DVB-H
standard, principles and services

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Outline

1. Background and motivation
2. General solution outline
3. Standardization
4. Use of DVB-H options and frequencies
5. Validation of DVB-H
6. Networks and services
7. Conclusive remarks
Drivers for Mobile phone TV

- TV service is missing from the mobile phone
- TV is a bigger application globally than telephony
- Daily amount of time spent with media is significant

- Digital convergence will happen in the handsets
- Broadcast paradigm will come to the mobile business environment
- IP Datacast technology delivers the best quality for the mobile environment
Mobile Phone TV

"mass distribution of media content to mobile users"

Content

Content
Content Aggregation

Infrastructure

Service Provider
Broadcast Network Operator
Telecom Network

Consumer

[Image of a person holding a mobile phone]
Motivation and the background

• The displays on handheld devices smaller than on fixed reception
  ➢ MPEG2 is probably too heavy, something else could be used

• DVB-T is known to have good mobile performance

• DVB-T based IP-data broadcasting (IPDC) could be the solution

BUT…
..3 MAIN PROBLEMS EXIST

1. Power consumption
2. Performance in cellular environment
   - C/N in mobile channel
   - Doppler in mobile channel
   - Impulse interference
3. Network design flexibility for mobile
   - Single antenna mobile reception in medium to large SFN

AND DVB-H SHOULD BE BASED ON DVB-T.
Transmission frame for DVB-T

Carrier-position $k_{\text{min}}$ (-0)

Continual Pilot

Data

Scattered Pilot

Carrier-position $k_{\text{max}}$

Continual Pilot

TPS-Pilot

Carrier spacing in 2k-mode - 4464 Hz, in 8k-mode - 1116 Hz

2k-mode: $k_{\text{max}}$ - 1704

8k-mode: $k_{\text{max}}$ - 6816
Critical points:
- Channel estimation / correction
- Memory technology

COFDM Channel Decoder
Where will **DVB-H** have to play a role?

DVB-UMTS Architectural Model

- **Broadcast Content Provider**
- **Co-operation Platform**
- **ISP**
- **Core network**
- **UMTS base station**
- **Mobile terminal**
- **DVB-UMTS**
- **DVB-T transmitter**
- **Broadcast network operator**

Power consumption is key !!!!
Solution: DVB-H System
(When Sharing the Multiplex with MPEG-2)

- MUX
- IP-Encapsulator
  - MPE
  - MPE-FEC
  - Time Slicing

- DVB-T Modulator
  - 8K 4K 2K DVB-H TPS

- DVB-T Demodulator
  - 8K 4K 2K DVB-H TPS

- Channel

Transmitter
Receiver

- New to DVB-H
- Existing
Solution elements

- **Based on DVB-T**, can share multiplex with DVB-T services (backwards compatible)
  - can share frequency band with DVB-T (spectrally compatible)
- **IP-based solution**, MPE used over DVB-T

- **New 1**: Time Slicing for power saving

- **New 2**: MPE-FEC (with virtual time-interleaving) for mobile performance and tolerance to impulse noise

- **New 3**: features to DVB-T PHY
  - Optional 4K mode and 4K symbol interleaver
  - Optional in-depth interleaver (=short time-interleaving) for 2K and 4K
  - Additional signalling in TPS
  - Mandatory use of cell-ID (for handover)
  - 5 MHz channels for non-broadcasting bands
Time Slicing 1

• In normal DVB-T MPEG-2 and data transmissions the transport streams from the services are multiplexed together with high frequency on the TS-packet level.

• This means that the services are transmitted practically in parallel.

• For a DVB-T receiver it is impossible to receive only the wanted TS-packets due to the high multiplexing rate. All data must be received -> high power consumption.
Time Slicing 2

- In time slicing IP-services within a MPE data service are organised:
  - One service will use the full DVB-H data capacity for a while, say 200 ms.
  - After that comes the next service and so on...
  - After longer period, say 4s, the first service is again in the air.

- The DVB-H service is just another “MPE-data pipe” for the DVB-system and can be freely multiplexed with other transport streams.
Time Slicing 3

- DVB-T is by default intended for continuous transmission
  - Synchronisation times are rather long: in the order of 200 ms
  - Thus long burst intervals have to be used to get the full gain
- The receiver has to know when to wake up
  - This is done by sending time difference to the next relevant burst
- Time Sliced and non-Time Sliced services in common multiplex
  - Only receiver switched off, transmitter on all the time
  - Support for Time Slicing not mandatory to receive Time Sliced service
- Buffer in terminal required for constant output rate
Time slicing 4

• The parameters can be selected from a large range of values: the burst lengths may be shorter or longer; the same with burst intervals
• The power savings in the receiver front-end can typically be of the order of 90 % or higher

• **NOTICE:** Bytes belonging to one service will be spread both in **TIME** and **FREQUENCY**
  • MPE-FEC virtual time-interleaving spreads in time (see later)
  • Time-slicing gives the **whole DVB-T bandwidth** in use (even when sharing with DVB-T!)

\[\text{FREQUENCY} \quad 8 \text{ MHz}\]
\[\text{TIME} \quad \text{e.g. 0.5 s}\]
Handover Support
due to time-slicing

- In normal DVB-T systems smooth handovers would require two front ends in a single terminal
- Time Slicing offers, as an extra benefit, the possibility to use the same receiver to monitor neighbouring cells during the off-time
MPE-FEC

- Additional data link layer Reed-Solomon coding for IP datagrams
- RS data delivered in special FEC sections (*virtual interleaving*)
- Reuses Time Slicing buffer (2 Mbit)
- MPE-FEC ignorant receiver simply ignores FEC sections
  - Support for MPE-FEC not mandatory to receive MPE-FEC services

![Diagram of MPE-FEC process]

Virtual time interleaving: bytes belonging to same RS codeword distributed in time
**MPE-FEC2 (in detail)**

- IP-Data is filled in vertical direction
- Table is padded
- RS-Code words are calculated in horizontal direction
- RS-Columns are formed in vertical direction
- Data is transmitted in vertical direction as MPE and FEC-sections
- The number of rows $K$ selectable, $K_{\text{max}} = 1024$
- The code may be punctured or shortened $\Rightarrow$ selectable robustness

![Diagram](image)

- Error here!

- Data is transmitted in vertical direction as MPE and FEC-sections
- The number of rows $K$ selectable, $K_{\text{max}} = 1024$
- The code may be punctured or shortened $\Rightarrow$ selectable robustness
Example of virtual time interleaving

- 8k, GI = 1/4, 16QAM 2/3 ("German mode") (DVB-H FEC ¾, 1024 rows)
- The DVB-T level bit rate (after RS) is 13.27 Mb/s
- Let us assume multiplex shared: 4 Mb/s for H (i.e. 3 Mb/s net) and 9.27 Mb/s for T
- The FEC codewords (rows) will be spanned in time
  - One word will take transmission time $t_i$ (interleaving depth time)

$$t_i = \frac{[(N - 1)K + 1] \cdot 8}{R_b}$$

Where $N$ is the number of bytes in a codeword, $K$ is the number of rows in the code table and $R_b$ is the net bit rate at DVB-T TS interface

- For this example we get **0.52 seconds**!
- This is very useful to support low mobility handhelds
4K mode and in-depth interleavers

- **Benefits:**
  - Mobility is increased by factor of two when compared to 8K
  - Maximum SFN-size is double when compared to 2K
  - If the 8K interleaver is used with 2K or 4K, impulse interference tolerance will increase

- **Compatibility:**
  - These new features are options in the DVB-T EN 300 744 standard, added there to give more flexibility for DVB-H
  - If DVB-H is using the existing DVB-T networks, these new features cannot be used
  - They are intended for future **dedicated DVB-H networks**
**Performance, effect of in-depth interleaver**

- Tolerance to impulse interference will be improved when using in-depth interleaver with 4K (or 2K)

![Graph showing BER performance with different SNR values](image)
**TPS-bits in DVB-T/H**

- DVB-H needs some robust PHY-level signalling to indicate that the signal is DVB-H and whether MPE-FEC is used.
- Two bits s48 and s49 out of the six free are used for this.

<table>
<thead>
<tr>
<th>S48</th>
<th>S49</th>
<th>DVB-H signalling</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>x</td>
<td>Time Slicing not used</td>
</tr>
<tr>
<td>1</td>
<td>x</td>
<td>Time Slicing used = DVB-H *)</td>
</tr>
<tr>
<td>x</td>
<td>0</td>
<td>MPE-FEC not used</td>
</tr>
<tr>
<td>x</td>
<td>1</td>
<td>MPE-FEC used *)</td>
</tr>
</tbody>
</table>

*) at least in one elementary stream

- Cell-Id is mandatory
- TPS length indicator set accordingly to 33.
- 4K and the interleavers are indicated in the “old” TPS-bits.
**DVB-H Standards Family**

- **TS 101 191**
  - SFN megaframe

- **EN 301 192**
  - Data broadcasting
  - *Time Slicing, MPE-FEC*

- **EN 302 304**
  - DVB-H System Specification
  - normative

- **EN 300 468**
  - DVB-SI

- **EN 300 744**
  - (v.1.5.1)
  - DVB-T

- **Annex F, G**
  - 4K
  - Interleavers
  - TPS
  - 5 MHz

- **DVB-H Implementation Guidelines**
  - TR 102 377

**New documents for DVB-H**

**Modified existing standards**

**Arrows indicate reference direction**
Standardization situation

- Standards now accepted in ETSI

- DVB-H Implementation guidelines v. 1.0 accepted by DVB-TM in September 2004
- => ETSI publication later 2005; 2005-03-29

ETSI EN 302 304 V1.1.1 (2004-11)

Digital Video Broadcasting (DVB); Transmission System for Handheld Terminals (DVB-H)
Use of the Options in DVB-H

- DVB-H means obligatory use of **Time Slicing** and **optionally** MPE-FEC over DVB-T physical layer.
- MPE-FEC **robustness can be selected** according to the needs;
  - if capacity is available one may build services that on mobile channels are 2-6 dB more robust than the basic mode (sacrificing 25% of the capacity for redundancy)
  - the virtual time-interleaving length can be adjusted
- All DVB-T options - including **the new ones** - are available:
  - 8K, 4K or 2K
  - Modulations QPSK, 16QAM, (even 64 QAM)
  - Code rates 1/2- 7/8, recommended 1/2 or 2/3
  - Native or in-depth interleavers in 2K and 4K
- **Implementation guidelines** will give further guidance in parameter selection
Use of DVB-H in frequency bands

- For terminals with integrated antennas only UHF (and higher) bands are really feasible
  - The gain of integrated antennas at VHF ~ -20 dBi!
- In UHF bands only channels 49 and below ( < 700 MHz) usable if GSM phone in the same terminal (otherwise no limitation)
- Broadcasters and administrators should take care that at least one H-multiplex can be built nationwide with channels ≤49 in UHF
- For non-broadcast bands also other frequencies maybe available/usable; like in experiments in USA around 1.7 GHz (5 MHz channel BW)
Validation and performance of DVB-H

- Validation work has been done, extensive report under publication

- Laboratory session in Berlin 18.-29.10.2004
  - *Successful interoperability* tests (3 modulators, several receivers)
  - *Very promising performance* tests (4k mode, MPE-FEC, time-slicing,..)

- Field tests run in several networks in 2004 and/or beginning of 2005
  - Barcelona
  - Berlin
  - Helsinki
  - Metz

- Further work under EU-project WING-TV

WORK continues 2005-2006
Example of FEC influence

TU6 Mobile channel

DVB-T vs DVB-H
(8K - gi 1/4 - QPSK 1/2 - MPE-FEC)

- ESR 5% (DVB-T)
- FER 5% (DVB-H without FEC)
- MFER 5% (DVB-H with FEC)

CAUTION:
Preliminary result of one prototype
(reference receiver work ongoing in DVB)

5-6 dB
Field test results (example)

Terminal A: QPSK MPE 3/4 1024 pedestrian urban

C/N (dB) vs. Probability of reception for DVB-T and DVB-H.
Validation resources for lab session (1)

- **DVB-H IP Encapsulator**
  - Thales Broadcast Multimedia (OPAL)
  - Nokia (UDCAST product)

- **DVB Multiplexer**
  - Thales Broadcast Multimedia
  - T-Systems

- **DVB-T/DVB-H Modulator**
  - Rohde & Schwartz
  - ProTV
  - TeamCast
Validation resources for lab session (2)

DVB-H Receivers:
- FREESCALE
  - Silicium Down Converter (will be integrated with BB)
- NOKIA
  - A – 7700 (w/o 4K, MPE-FEC & w TS)
  - B – FPGA based (w 4K & measurement capabilities)
- SIDSA
  - C – Integrated receiver (w/o 4K, w MPE-FEC & TS)
  - (4K version available in December)
- SONY - UK
  - D – FPGA based (w 4K, MPE-FEC, TS)
- DIBCOM
  - E – Integrated receiver (w/o 4K, w MPE-FEC & TS in PC)
- PANASONIC
  - F – Integrated receiver (w/o 4K, w MPE-FEC & TS in PC)
The System Architecture in a Nutshell

DVB-T/H Transmitter

Service System

IPE Manager

E-Commerce

IP Encapsulator

Multicast Intranet

BSC

SGSN

GGSN

BTS

Terminal

Cellular network

Producer

Terminal
• DVB-H services in DVB-T network with multiplexing or using hierarchy
• The DVB-T network should support portable indoor reception.
Dedicated DVB-H Network

- New DVB-H network built by the operator.
As a service mobile phone TV has great potential

- Acceptance of Mobile TV is high
- Mobility and flexibility are strongest perceived benefits of mobile TV.
- News and regional information are the most demanded content.
- Willingness to pay is high: More than 80% of the potential users could imagine to pay on average more than 12 Euro per month (The packaging of channels is the favored service model)
- Nearly 50% of Potential Users can imagine to change their mobile service provider, if mobile TV was not offered by their current network operator.

20% can imagine to use mobile TV regularly in daily-life!

Source: bmco User Survey (Auditorium Test) / Goldmedia GmbH, July 2004
High Acceptance of Mobile TV

77.8% regarded mobile TV as a good or excellent idea
Only 7.62% totally disliked the idea

What do you think about using Mobile TV?

- It is an excellent idea: 23.44%
- It is a good idea: 54.30%
- It is not such a great idea: 14.65%
- I don't like the idea: 7.62%

Source: bmco User Survey (Auditorium Test) / Goldmedia GmbH, July 2004
Benefits for all players

- **Consumers:** good, understandable service
- **New revenue opportunities for all industry players**
- **Media & broadcasters:** re-use of popular content and new distribution platform
- **Broadcast network operators:** operating new DVB-H networks
  - **Mobile operators:** Offering Mobile TV services to customers and additional opportunities for interactive services
  - **Regulators:** good use for the spectrum released in digital switchover
  - **Equipment vendors:** new DVB-H network elements, DVB-H enabled mobile phones
Final message

- DVB has defined lowest layers of DVB-H ⇒ now standards accepted in ETSI
- DVB-H implementation guidelines v.1.0 accepted by DVB-TM in September 2004 ⇒ currently in ETSI process
- DVB-T remains the optimal solution for digital TV for fixed reception, DVB-H is the optimal solution for handhelds

Commercial start of DVB-H networks and services expected year 2005/2006 with full commercial operation from year 2007 on
Thank You!
Solution DVB-H (receiver part)

Power Consumption & Hand Over
- Turn off the radio when you don’t use it!
- Data is organised to 1-2 Mbit bursts.
- This is called Time Slicing.
- Up to 90% power saving with video streaming.
- 2 Mbit buffer for constant output.
- Handover possible during off time.

Network Design Flexibility and Signalling
- With 4k practical SFN is still possible with very good mobile performance.
- Flexible use of interleavers [ 8k in 4k or 2k ].
- New TPS bits to signal Time Sl. and MPE-FEC
- Cell id is mandatory.
- Very low additional complexity.

Mobile Performance
- New error correction (RS) for the MPE-sections.
- Virtual interleaver re-using Time Slice buffer.
- Doppler and CN-improved in mobile&portable.
- Impulse interference tolerance improved.
- Possibility to vary the level of robustness.
**DVB-T standard Tx**

- MUX, adaptation, energy dispersal
- Outer coder RS
- Outer interleaver (byte interleaver)
- Inner coder Convolutional
- Inner interleaver (carrier bit interleaver)
- Mapper
- Frame adaptation
- OFDM (IFFT)
- Guard interval insertion
- D/A
- Pilot & TPS signals
- IF/RF trans

- Structure of DVB-T transmitter functions
**4K mode and in-depth interleavers**

- Scaled solution from 2K and 8K mode
  - Directly scaled parameters
  - Dedicated 4K mode symbol interleaver
  - Continual pilots from the same arrangement (8k)
  - Easy implementation, only some control logic needed

- 8k interleaver can be used with 4K or 2K
  - DVB-T physical level native interleaver works within one OFDM-symbol
  - When 8k interleaver is used with 4k, interleaving happens over two symbols
  - When 8k interleaver is used with 2k, interleaving happens over four symbols
TPS-bits in DVB-T/H

- DVB-H needs some robust PHY-level signalling to indicate that the signal is DVB-H and whether MPE-FEC is used
- Two bits are used for this
- Use of **Cell-Id is mandatory**
- 4K and the interleavers are indicated extending the contents of the “old” TPS-bits
MPE-FEC performance with impulse noise, DTG6

- Impulse noise model from DTG (UK); profile # 6
- MPE-FEC gives clear 7 - 8 dB benefit with impulse noise (DTG6)
  - 7 dB benefit with “streaming error criteria” (IP PER < 10^-2)
  - 8 dB Benefit with “file delivery error criteria” (FER <10^-3)
MPE-FEC Performance in TU6, $F_{\text{max}}$

- MPE-FEC gives clear 21 - 58 Hz benefit in TU6 with maximum Doppler frequency, $F_{\text{max}}$
  - 21 Hz benefit with “streaming error criteria” (IP PER < $10^{-2}$)
  - 58 Hz Benefit with “file delivery error criteria” (FER < $10^{-3}$)
Network Sharing with MPEG-2 DTV by Multiplexing

- Introducing DVB-H services in existing DVB-T network with multiplexing.
- The DVB-T network should support portable indoor reception.
Network Sharing with MPEG-2 DTV by Hierarchy

- Introducing DVB-H services in existing DVB-T network with hierarchy.
- The DVB-T network should support portable indoor reception.
Known commercial activity

- **Nokia Media device 7700**, Nice, October 2003 with a battery pack accessory called **Nokia Streamer**

- **Sony SES and Motorola SPS** front-end proposal

- **DIBCOM** By May 04, in phase 3 model supporting e.g. time slicing and MPE-FEC; cell handover and monitoring features are included.

- **Panasonic** DVB-H Validation Receiver hardware includes antenna, DVB-T front-end, PC-card type demultiplexer and laptop.

- **SIDSA** will be able to perform e.g. MPE-FEC, IP-de-encapsulation and time slicing analysis. Final goal is to develop a Mobile Communicator with Wi-Fi, GPRS, UMTS and DVB-H connections.

- **ProTelevision Technologies** from Denmark has announced 4k modulator with DVB-H capabilities.

- **ETC**
Nokia 7700 and Streamer

• 28.10.2003 in Nokia Mobile Internet Conference in Nice Nokia has published a new phone model, Nokia 7700 Media Device.
• It has a DVB-H based IPDC reception capability via a battery pack accessory called Nokia Streamer.
• Streamer is world’s first DVB-H Mobile Phone TV receiver, supporting Time Slicing
• It is intended to support the DVB-H Pilot projects

DVB-H - European Innovation in Broadcast

Benefits:

- **Consumers:** new, attractive services
- **Media & broadcasters:** re-use of popular content via new distribution platform
- **Broadcast network operators:** additional core business opportunity
- **Mobile operators:** provision of interactive services and potential new roles in digital broadcast business
- **Equipment vendors:** new products and features

Happy Consumer
Market study on DVB-H

- A study with 512 persons (cell phone users) in Berlin Area
- 78% thought that mobile TV is a **good or excellent** idea
- Average additional amount that people were willing to pay for mobile TV services was **€12/month**