first operation mode demodulates the DVB-T signal and outputs the transport stream via UDP/IP.
- The second mode does not use the demodulator, but takes a transport stream file as input. This mode is used for testing purposes to be able to simulate the DVB chain without the necessary hardware (modulator / demodulator).

Control

Like the other modules on the client side the DVB-Rx module implements a JSON-RPC interface for controlling the modules functionality and sending notification messages to other modules. The detailed interface description can be found in Appendix B.

2.3 Performance and quality

As it is known that the spectrum for terrestrial frequencies is very rare and normally there are more services multiplexed together in one channel the realistic bit-rate per service is is quite low. Although DIOMEDES intends to produce a proof of concept prototype, to show the synchronious DVB-and-P2P delivery to media consumers, and that the experimental spectrum is not loaded with other channels, selected source data rates still should be realistic for deployment in consumer market. The video format requirements were described in D2.1 and subsequently updated in D2.2. The mostly used video resolutions in DIOMEDES are 1920x1080p/25, 1280x720p/25 and 1280x720p/50. Source camera views converted to YUV 4:2:0 are encoded using the Scalable Video Coding (SVC) extension of MPEG-4 Part 10/ H.264 Advanced Video Coding (AVC) standard. Only the AVC-standard compliant base quality layer (at Scalable High Profile Level 4.0/ 4.1) of each view of the stereoscopic video is transmitted over DVB-T (One view only according to Scenario 1 in 2.2.1.2, or both views according to Scenario 2). No explicit source (elementary stream) data rates were depicted in previous WP 2 deliverables, but it was stated that the resultant 3D HD video services should be of high quality for broadcasting. According to the Table 1 in 2.1.1, the total useful data ranges between ~3 Mbps to ~32 Mbps, but most typically the used rate is around 24 Mbps per multiplex, with the respective combination of the DVB-T related coding and modulation parameters. This range can be extended by around 50% with the deployment of DVB-T2. This section outlines the 3D video quality results for various stereoscopic HD video sequences (in the depicted resolutions) at various bit-rates, in the recommended transmission rates per HD service (e.g. to allocate at least 2-3 such HD-3D services in the same multiplex). The 3D quality metric for stereoscopic video derived in T3.2 and described in D3.4 is used.

Figure 2, Figure 3 and Figure 4 show the 3D quality values with respect to the necessary bit-rate to encode several stereoscopic videos (using the encoder settings depicted above), for 1920x1080p/25, 1280x720p/25 and 1280x720p/50 resolutions, respectively. In all three figures, the horizontal axis represents the total stereoscopic video bit-rate (in Mbits/s) and the vertical line represents the 3D objective quality metric for stereoscopic videos, described in D3.4 (Report on the QoE model, and the audio and video attention models). The deployed objective quality assessment of the stereoscopic videos relies on Video Quality Measurement (VQM) tools, which is known to be fairly linearly correlated with subjective scores. The video quality axis is normalised to [0,1]. Values near 1.0 indicate imperceptible distortions by viewers, whereas values in the close range of 0.8 indicate perceptible, but not effective (annoying) distortions. Values under 0.75 can be considered as gradually dropping viewing quality and as the video quality hits 0.5, distortions become visibally annoying. We therefore can consider the close range of 0.8 as good broadcast quality.

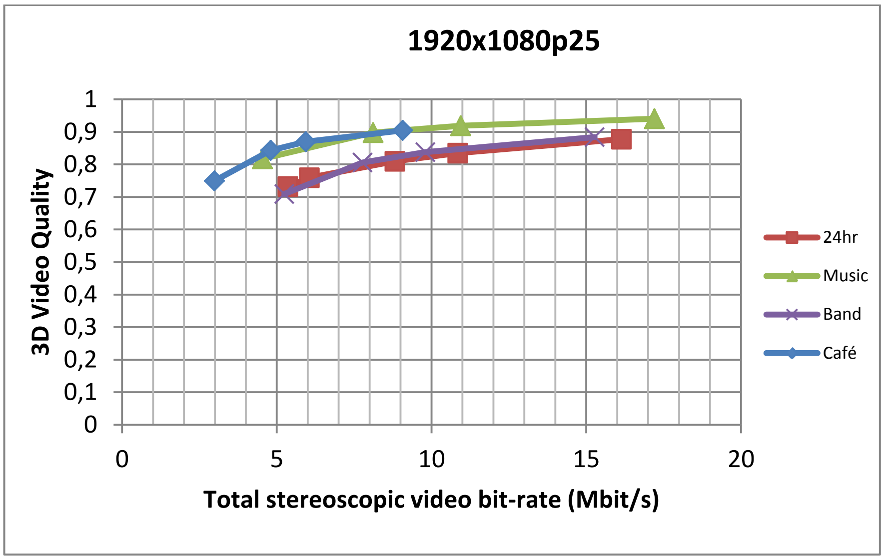

Figure 2: Stereoscopic video quality scale with respect to bit-rate (1920x1080p/25)

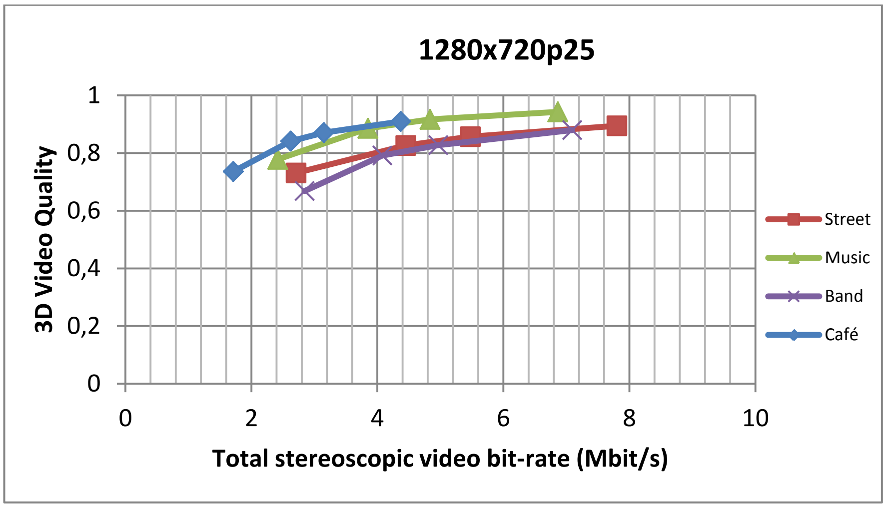

Figure 3: Stereoscopic video quality scale with respect to bit-rate (1280x720p/25)

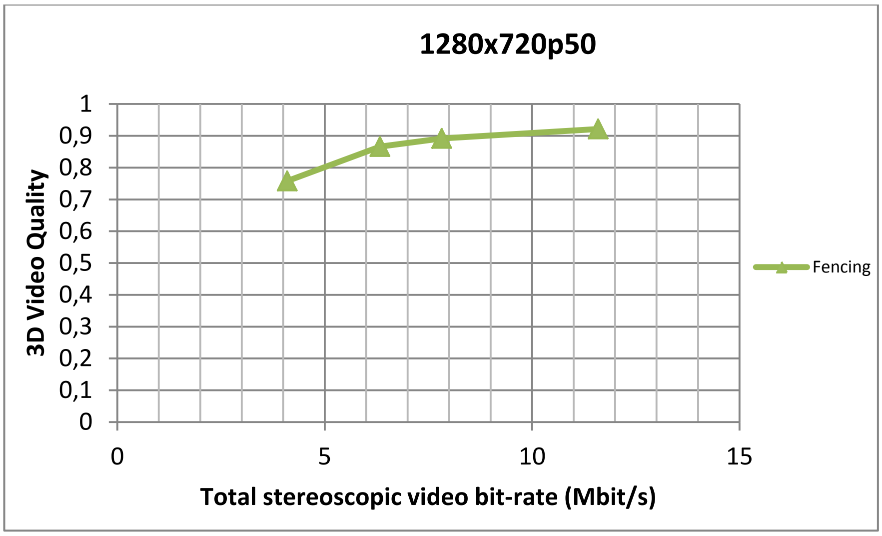

Figure 4: Stereoscopic video quality scale with respect to bit-rate (1280x720p/50)

24Hour sequence involves a highly dynamic scene with fast motion (car racing) and frequent scene changes. *Band* sequence as well involves singers performing on stage, dancing at the same time. *Fencing* sequence involves two fencers who are relatively actively moving, and is originally shot at 50 fps. Hence, these three sequences can be considered temporally complicated, while *24Hour* exhibits textural complexity too. On the other hand, *Street*, *Café* and *Music* sequences involve rather slower motion and steadier texture. From the results, it can be seen in general that a stereoscopic stream at 1920x1080 resolution and 25 fps would need at least around 5-9 Mbit/s, a stereoscopic stream at 1280x720 resolution and 25 fps would need 2.5 - 4.5 Mbit/s and a stereoscopic stream at 1280x720 resolution and 50 fps would need at least around 5 Mbit/s to be at a good perceptual quality. In accordance with these results, it can be concluded that more than one stereoscopic 3D video broadcast service can be accommodated depending on its resolution and frame rate without heavily affecting other existing services, by encoding at the mentioned bit-rates.

Regarding the performance for the DVB-T-transmission both modules (DVB-Tx and DVB-Rx) are compliant to the standards described in 2.1. Based on the quality tests described above the following parameters are chosen for the DVB-T transmission:

According to Table 1 and the bitrate requirements presented above QPSK modulation with code rate 3/4 and guard interval 1/8 are sufficient for 720p/25 and 720p/50 transmission. For 1080p/25 QPSK with code rate 7/8 and the same guard interval could be used. However the system components where tested with modulation settings resulting in bitrates up to 31 Mbit/s, so they are able to cover all standard compliant DVB-T modulation settings (see 2.1).

3 CONCLUSIONS

This document has described the DIOMEDES DVB transmission and reception modules in the server and the user terminal which are capable of handling 3D content in the delivery path. All DVB-related modules are standards compliant with respect to the known standards.

REFERENCES

[1] ETSI EN 300 744, v1.6.1, 2009-1, Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television

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[3] DVB-T – Digital Terrestrial Television, Fact Sheet; http://www.dvb.org/technology/fact_sheets/DVB-T_Factsheet.pdf

[4] ETSI EN 302 755 v1.3.1, 2011-11, Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

[5] DVB-T2 – 2nd Generation Terrestrial Broadcasting, Fact Sheet; http://www.dvb.org/technology/fact_sheets/DVB-T2_Factsheet.pdf

[6] Homepage Dektec, http://www.dektec.com

APPENDIX A: GLOSSARY OF ABBREVIATIONS

A	
AVC	Advanced Video Codecs
B	
BCH	Bose-Chaudhuri-Hocquenham
C	
C/N ratio	Carrier-to-Noise ratio
D	
DVB	Digital Video Broadcasting
DVB-C/C2	Digital Video Broadcasting – cable
DVB-S/S2	Digital Video Broadcasting – satellite
DVB-T/T2	Digital Video Broadcasting – terrestrial
E	
ETSI	European Telecommunications Standards Institute
G	
GUID	Globally Unique Identifier
H	
HP Stream	High Priority Stream
F	
FEC	Forward Error Correction
FEF	Future Extension Frames
FFT	Fast Fourier Transformation
Fps	Frames per second
I	
i	Interlaced scan
J	
JSON	JavaScript Object Notation
L	
LDPC	Low Density Parity Check
LP Stream	Low Priority Stream
M	
Mbit/s	Mega bit per second
MPEG	Motion Picture Experts Group
O	
OFDM	Orthogonal Frequency Division Multiplex
P	
p	Progressive scan
P2P	Peer to Peer
PCR	Program Clock Reference

Q	
QAM	Quadrature Amplitude Modulation
QoE	Quality of Experience
QPSK	Quadrature phase-shift keying
S	
SI	Service Information
SVC	Scalable Video Coding
V	
VQM	Video Quality Metric
W	
WFS	Wave Field Synthesis

APPENDIX B: DVB RX CONTROL INTERFACE

Parameter Description	JSON Message	JSON Message Period	Final Comment & Rationale
OUTPUT			
Availability of DVB Input	{ "id":0, "jsonrpc":"2.0", "method":"AvailabilityOfDVB", "params": { "connNumber":5, "DVBStatus": 1 } }	when DVB status changes	"0" means not available, "1" means available
Mode of DVB Input	{ "id":0, "jsonrpc":"2.0", "method":"ModeOfDVB", "params": { "connNumber":5, "DVBMode": 0 } }	when DVB mode changes	"0" means single view, "1" means stereo. It is known by the system that if mono-view is streamed over DVB-T, this is always the left view of the stereo-pair
INPUT			
DVB Start	{ "id":0, "jsonrpc":"2.0", "method":"DVBRxStart", "params": { "connNumber":701 } }	when user clicks the "Start" button on "DVB-T Rx" tab on Interaction Device	
DVB Stop	{ "id":0, "jsonrpc":"2.0", "method":"DVBRxStop", "params": { "connNumber":702 } }	when user clicks the "Stop" button on "DVB-T Rx" tab on Interaction Device	
DVB Switch Channel	{ "id":0, "jsonrpc":"2.0", "method":"DVBRxTune", "params": { "connNumber":703, "channel":"2" } }	when user clicks the "Switch" button on "DVB-T Rx" tab on Interaction Device	
DVB Get SNR	{ "id":0, "jsonrpc":"2.0", "method":"DVBRxGetSnr", "params": { "connNumber":704 } } return message is: { "id":0, "jsonrpc":"2.0", "result":-20 }	when user clicks the "Update" button on "DVB-T Rx" tab on Interaction Device	SNR value is get from return message.