DVB-RETURN CHANNEL-TERRESTRIAL: AN UPDATE

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ABSTRACT

As DVB-T is rolling out throughout Europe, in Asia and in Australia, the interest for new services is growing. In the commercial deployment phase, the need for a return path to implement interactive services has emerged.

Thus, DVB endorsed the DVB-RCT specification in April 2001, ETSI ratified & published it in March 2002 - EN 301 958 v1.1.1 (2002-03) - and ITU-R recommended the DVB-RCT system as “the preferred wireless return path” for the DVB-T Digital Terrestrial TV.

Besides, to make the DVB-RCT system come true, a couple of technical EU-funded projects are under way. The WITNESS project (part of IST program) was launched in October 2000 and deployed two DVB-RCT platforms in Ireland (Dublin) & France (Rennes) to perform field trials to check the suitability of the DVB-RCT system in rural & urban environments. On the receiver side, the IM4DTTV project, (part of MEDEA+ program) was launched in May 2001, the first goal being to design silicon components to build the first ever DVB-RCT set-top-boxes. Another goal for IM4DTTV is the design of the network equipment allowing the deployment of DVB-T & DVB-RCT network infrastructure.

Following a summary of the DVB-RCT basic principles, this paper briefly reports the main results obtained in the field by the WITNESS, as well as the progress of the IM4DTTV project.

INTRODUCTION

DVB-T is a powerful means to provide, wirelessly, broadband data to customers (either stationary or mobile), but it is a mono-directional means. Thanks to DVB-RCT, the DVB-T platform can become a bi-directional, asymmetric, broadband and wireless path between broadcasters and customers. In turn, this can open the door to new services, hence generating revenues.

DVB-T when completed with DVB-RCT can be used not only for interactive TV (voting, quiz, etc.) but also for interactive web sessions and for light IP telecommunication services.

Various degrees of interactivity should be offered, without implying any return channel back from the user to the service provider: data carrousel or Electronic Programs Guides (EPG) are examples of such enhanced TV services which make use of “Local Interactivity”, without any return path from customer to provider.

Other services like T-Commerce are more demanding and require full interactivity between the users and the service providers. When using existing telecom networks (PSTN, ISDN or GSM), the connection time delay considerably limits the category of possible interactive services: pay-per-view and video-on-demand are examples of services which can cope with such a long latency connection time.

To implement new interactive services having a strong and real-time relationship with the TV programs, like interactive advertising, tele-voting, tele-quiz, etc. a low latency return channel technology is definitively mandatory, and this is the goal of the DVB-RCT.

DVB-RCT is the solution that offers a wireless interaction channel for these real-time interactive digital terrestrial television services for the following reasons:

- DVB-RCT is spectrum efficient, low cost, powerful and it provides a flexible wireless Multiple Access OFDM system;
- DVB-RCT can serve large cells, up to 65km radius, providing a typical bitrate capacity of several kilobits per second, for each TV viewer;
- DVB-RCT can handle very large peaks in traffic, as it has been specifically designed to process up to 20,000 short interactions per second, in each sector of each cell;
- DVB-RCT can be employed with smaller cells, to constitute denser networks of up to 3.5km radius cells, providing to the user a bitrate capacity of several Megabits per second;
- DVB-RCT has been designed to use any gaps or under-utilized spectrum anywhere in Bands III, IV and V without interfering with the primary analogue and digital broadcasting services;
- DVB-RCT is able to serve portable devices, bringing interactivity everywhere the Terrestrial Digital broadcast signal is receivable;
- DVB-RCT can be used around the world, which uses the different DVB-T system: 6, 7 or 8 MHz channels;
- DVB-RCT does not require more than 1W (30 dBm) power transmission from the User Terminal or Set Top Box to the base station.

HOW DOES DVB-RCT PROVIDE THESE PERFORMANCES?

The interactive system consists of a forward interaction channel (downstream) conveyed to the user via a DVB-T compliant terrestrial broadcast network, and a return interaction channel based on a wireless VHF/UHF transmission (upstream) of the same type, as illustrated in Figure 1.

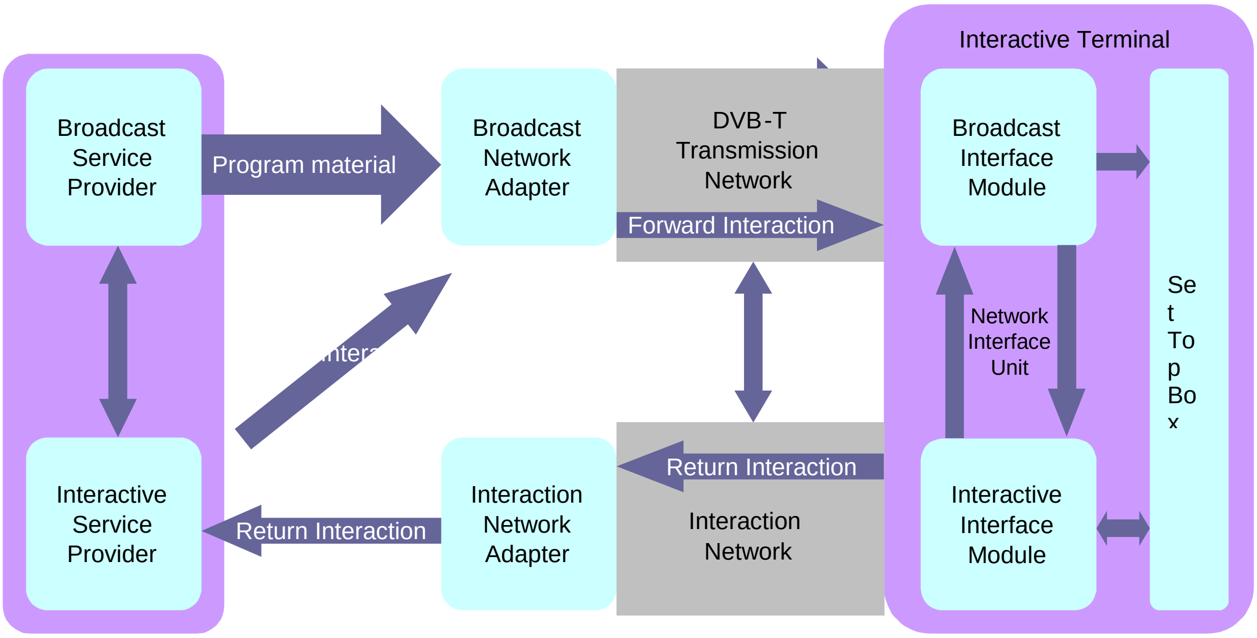

Figure 1: DVB-RCT network

The downstream transmission from the Base Station provides synchronization and information to all RCT Terminals (RCTTs). Hence, the RCTTs can synchronously access the network and then transmit upstream-synchronized information to the Base Station.

The DVB-RCT system works as follows:

- Modulation scheme is OFDM for both downstream (fully DVB-T compliant) and upstream channels; hence, several parallel carriers are available in the upstream to be allocated to different users, in different time slots, for transmitting data and commands back to the Base Station;
- Each authorized RCTT transmits one or several low bit rate modulated carriers towards the Base Station;
- The carriers are frequency-locked and power-ranged, and the timing of the modulation is synchronized by the Base Station;
- In the Base Station, the upstream signal is demodulated, using a FFT process, just like the one performed in a DVB-T receiver.

Channel Partitioning

To allow access by multiple users, the VHF/UHF return channel is partitioned in both frequency and time domain. This channel partitioning is a powerful way of sharing the RF medium between RCTTs.

Each available time-frequency slot is allocated to a given user under the control of the Base Station (BS). Multiple slots allocation is possible (both on the same carrier and onto different parallel carriers) to cope with bandwidth peak demands.

The DVB-RCT standard has defined three values of carrier spacing approximately 1, 2 and 4kHz – corresponding to three symbol durations. This provides three basic modes that refer to the downstream DVB-T reference clock, and this, for each existing channel raster (i.e. 6, 7 or 8MHz channels). For instance, for an 8MHz channel raster, the RCT channel bandwidth varies from about 1MHz to 7.6MHz, with 1kHz and 4kHz carrier spacing respectively.

Furthermore, the DVB-RCT channel can be frequency divided in either 1024 or 2048 carriers. Thanks to the three carrier spacings offered, the bandwidth of the DVB-RCT channel can occupy 1 or 2 or 4 or 8MHz.

In short, in addition to its intrinsic spectrum efficiency, the DVB-RCT uses any unused or underused megahertz of spectrum, to provide a DVB-T return path.

Transmission frames

To structure the RF channel further, beyond the time-frequency partitioning, the DVB-RCT offers two transmission frames.

The first transmission frame (TF1) makes use of each OFDM symbol period for a dedicated activity. Thus, the first symbol of the frame is null (which allows the BS to detect jammers). The six following symbols are devoted to the ranging procedure, while the remaining 176 symbols are used by the RCTT to transmit data.

The second transmission frame (TF2) does not implement null symbol but is made of general-purpose symbols. TF2 is made of 48 symbols, organized in 8 groups of 6 consecutive symbols. Within each group, the 1K or 2K carriers are distributed over sub-channels (made of 4, 29 or 145 carriers), to perform ranging functions using MC-CDMA technique. In short, TF2 structures the activities in the frequency domain while TF1 performs them in the time domain.

Burst Structures

Within the resources provided by the transmission frames, the RCTT can perform data transmissions using three types of time-frequency patterns called burst structures. Whatever the pattern used, the data burst is made of 144 modulated symbols in which 30 or 36 pilots carriers are inserted (for a coherent demodulation in the BS).

The three bursts structures allow various trade-offs between burst duration and frequency diversity. Shorter burst duration is more robust against interference, but requires the user to use several carriers in parallel, and then to spread the available power over them. Hence, each burst structure allows covering various cell radiuses.

Bitrate capacity

Under control of the BS, to transmit data, the RCTT modulates the carrier(s) of the burst structure using either 4QAM, 16QAM or 64 QAM constellation, protected with a Forward Error Coding rate of 1/2 or 3/4.

Such constellations combined with 2 burst structures, 3 carrier spacing modes, and 4 possible guard intervals, typically provide the DVB-RCT system with a net bit-rate per carrier ranging from 0.6kbps to 15kbps. When all carriers are used, the BS is able to collect from 1Mbps to 30Mbps of user data from the DVB-RCT channel.

The most robust modes offer the lowest bit-rate, over a large radius cell whilst the weakest modes offer the largest bit-rate over a small radius cell.

Dynamically-Assignable Adaptive Modulation

DVB-RCT supports within the same cell the simultaneous use of different types of modulation. This feature called "Dynamically-Assignable Adaptive Modulation" enables the service provider to control the level of interference from a given cell into neighboring co-channel cells while, at the same time, providing the maximum bitrate to each users, hence optimizing the spectrum use.

Advanced DVB-RCT features

In addition, DVB-RCT includes many advanced features, of interest.

- DVB-RCT authorizes the use of both Concatenated Coding (Reed Solomon and convolutional coding) or Turbo-Coding. The latter can provide a further 2dB (or more) reduction of the C/N threshold for a given BER.
- DVB-RCT provides a scheme to "time-interleave data" when mapping over the burst structures. This can provide at least an additional 5dB improvement against impulsive interference.
- DVB-RCT provides a "power ranging" feature, which reduces interference and increases the system spectrum efficiency.

CURRENT STATUS OF THE DVB-RCT SYSTEM

The DVB-RCT system has been largely developed through different collaborative research projects driven by the European Community:

- iTTi ("interactive Terrestrial TV integration" – 1997-1999), which developed and demonstrated the first solution for terrestrial interactivity;
- WITNESS ("Wireless Interactive Terrestrial Network System and Service" – 2000-2002), which focused on upgrading, testing and validating equipment and planning algorithms, to support the standardisation process;
- IM4DTTV ("Integrated Modem for Digital Terrestrial TV - 2001-2003), which focuses on validating the DVB-RCT specification, developing of a prototype VLSI solution for the DVB-RCT terminal, and all necessary investigations and tests needed to assess the DVB-RCT specification before completion of the ETSI standardisation process.

While work is not yet completed, the latter two projects have drastically contributed to the move of DVB-RCT from a "lab technology" to a "practically usable technology".

THE IST "WITNESS" PROJECT

WITNESS (2000-2002) main mission was to validate the operation of a Terrestrial Return Channel service from field tests, by:

- deploying up-graded interactive wireless terminals in two test sites: Ireland (Dublin) and France (Rennes);
- developing spectrum planning and frequency usage recommendations for Terrestrial TV services.

The main results of the "Witness" field trials

The results are extremely good, demonstrating that DVB-RCT is meeting the expected requirements in terms of coverage, both for fix roof-top and indoor antennas.

DVB-RCT coverage with fix roof-top antennas

The objective of this first measurement campaign was to verify that, even with a limited power of 1W (30 dBm), the upstream DVB-RCT transmission cell replicates the downstream DVB-T distribution one. Besides, to verify that the DVB-RCT receiver is able to demodulate a weak DVB-RCT signal, when located in a TV transmission site radiating kilowatts of TV signals.

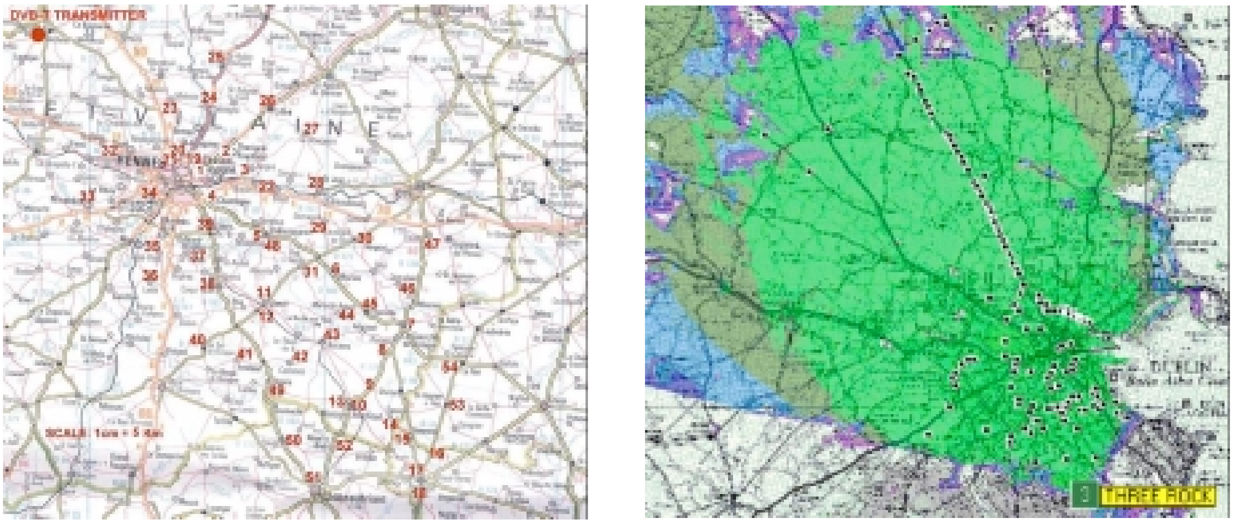

Figure 2: measurement points in Rennes & Dublin areas

The results of the field trials in Rennes & Dublin surpassed expectations: they demonstrate very clearly that DVB-RCT services can be provided everywhere the DVB-T signal is available and also that, even in an saturated spectrum environment, DVB-RCT reception remains possible.

At a distance of up to 80 km from the transmitter site, the DVB-T signal is well demodulated by the consumer receiver, even with a received power level of less than -80 dBm (thanks to the 16QAM, 2/3 used, which offers a C/N threshold of -87 dBm).

In addition, it has been checked that even at the extreme border of the DVB-T service area (again up to 80 kms from the DVB-T downstream source), a successful DVB-RCT return transmission has been established using a transmitting power of 15 to 20 dBm, far below the maximum power level defined at 30 dBm.

These good results have been obtained in both trials, although having different transmission and propagation parameters, which consolidates the positive conclusion of these field trials.

Figure 3: DVB-RCT field trials in Rural & Urban area of Rennes (France)

DVB-RCT coverage with indoor antenna

Two different base station set-ups have been built in Rennes urban area:

- The first one was using a base station located very close to the targeted urban area (Rennes);
- The second one was using a base station located 30 km away, with use of a co-channel "return channel booster", close to the targeted urban area.

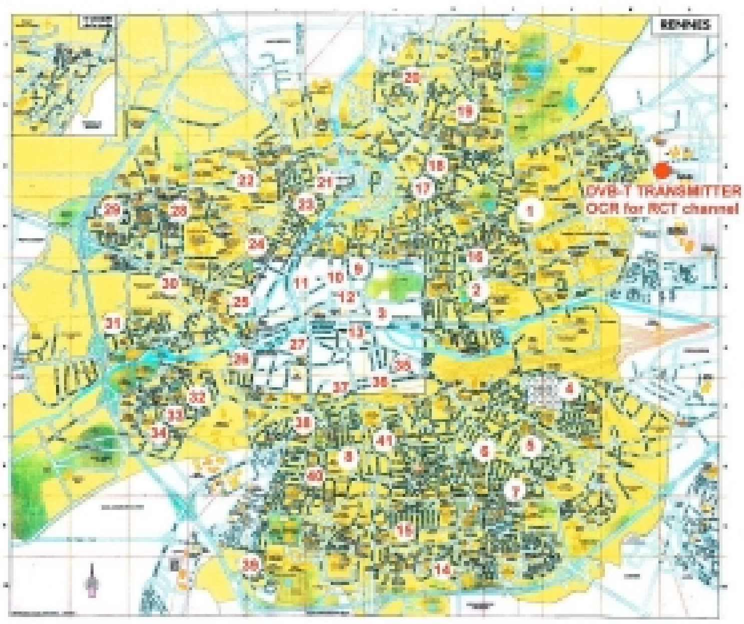

Figure 4: DVB-RCT "indoor" transmission test points in Rennes city

Again the results of this DVB-RCT "indoor" measurement campaign have been extremely positive:

- Using the urban base station, 100% of the tested points have worked successfully, without requesting more than 20 dBm DVB-RCT power level. Globally, the attenuation from outdoor to indoor transmission is about 9 to 12 dB and it does not compromise the DVB-RCT suitability;

- The solution with a co-channel booster has also given excellent results. Giving a 95 dB amplification to the weak signal provided by the “indoor” DVB-RCT terminal, it has been retransmitted successfully to the distant base station.

From these results, it has been suggested that planning of DVB-RCT networks can be simplified and improved by the use of “channel boosters”. For instance:

- A large DVB-RCT cell around a main DVB-T transmitter (radius up to 80 km) can be deployed to cover outdoor transmission for rural users;
- For indoor terminals inside a city, on-channel boosters are a good solution.

The conclusions that can be drawn from these WITNESS field trials are that:

- The practical suitability of DVB-RCT technology for outdoor and indoor wireless return channel transmissions has been demonstrated;
- The power levels required were lower than the maximum specified levels, leaving head-room for future real network deployment.

THE MEDEA “IM4DTTV” PROJECT

The IM4DTTV project (2001-2004), aims at demonstrating the feasibility of an integrated DVB-RCT end to end solution (base station and user terminal), able to meet the technical and cost requirements of the forthcoming Terrestrial interactive TV services.

IM4DTTV will provide a 1G-silicon solution and a complete hardware validation platform covering all aspects of the DVB-RCT system.

It will contribute to the finalisation of the standardisation process and to the promotion of the system.

IM4DTTV is chaired by ST Microelectronics (Italy).

So far tangible results are already available:

- The detailed specifications of every piece of equipment as well as the functional & physical interfaces have been established;
- Deep simulations have been made to verify the performance of the DVB-RCT modes and to verify a common understanding of the standard between the partners who design ASIC;
- The design of network equipment constituting the Base Station (DVB-RCT demodulator, MAC controller, MAC inserter, etc.) has been started by the professional equipment manufacturers involved in the project. Some parts are already available as prototypes;
- The design of the VHDL models has been started by the chip manufacturers involved in the project;
- The implementation of some parts of the DVB-RCT modulator has been done using FPGAs;
- The definition of the test protocols & procedures has started and is discussed between all partners.

Figure 5: DVB-RCT equipment designed within the IM4DTTV project (courtesy of RUNCOM)

IM4DTTV' partners expect the first DVB-RCT ASIC (probably including both DVB-T demodulator and DVB-RCT modulator) will be available mid-2003. As for the first prototypes of interactive set-top-boxes using DVB-T and DVB-RCT, they will probably be delivered by the project, at the end of 2003.

CONCLUSIONS

DVB-RCT has made significant progress on both the standardisation and the technical sides. The WITNESS project achieved first DVB-RCT field trials with very good results, while the IM4DTTV project started the design of ASIC for set-top boxes and DVB-RCT network equipment.

Altough more work is still required for getting the necessary large volume consumer products, the DVB-RCT is already a real asset for a successful deployment of interactive terrestrial digital TV worldwide.

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