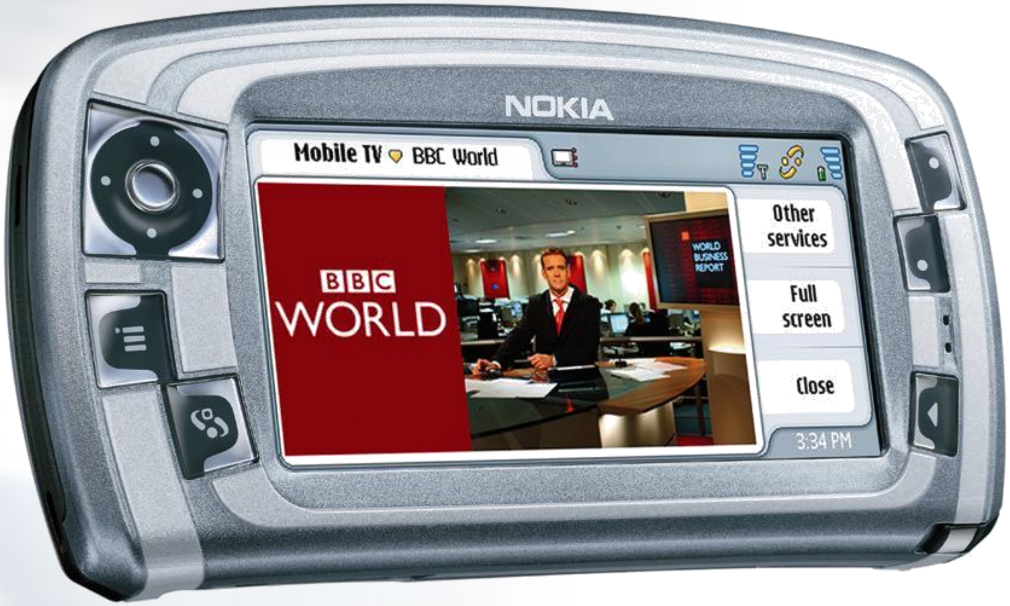

DVB-H Standard Overview

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2005

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Background

- Research for DVB-T based mobile applications started with the EU-funded ACTS Motivate project in 1998.
- Simultaneously we in Nokia did things like MediaScreen and CarTV, the forerunners of current IP-Datacasting.
- The Japanese were also developing a terrestrial digital TV-standard called ISDB-T.
- Questions raised:

Is DVB-T good enough?

Should we modify it somehow?

Can we compete with ISDB-T?

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DVB-T SE

- All these questions we discussed in DVB-circles.
- Political pressure, however, not to modify DVB-T, was very high due to the standard stability.
- A permission to start secret studies on the subject was given in late 2000 by TM chairman Ulrich Reimers.

- DVB-T SE [Standard Extensions]
  - Start in late 2000
  - Chaired by Jukka Henriksson, Nokia
  - Final Report December 2001: add 4k and time interleaving
  - Power consumption was not yet very high on the agenda, although it was known to be a problem.

DVB-M (CM)

- Nokia made an initiative to form a group within DVB-Commercial Module to draft requirements for DVB-M (Mobile) Physical Layer.
  - Should be based on the discoveries of the SE-group.
  - Take account power consumption limitations in mobile. handsets

- DVB-MOB (CM)
  - Start in January 2002
  - Chaired by Juha Salo, Nokia
  - Requirements accepted by the CM in August 2002
    - Co-existence with Mobile Phones = hand portable indoor reception.
    - Mobility with single antenna reception
    - Low power consumption

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DVB-H (TM)

- Technical group to develop solution for DVB-M commercial requirements.
- Started in September 2002
- Chaired by Jukka Henriksson, Nokia
- First task was to find out if DVB-T meets the requirements
  - Report to TM in January 2003:

> DVB-T does not do the Job
> Main problem: power consumption

- Call For Technology out in Jan/Feb 2003
  - Solution should be based on DVB-T and be as compatible as possible
  - 12 responses received, technology elements rather than concepts
- Out of the technology elements 3 full concepts were formed in April.
- Final concept was formed in August 2003.
- Standards accepted by the TM in January 2004.
- ETSI is the next round, output expected in the autumn of 2004.

Motivation and The Problem

- TV is the biggest media and the last one missing from mobile phones - DVB-H will bring this convergence to life.
- Cellular systems like 2.5G/3G could be used but are expensive.
- DVB-T based IP-data broadcasting (IPDC) could be the solution.

BUT 3 MAIN PROBLEMS EXIST.

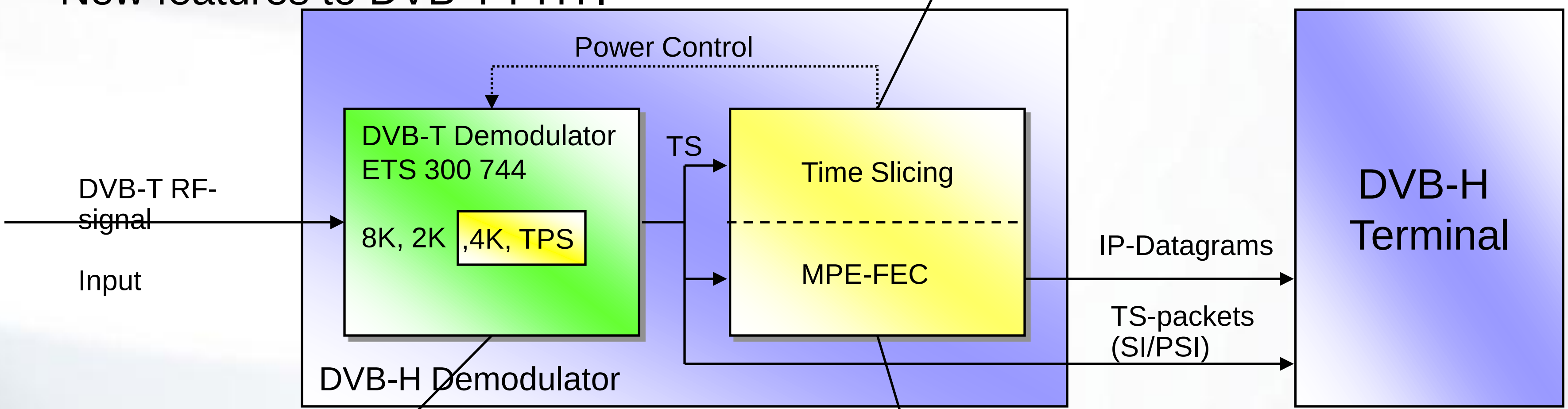
1. Power consumption
2. Performance in cellular environment
   - C/N in mobile channel
   - Doppler in mobile channel
   - Impulse interference
3. Network design flexibility for mobile
   - Single antenna mobile reception in medium to large SFN

AND DVB-H SHOULD BE BASED ON DVB-T.

Solution

- IP-based solution, MPE used over DVB-T.
- Time Slicing for power.
- MPE-FEC for mobile performance.
- New features to DVB-T PHY.

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.

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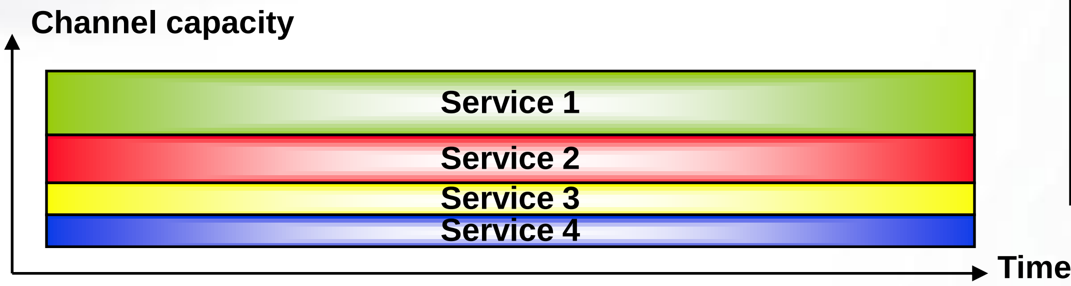
Time Slicing 1

- 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, each service having it’s share of the TS-packets.



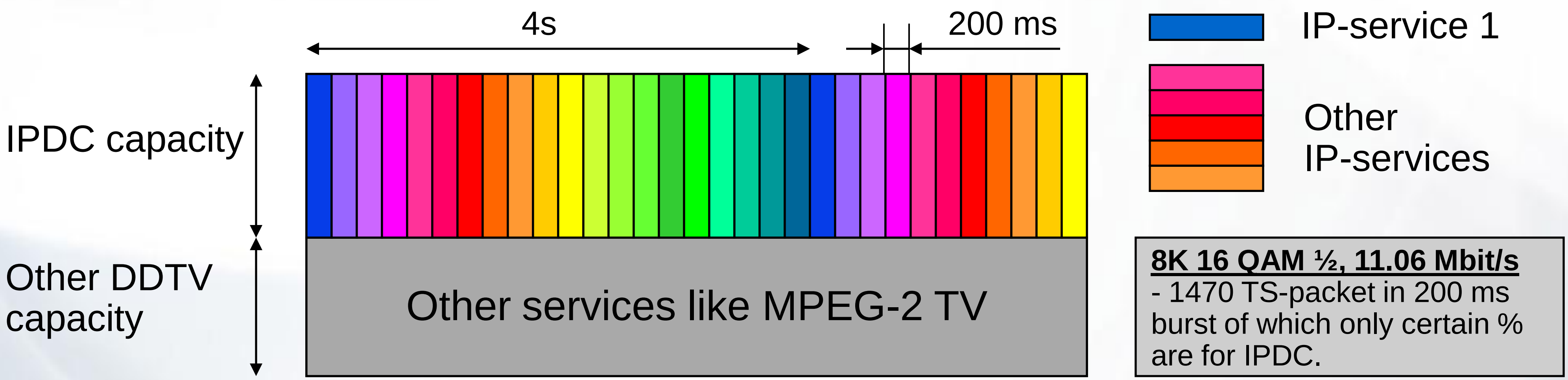
<u>8K 16 QAM ½ 1/8, 11.06 Mbit/s</u>

-7.412 TS-packets/OFDM-symbol
-1 Symbol = 1008 us
-136 us / TS-packet

- 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

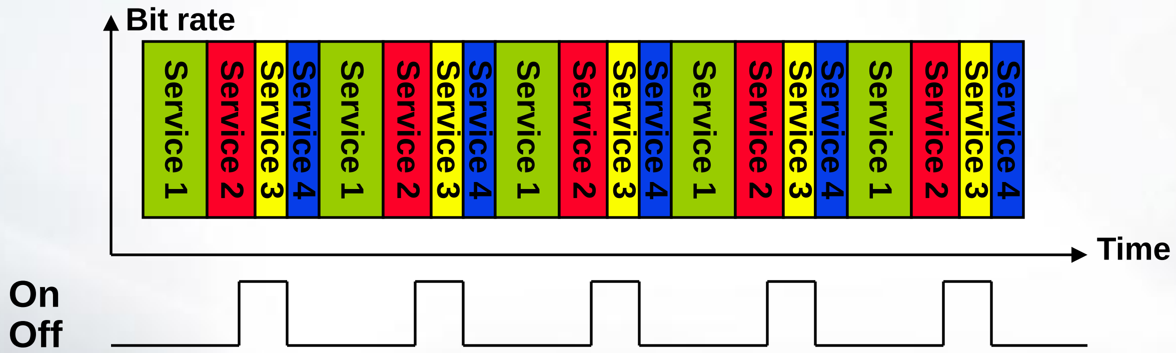
- Let’s organise the IP-services in within a MPE data service so that:
  - One service will use the full data capacity of the MPE-service for a while, say 200 ms.
  - After that comes the next service and so on…
  - After longer period, say 4s, the first service is again in the air.



- The IPDC 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 time intervals have to be used to have full gain.
- The receiver has to know when to wake up
  - This is done by sending time difference to the next relevant burst
  - Real time signalling per elementary stream using Delta-T method.
- PSI/SI not Time Sliced
  - Not required for power saving
- 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



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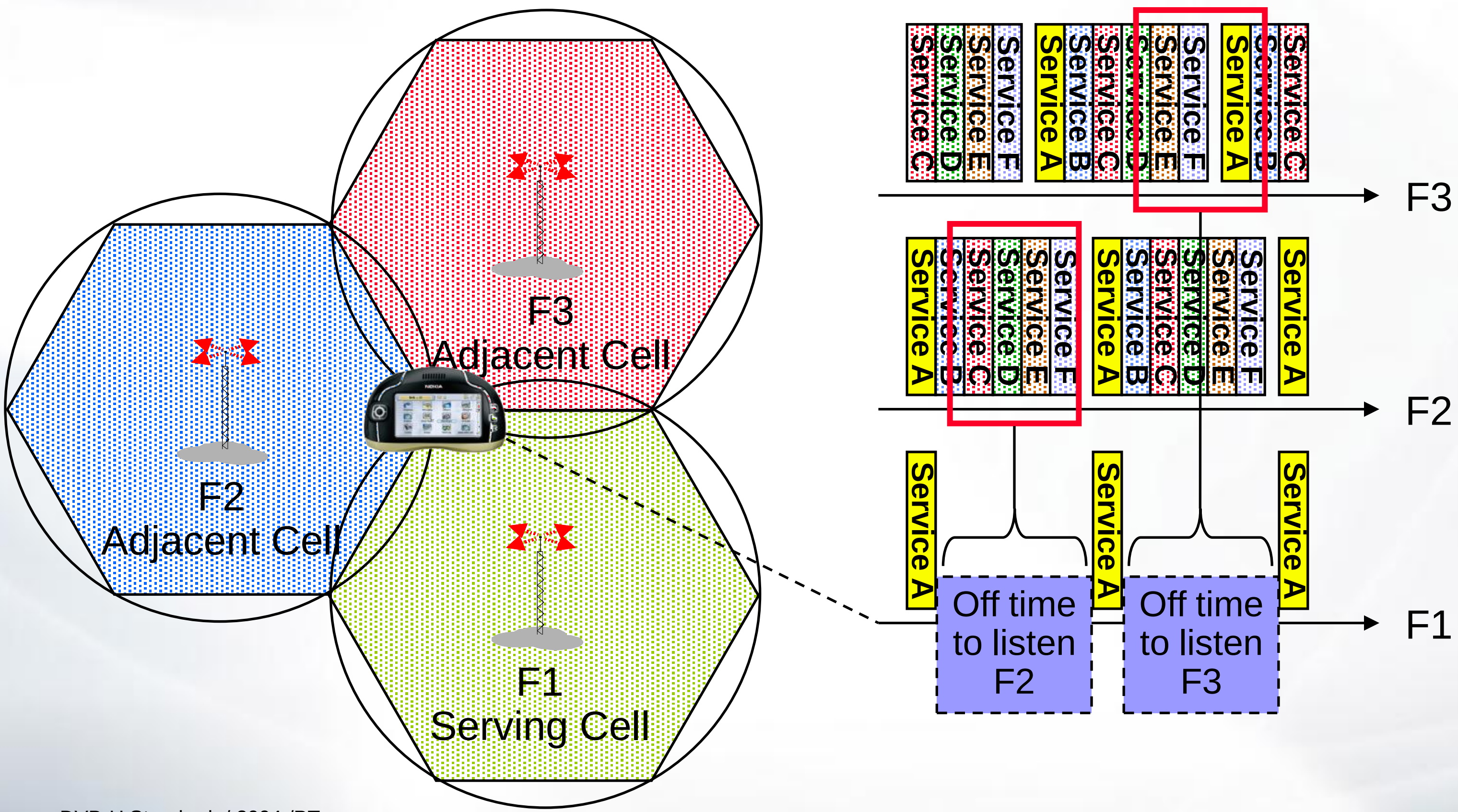
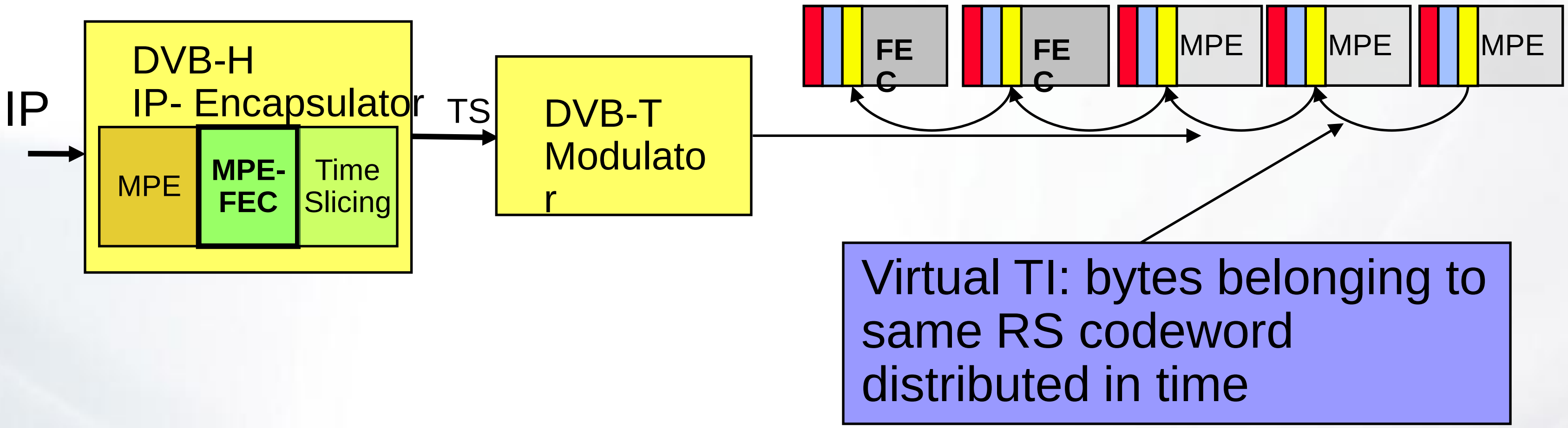
Handover Support

- 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.
- Soft handover, maintaining the service, is possible.



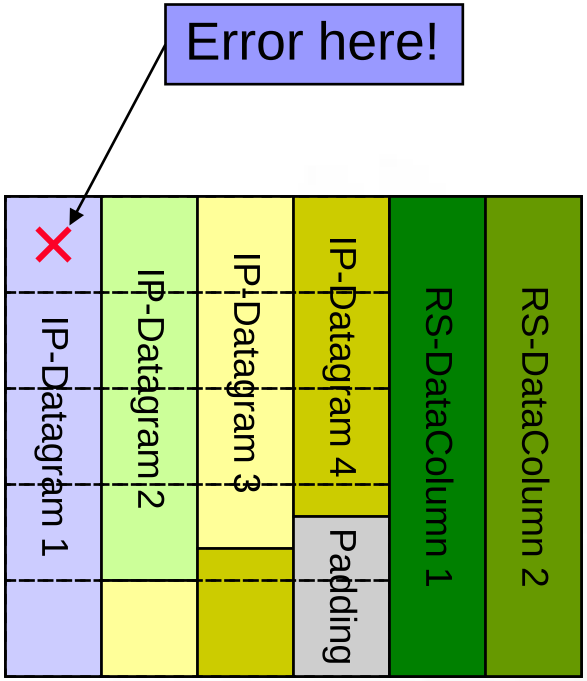
MPE-FEC 1

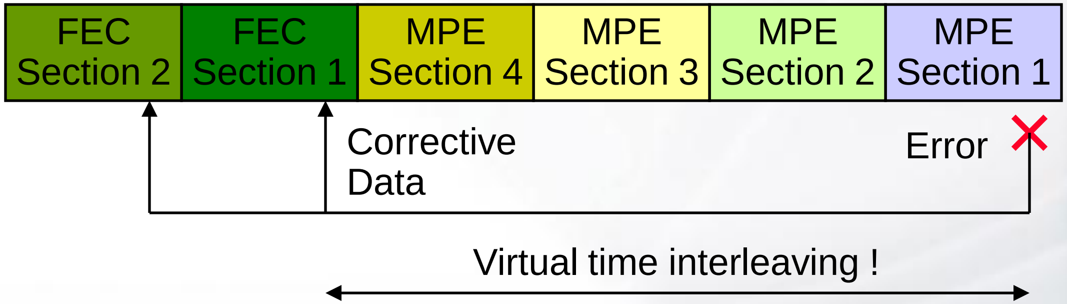
- Additional data link layer Reed-Solomon coding for IP datagrams.
- RS data delivered in special FEC sections (virtual interleaving).
- Reuses Time Slicing buffer (2 Mbit) .
- MPE-FEC ignorant receiver simply ignores FEC sections
  - Support for MPE-FEC not mandatory to receive MPE-FEC services



MPE-FEC 2

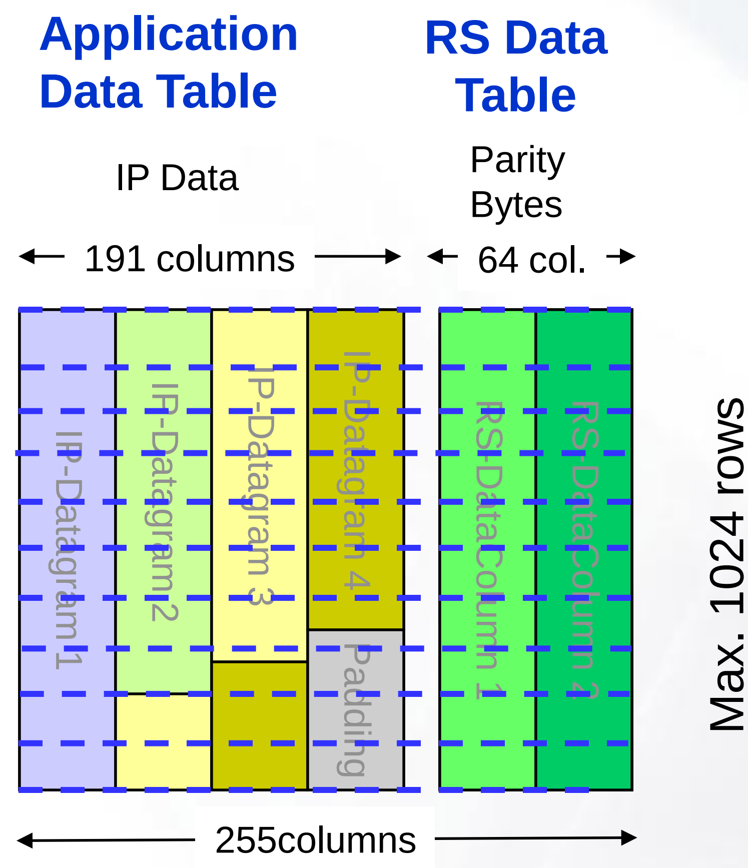
- IP-Data is filled in vertical direction.
- Table is padded.
- RS-Code words are calculated in horizontal direction.
- RS-Columns are formed in vertical direction.
- Data is transmitted in vertical direction as MPE and FEC-sections.





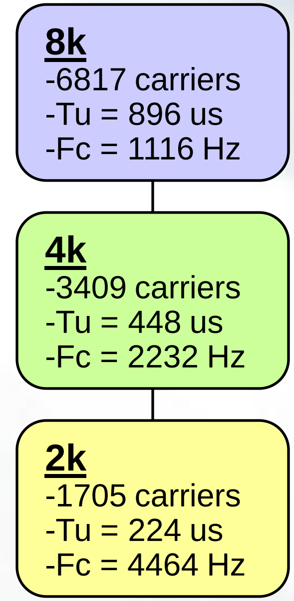
MPE-FEC – Frame Structure

- Practical MPE-FEC consists of
  - 256, 512, 768 or 1024 rows
  - and constantly 255 columns
- Different size MPE-FEC frames are needed for optimal planning (Number of services, capacity of each service, Time Slicing on/off times, etc)
- Maximum buffer size for the frame is approx. 2 Mbit (8 x 255 x 1024)

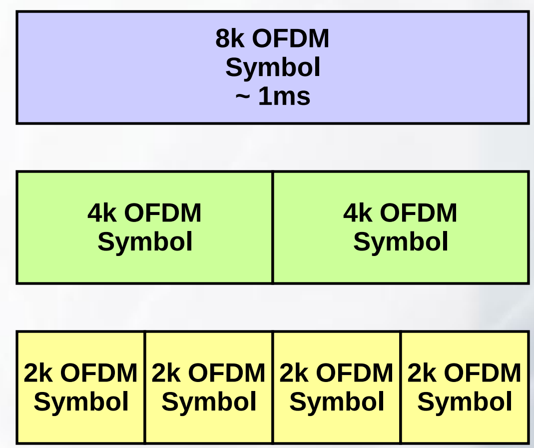


4k and In-depth Interleavers 1

- Interpolated 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.



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4k and In-depth Interleavers 2

- Benefits:
  - Mobility is increased by factor of two when compared to 8k.
  - Maximum SFN-size is double when compared to 2k.
  - 4k is really a compromise between 8k and 2k and decreases the step in FFT-size selection.
  - 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.
  - They are not themselves DVB-H, they are DVB-T!
  - If DVB-H is using the existing DVB-T networks, these new features can not be used.
  - They are intended for future dedicated DVB-H networks.

TPS-bits in DVB-T

- 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.

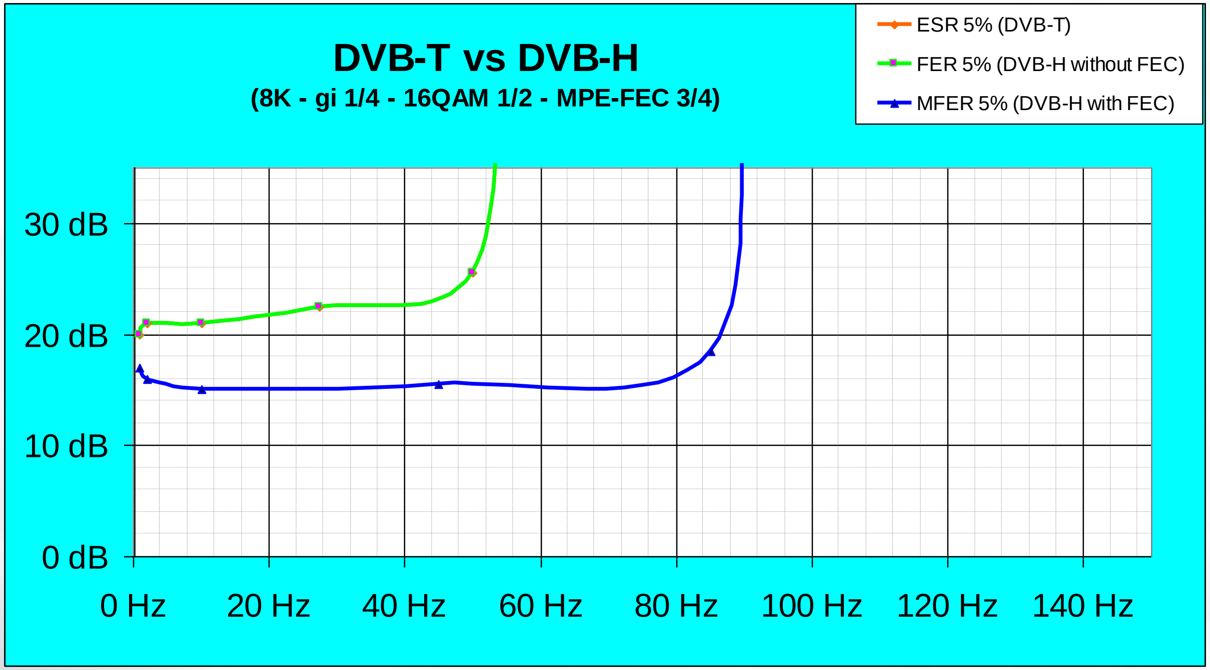
S48	S49	DVB-H signalling
0	x	Time Slicing not used
1	x	Time Slicing used = DVB-H *)
x	0	MPE-FEC not used
x	1	MPE-FEC used *)

*) at least in one elementary stream

- Note that as Time Slicing is mandatory, bit S48 is in fact indicating DVB-H.
- Cell-Id is mandatory
- TPS length indicator set accordingly to 33.
- 4k and the ineterleavers are indicated in the “old” TPS-bits.

Performance of DVB-H

- Exact full performance figures are still to be derived by the Wing-TV!
  - Virtual interleaving provided by FEC gives a real improvement to tolerance to Doppler by 50% and more.
  - MPE-FEC gives several dB improvement in tolerance to impulse interference in some relevant scenarios and typical impulse noise levels.
  - General improvement in tolerance to noise.



C/N in Gaussian and Portable Channels

Gaussian Channel:

Modulation	Code rate	Gaussian MPE-FEC CR=3/4
QPSK	1/2	4,6
QPSK	2/3	6,4
16-QAM	1/2	10,3
16-QAM	2/3	12,7

Portable Channel:

Modulation	Code rate	Portable MPE-FEC CR=3/4
QPSK	1/2	6,4
QPSK	2/3	9,4
16-QAM	1/2	12,3
16-QAM	2/3	15,3

Mobile Channel Performance

- DVB-H Implementation Guidelines defines currently two 8MHz reference receivers "Typical" and "Possible".
- Typical has good enough performance for the 8 MHz UHF use.
- Possible can be used when more performance is needed, for example in 5 MHz and 6 MHz cases or at higher frequencies.

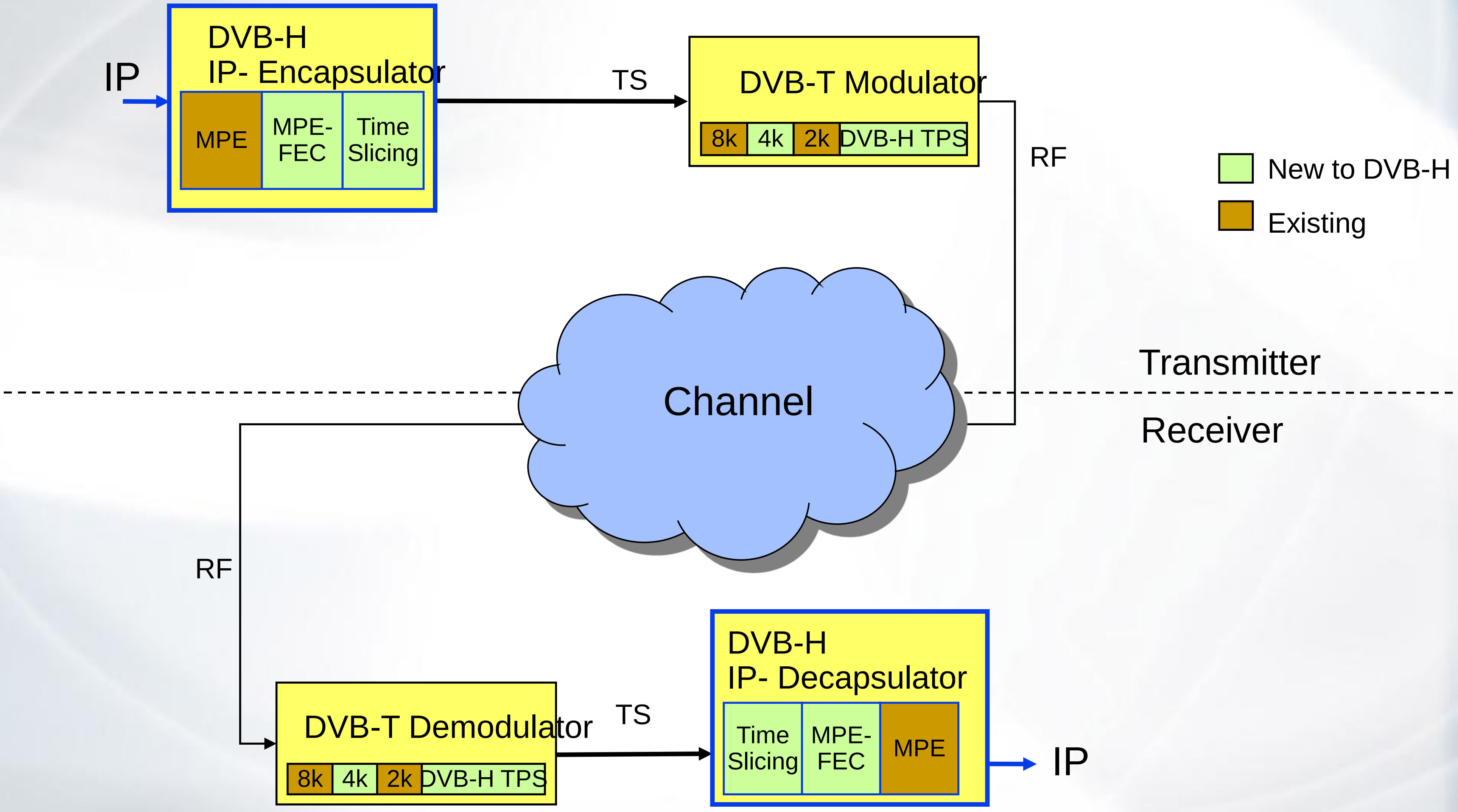
"Typical" Reference Receiver Guard interval = 1/4			**2k**		**Speed at Fd_{3dB} [km/h]**		**4k**		**Speed at Fd_{3dB} [km/h]**		**8k**		**Speed at Fd_{3dB} [km/h]**	
Modulation	**Code rate**	**Bit rate [Mbit/s]**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**
QPSK	1/2	4,98	9,5	380	866	588	9,5	190	433	294	9,5	95	216	147
QPSK	2/3	6,64	12,5	360	820	557	12,5	180	410	279	12,5	90	205	139
16-QAM	1/2	9,95	15,5	340	775	526	15,5	170	387	263	15,5	85	194	132
16-QAM	2/3	13,27	18,5	320	729	495	18,5	160	365	248	18,5	80	182	124

"Possible" Reference Receiver Guard interval = 1/4			**2k**		**Speed at Fd_{3dB} [km/h]**		**4k**		**Speed at Fd_{3dB} [km/h]**		**8k**		**Speed at Fd_{3dB} [km/h]**	
Modulation	**Code rate**	**Bit rate [Mbit/s]**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**	**C/N_{min} [dB]**	**Fd_{3dB} [Hz]**	**474 MHz**	**698 MHz**
QPSK	1/2	4,98	8,5	520	1185	805	8,5	260	592	402	8,5	130	296	201
QPSK	2/3	6,64	11,5	520	1185	805	11,5	260	592	402	11,5	130	296	201
16-QAM	1/2	9,95	14,5	480	1094	743	14,5	240	547	371	14,5	120	273	186
16-QAM	2/3	13,27	17,5	480	1094	743	17,5	240	547	371	17,5	120	273	186

Use of the Options in DVB-H

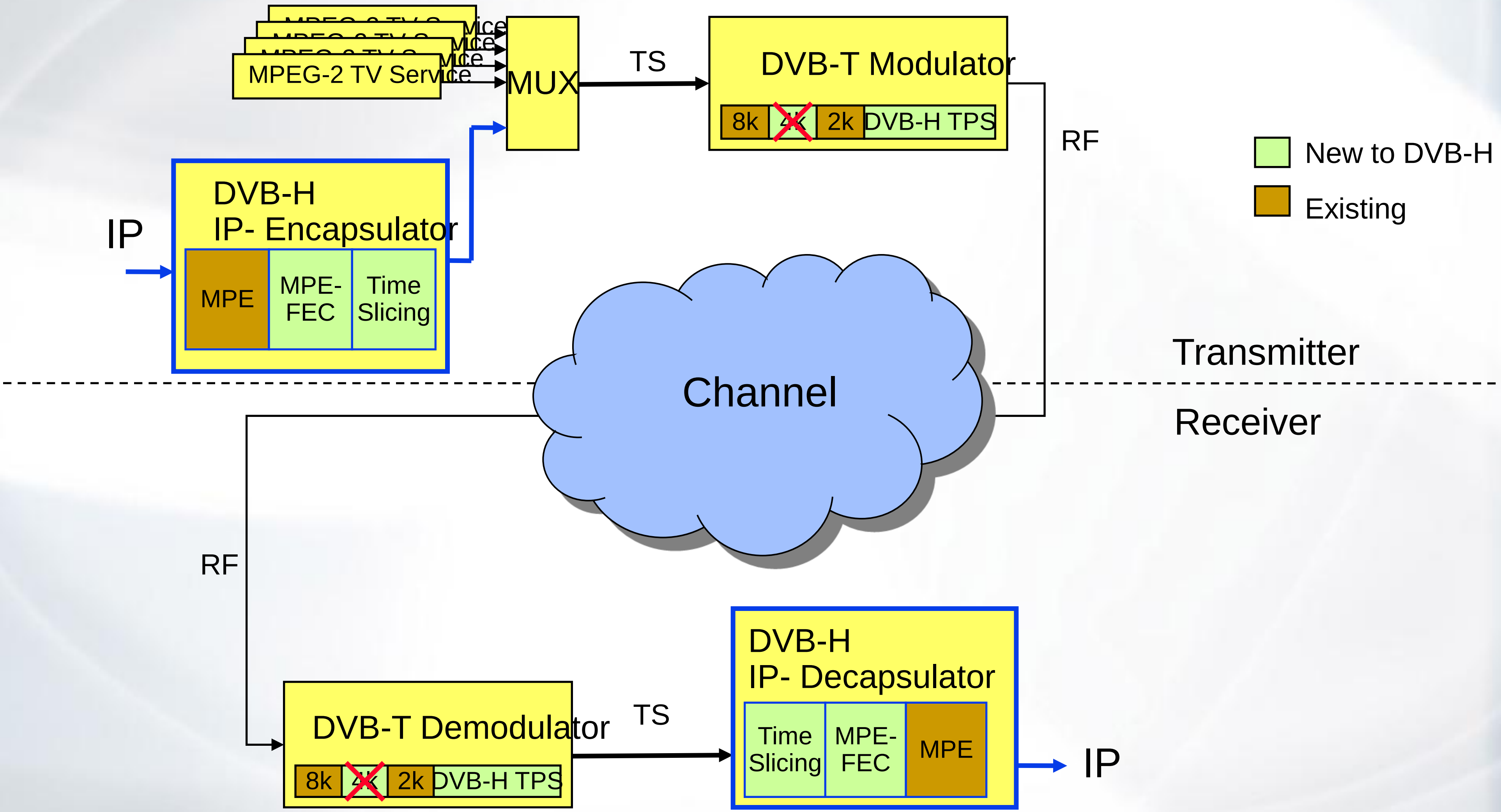
- DVB-H means using Time Slicing and optionally MPE-FEC over DVB-T physical layer.
- MPE-FEC robustness can be selected according to the needs; if capacity is available one may build services that are 2-5 dB more robust than the basic mode (which has 25% redundancy).
- On the DVB-T PHY DVB-H signalling and Cell-ID are mandatory.
  - Faster signal acquisition and better support for handover
- Otherwise all the DVB-T options including the new ones are available:
  - 8k, 4k or 2k
  - Modulations QPSK, 16QAM, 64 QAM
  - Code rates 1/2- 7/8, recommended 1/2 or 2/3
  - Native or in-depth interleavers in 2k and 4k

DVB-H System


IP
DVB-H
IP- Encapsulator
MPE
MPE-FEC
Time Slicing
TS
DVB-T Modulator
8k
4k
2k
DVB-H TPS
RF
New to DVB-H
Existing
Channel
Transmitter
Receiver
RF
DVB-T Demodulator
8k
4k
2k
DVB-H TPS
TS
DVB-H
IP- Decapsulator
Time Slicing
MPE-FEC
MPE
IP

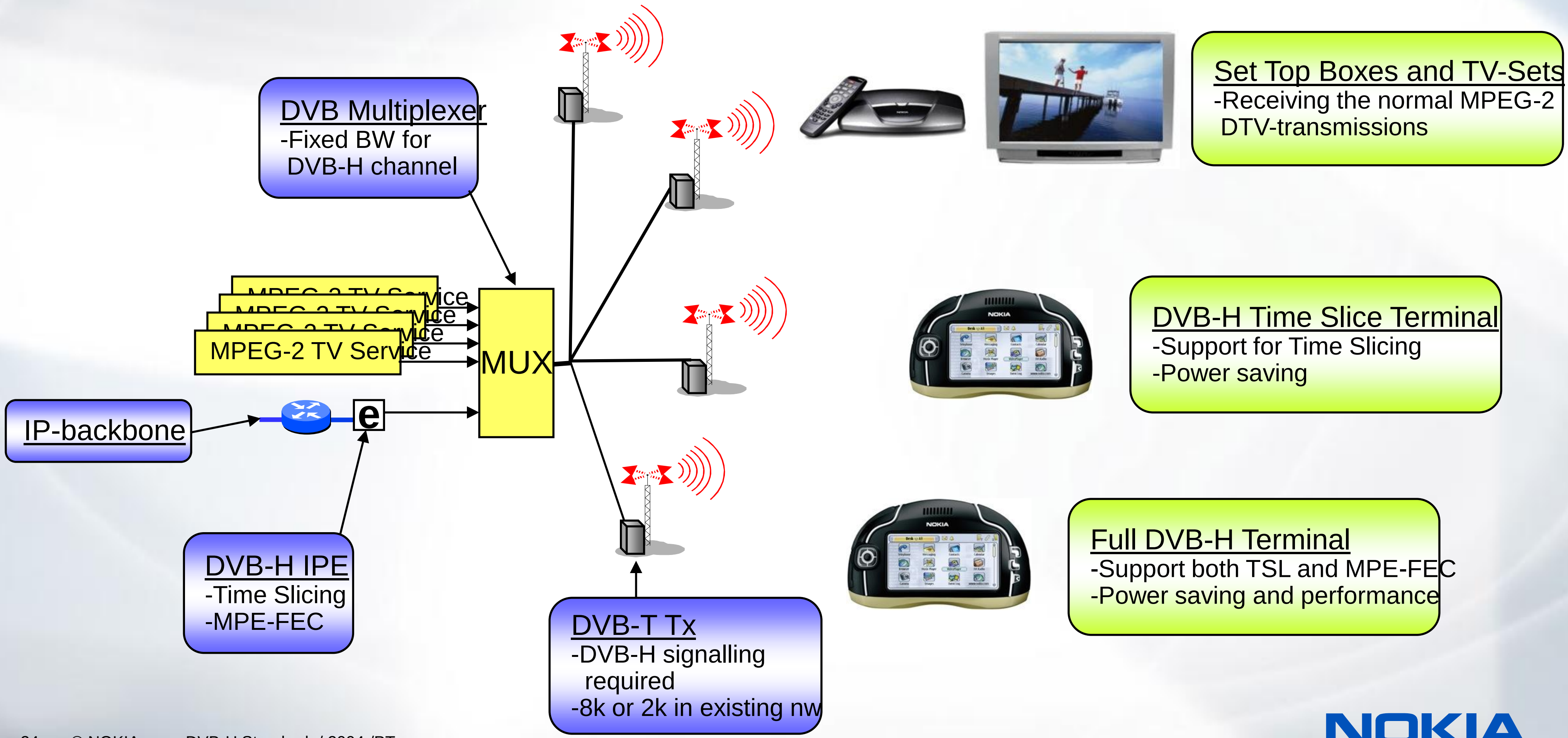
DVB-H System

When Sharing the Multiplex with MPEG-2



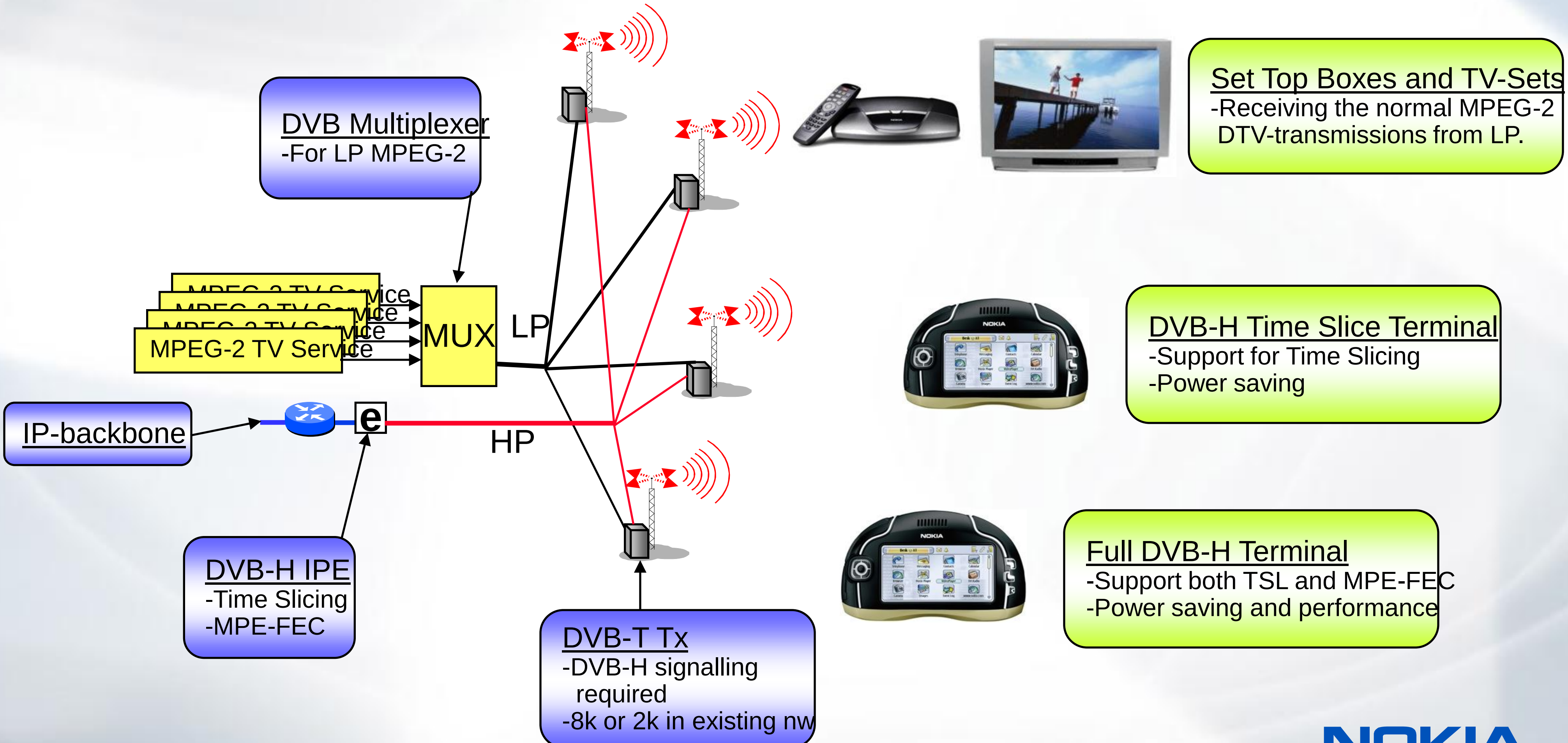
Network Sharing with MPEG-2 DTV by Multiplexing

- 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.



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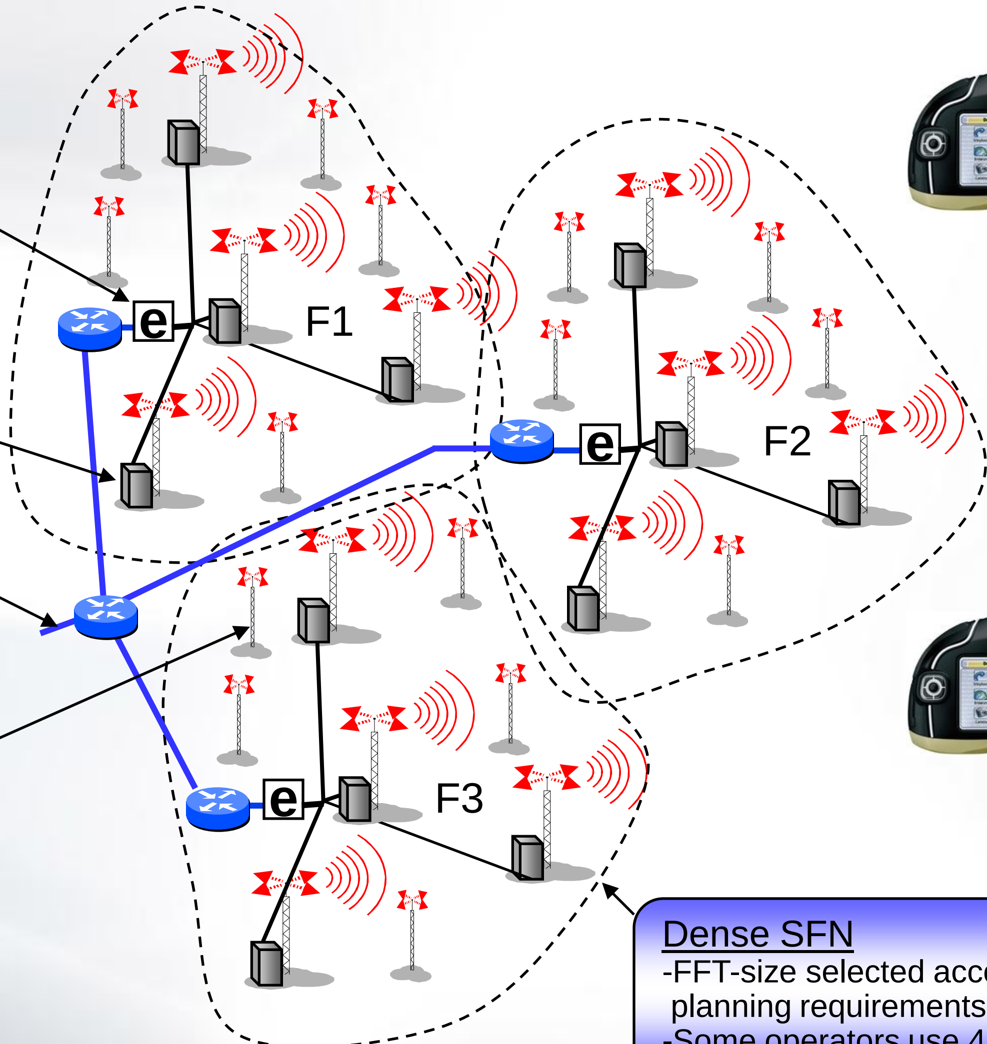
Dedicated DVB-H Network

- New DVB-H network built by the operator.



DVB-H IPE
- Time Slicing
- MPE-FEC

DVB-T Tx
- 4k capable, if needed
- TPS

IP-backbone

Repeater
- Repeaters may be used.

Dense SFN
- FFT-size selected according the planning requirements
- Some operators use 4k some 8k

DVB-H Time Slice Terminal
- Support for Time Slicing
- Power saving

Full DVB-H Terminal
- Support both TSL and MPE-FEC
- Power saving and performance

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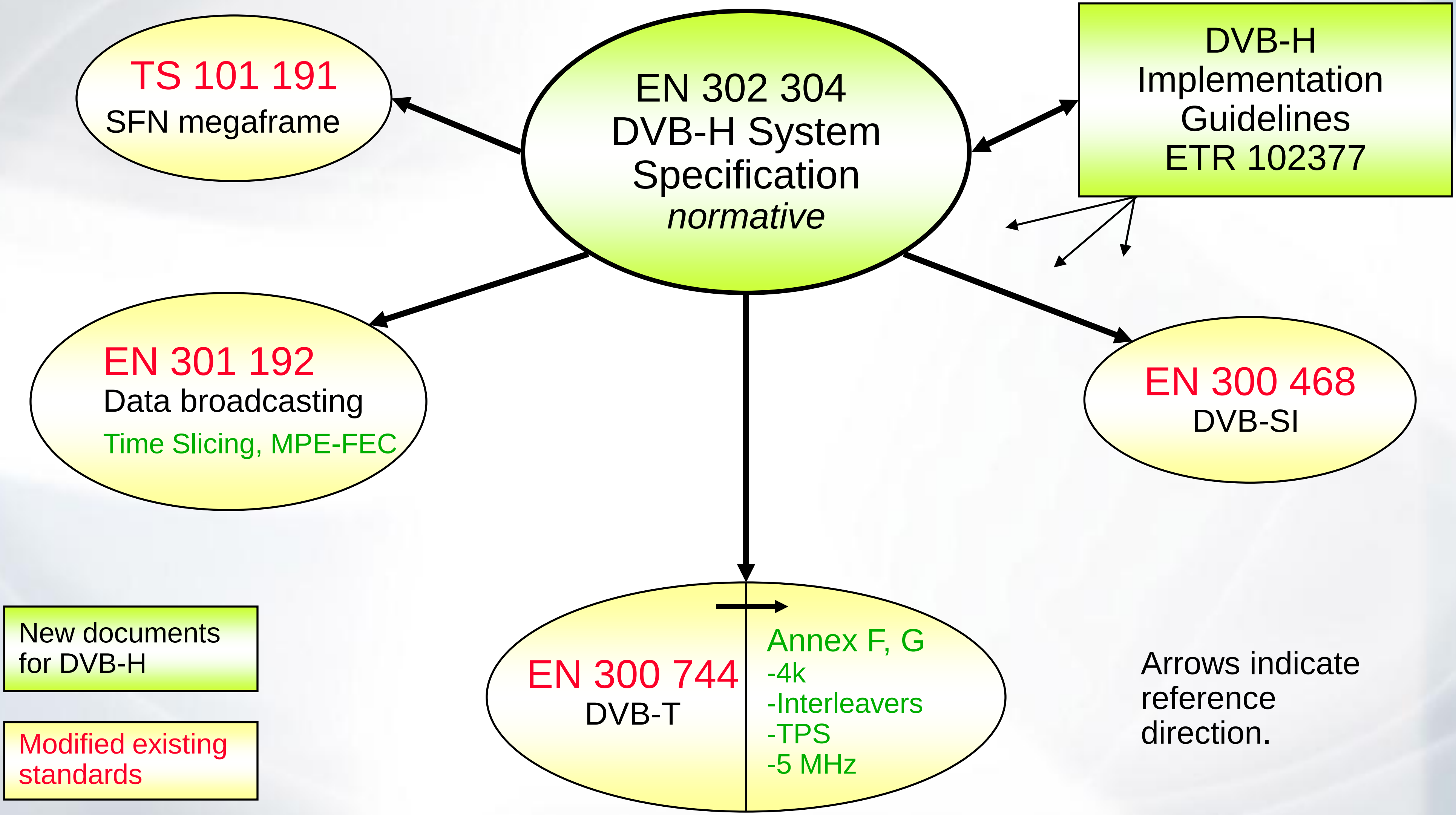
DVB-H Standards

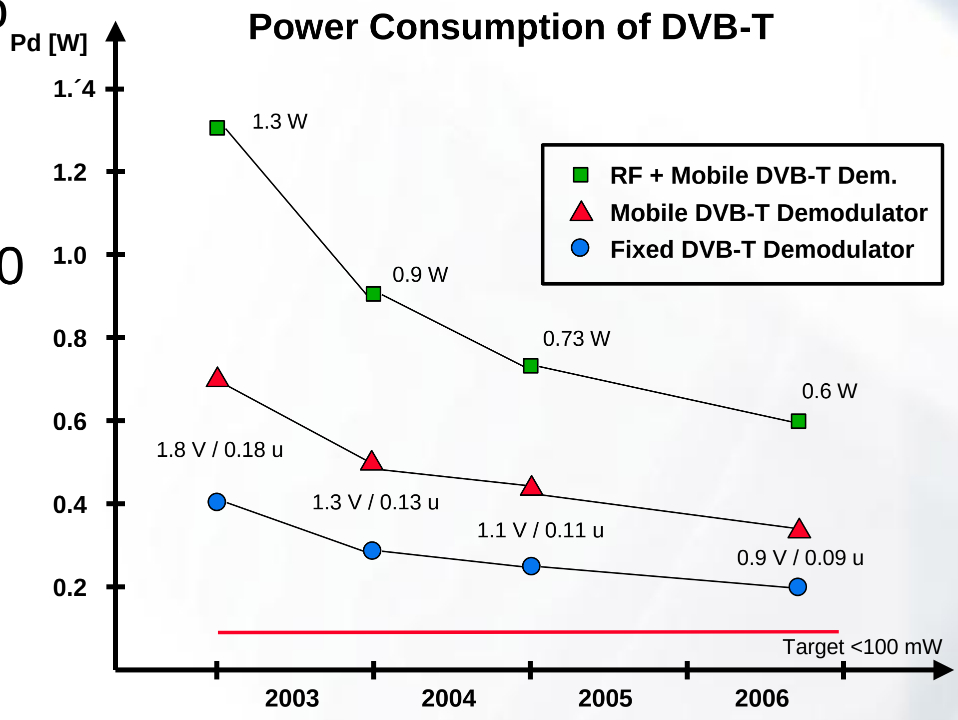


Conclusions

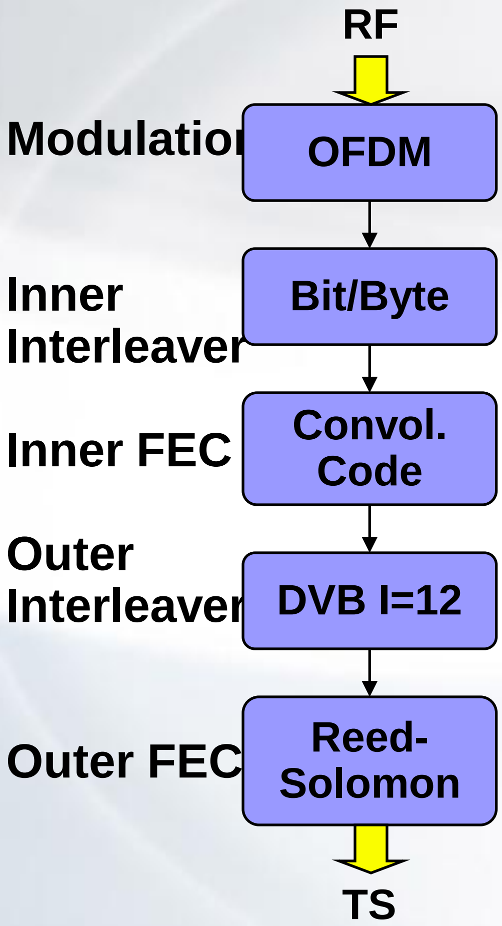
- Based on DVB-T, **backwards fully compatible**
- Gives additional features to support **Handheld** reception
  - Battery saving
  - Mobility with high data rates, single antenna reception, SFN networks
  - Increased general robustness, improved impulse noise tolerance
  - Support for seamless handover
- The above have been achieved by adding options
  - Time-slicing for power saving
  - MPE-FEC for additional robustness and mobility
  - 4k mode for mobility and network design flexibility
  - Enhanced TPS signalling
- DVB-H is meant for **IP-based services** via MPE insertion
- DVB-H **can share DVB-T multiplex** with MPEG2 services

DVB-T Report

- DVB-T fulfils the majority of the DVB-M commercial requirements.
- The DVB-T standard is very flexible and has a very wide range of parameters to choose from.
- But DVB-T can not promise:
  - Power consumption of less than 100 mW.
  - AND data rate of 15 Mbit/s.
  - AND operation in a large single frequency network.
  - AND reception at high driving speeds.
  - AND with only one antenna.
  - AND no handovers with single FE.



What can be done with DVB-T?



- The DVB-T standard could be used as it is but **DVB-H should have more flexibility.**
- The Doppler tolerance in 8k is worse than 2k. **4k would be a nice compromise.**
- The DVB-T Interleavers are not very long, as they are optimised for fixed reception. **DVB-H should give more interleaving.**
- The lower constellations (QPSK,16 QAM) tolerate fair amount of Doppler and require reasonable C/N.
- The code rates ½ and 2/3 most suitable. **Additional FEC would also increase performance.**
- Both MFN and SFN topologies can be used.
- Transmitter frequency is an important parameter for maximum speed.

Back to the drawing board!