Development of Mobile TV standards in DVB

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Outline

1. DVB & History
2. DVB-T
3. DVB-H
4. DVB-T2
5. NGH
6. Conclusions

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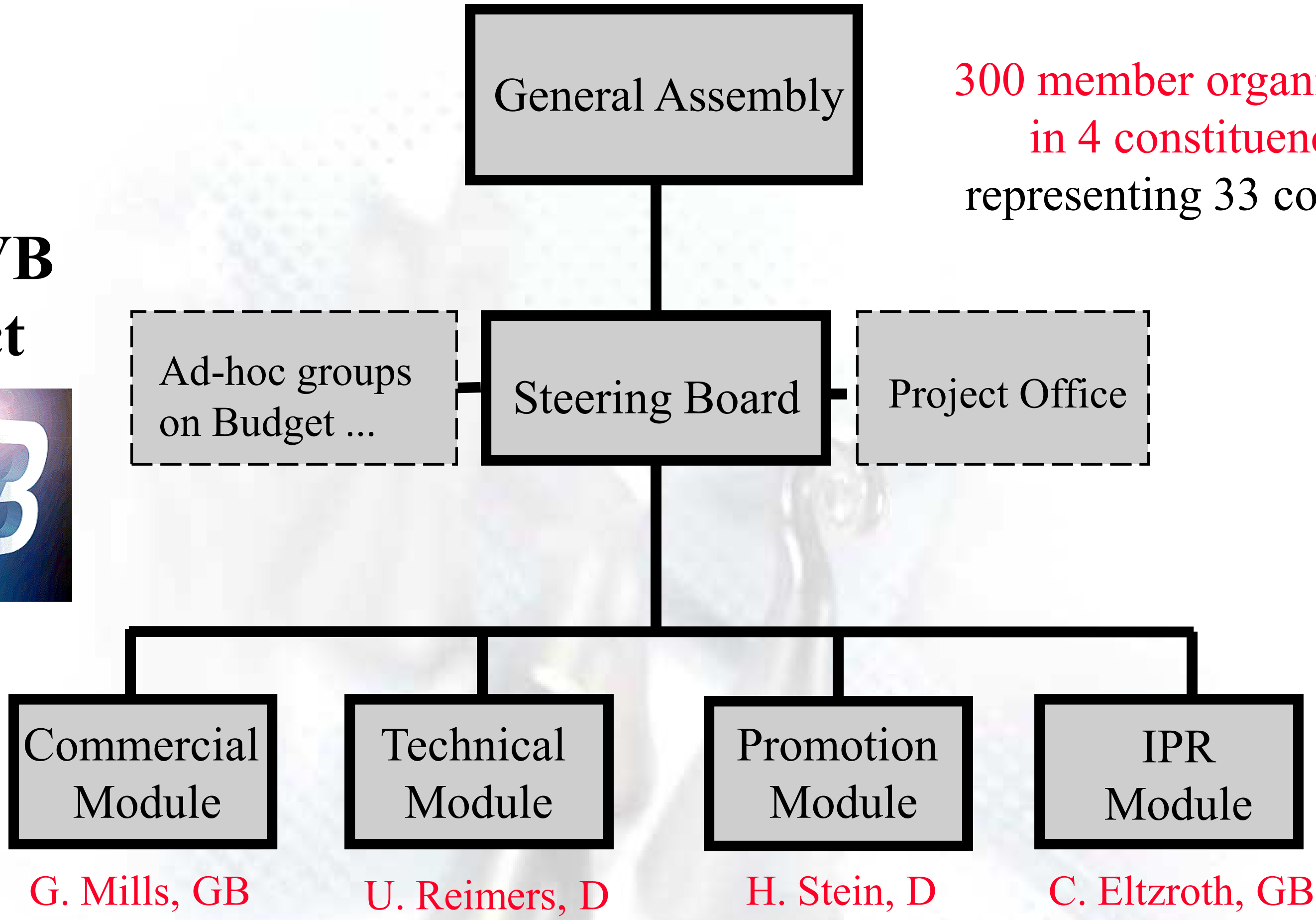
DVB

The DVB Project

300 member organisations
in 4 constituencies
representing 33 countries



From DVB-T to DVB-H
(Nokia-centric view ☺)

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From DVB-H to DVB-NGH

N96

DVB-NGH

(Or DVB-H2?)

NGH Study mission

NGH Std work starts

NGH/H2 Commercial launch

?

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016

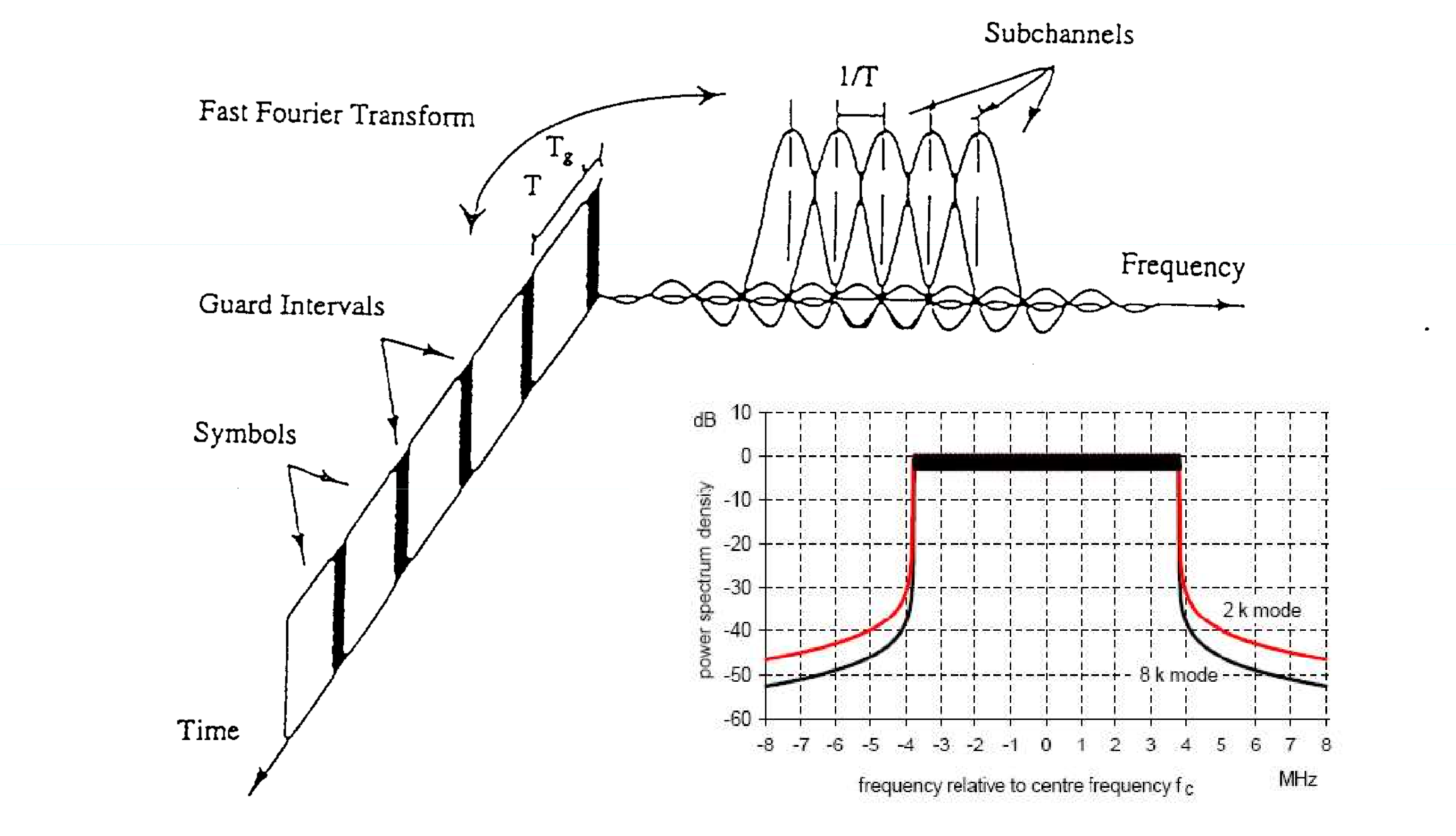
DVB-T2 work started

Study mission

EN 302 755
DVB-T2

DVB-T

COFDM based DVB-T is the basis

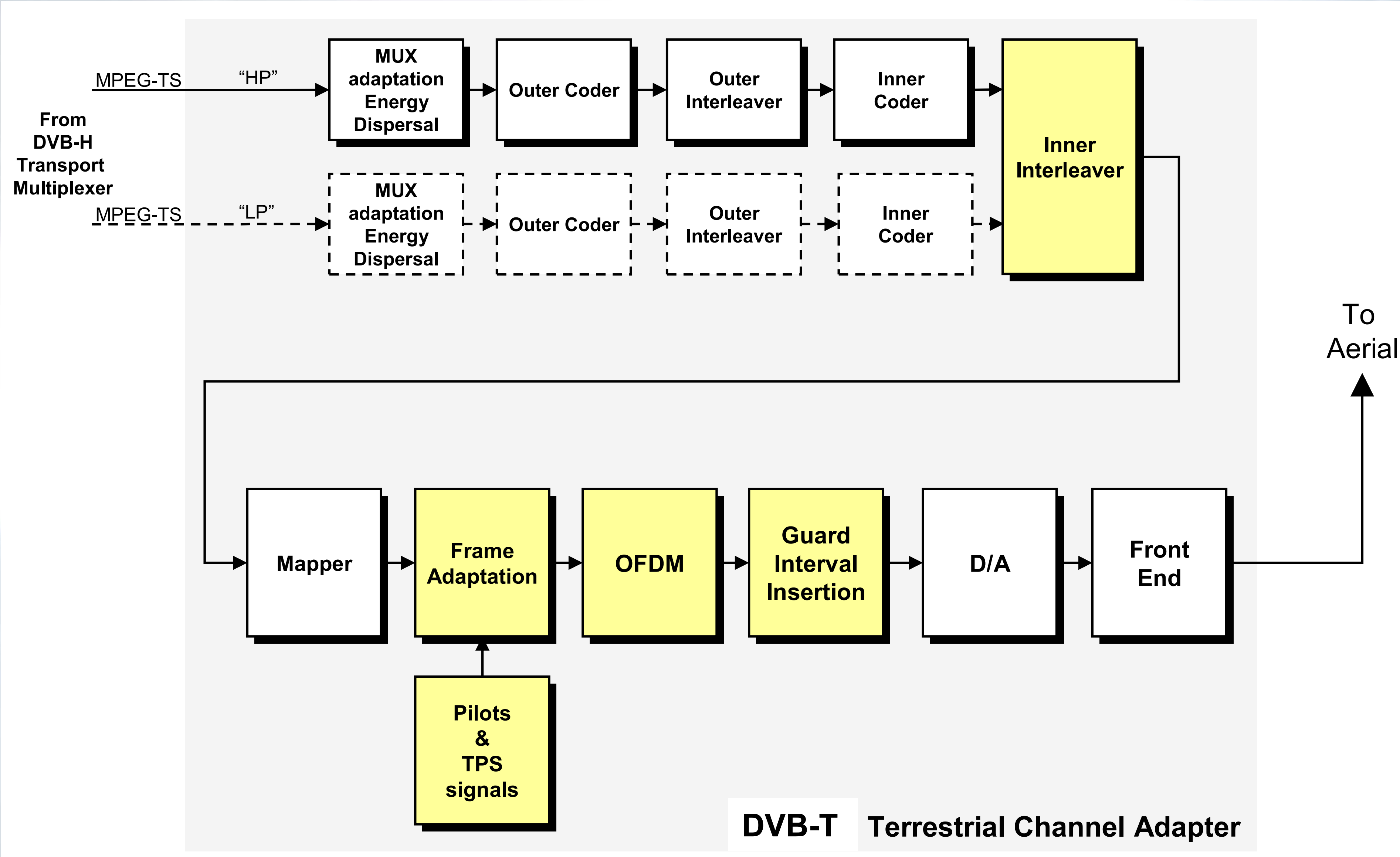


- You may want to visit, e.g., BBC web for COFDM tutorials:

http://www.bbc.co.uk/rd/pubs/papers/index-digitalbroadcasting-comp.shtml

- Also http://www.dvb.org/ or http://www.dvb.org/index.php?id=278

DVB-T transmitter



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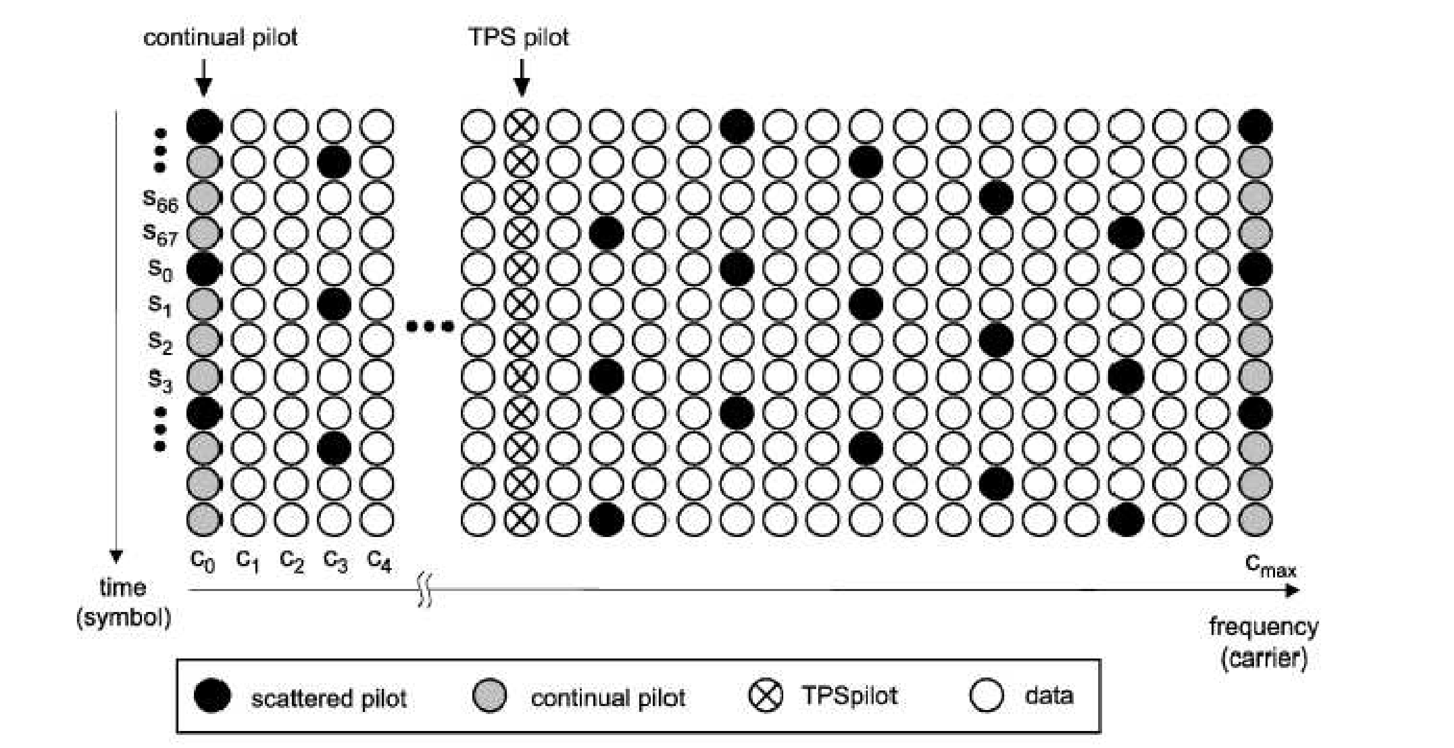
Pilot structure



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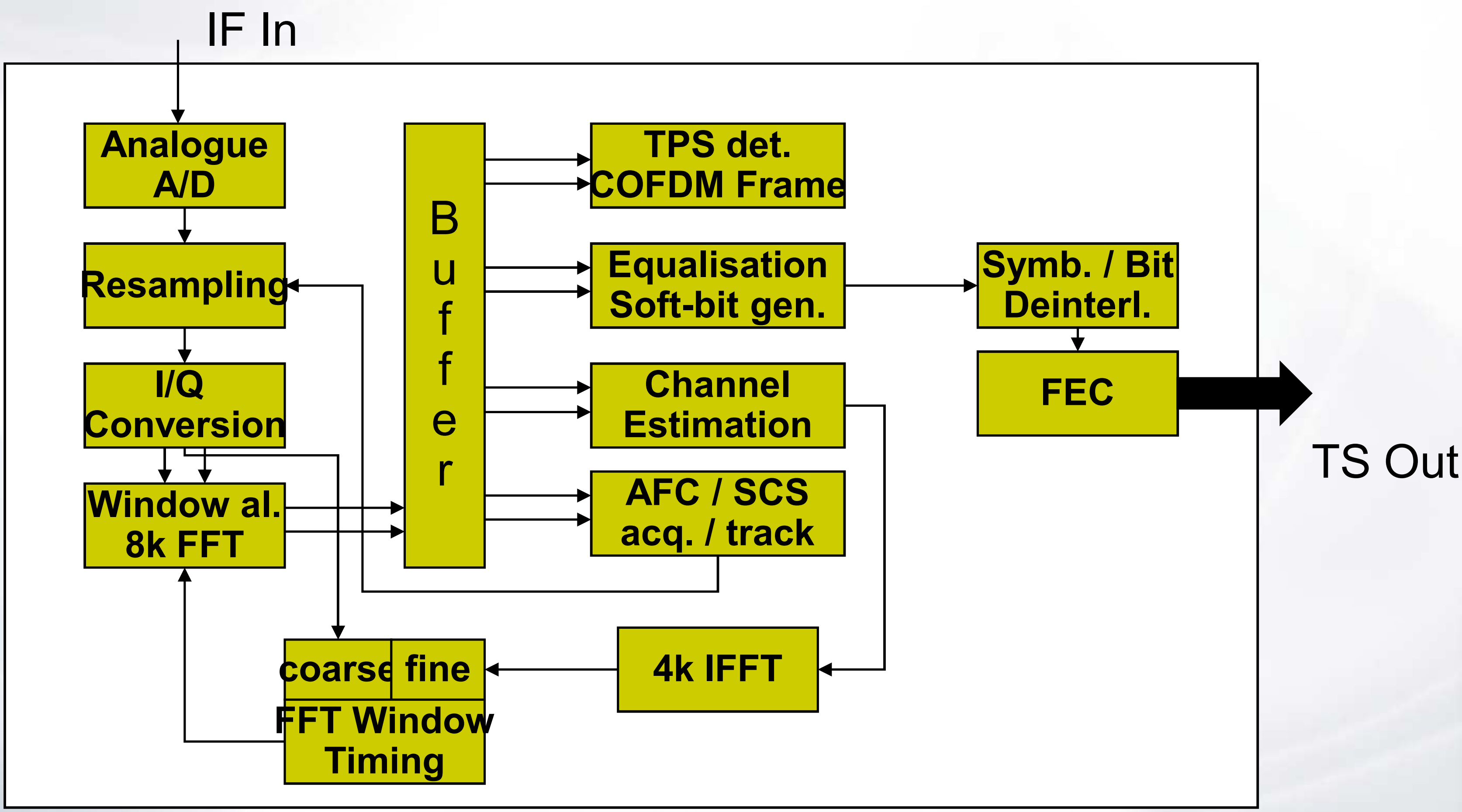
COFDM Channel Decoder

- Critical points:
  - Channel estimation / correction



Features of DVB-T

- FFT sizes 2k and 8k
- Convolutional code rates ½, 2/3, ¾, 5/6, 7/8
- Reed-Solomon code (255, 239) (t=8)
- Modulations 4QAM, 16QAM, 64 QAM
- Four guard intervals 1/32, 1/16, 1/8, ¼
- Supports 6,7 and 8 MHz channels
- Intended for VHF and UHF BC bands

- By selecting various parameter combinations one can support networks from high mobility (car reception) to large (nationwide) SFNs

- SFN = single frequency network

Why a new standard?

DVB-H

Why & how?

Why a new standard?

- **Broadcast** is the way to get cost down (cf. cellular systems, point-to-point)
- **DVB-T is existing and known to have good mobile performance**
- The **displays on handheld devices smaller** than on fixed reception
  - MPEG2 is probably too heavy, something else could be used
- DVB-T based IP-data broadcasting (IPDC) could be the solution

BUT…

…3 MAIN PROBLEMS REMAIN

- 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 FOR EASY CO-EXISTENCE

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Solution: DVB-H based on DVB-T

Making TV mobile

MPEG-2 over DVB-T

4-5 Mbps/program

3 - 5 TV channels
on big screen

Indoor reception

Power saving

Optimal use of capacity

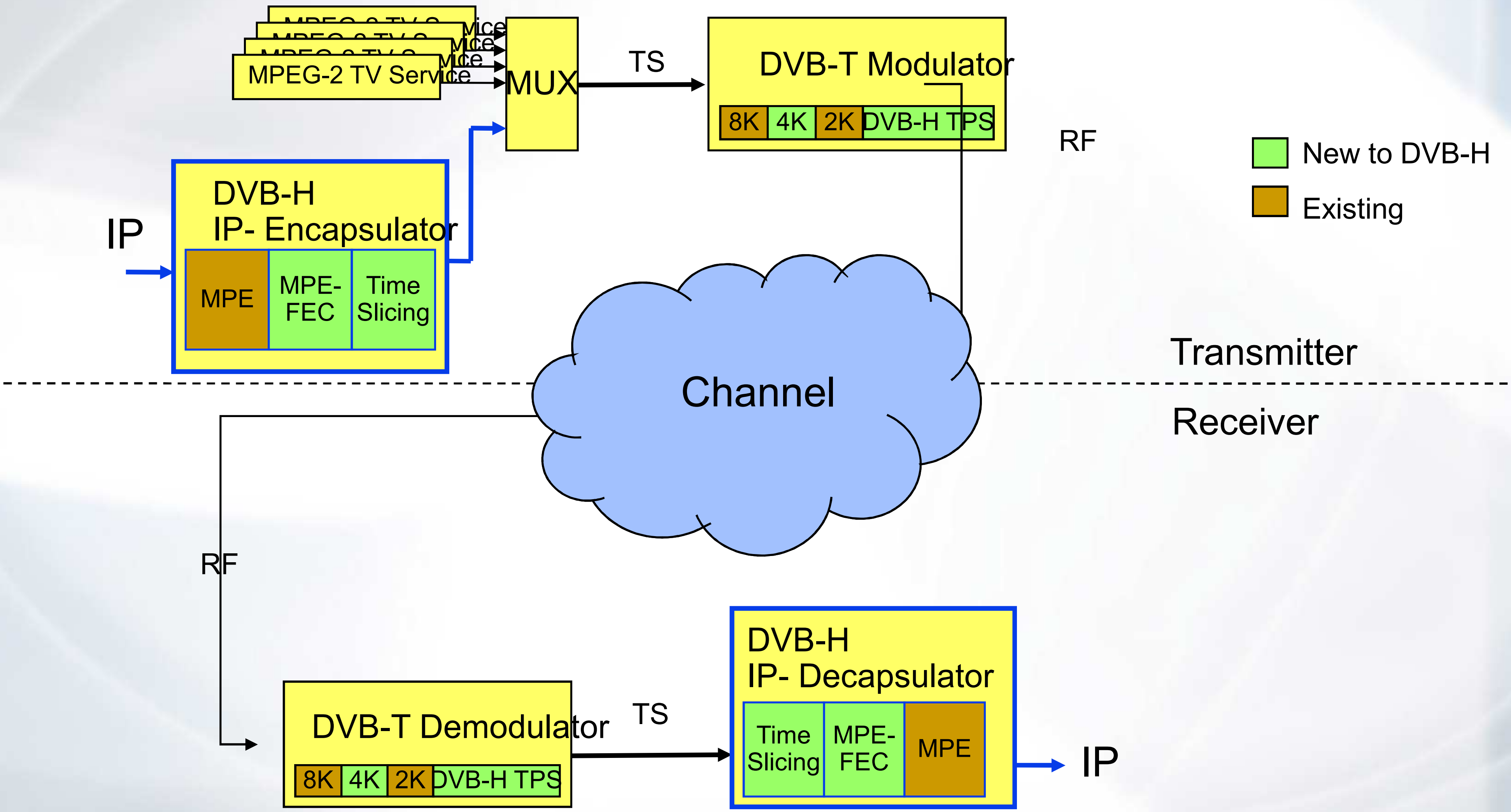
IP Datacast over DVB-H

(MPEG-4)

200 - 500 kbps/program

10 – 55 channels
on small screen

Solution: DVB-H System
(When Sharing the Multiplex with MPEG-2)



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**, Multi Protocol Encapsulation (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
  - 5 MHz channels for non-broadcasting bands
  - + something else…

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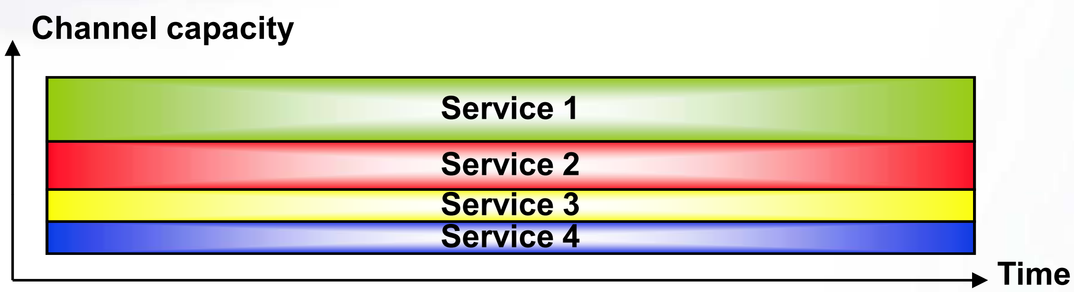
Time Slicing 1

- 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.



- 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.

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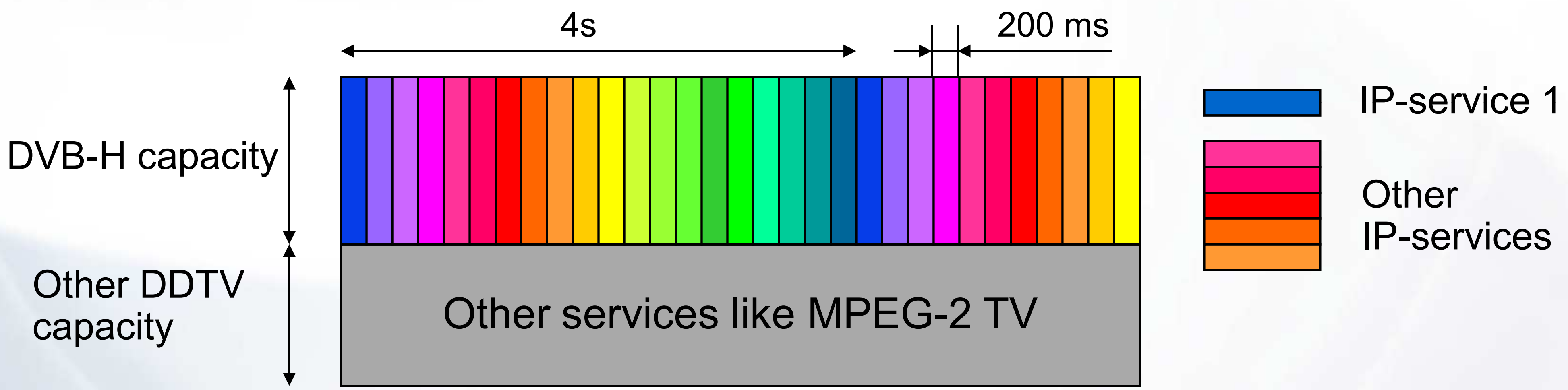
Time Slicing 2

- 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 2-4s, the first service is again in the air
  - There might be some 20-50 H –services depending on MUX and service properties



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

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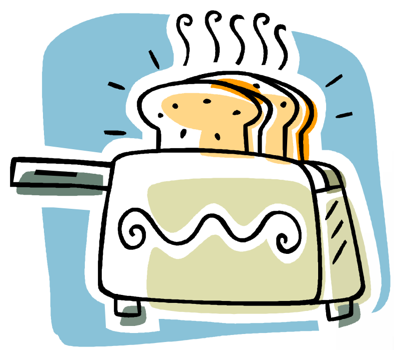
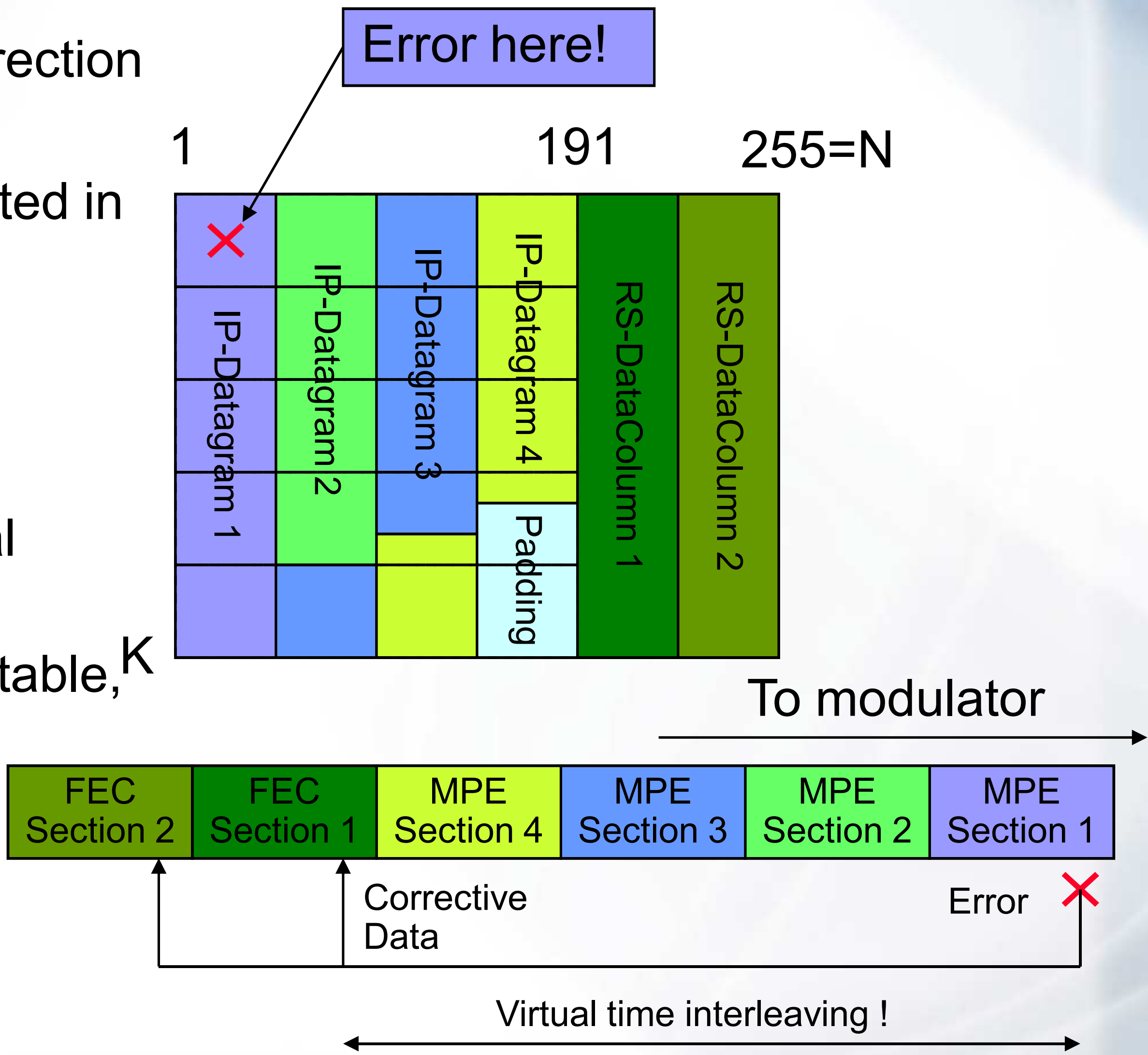
Best invention since sliced bread?



At least we have time slicing!

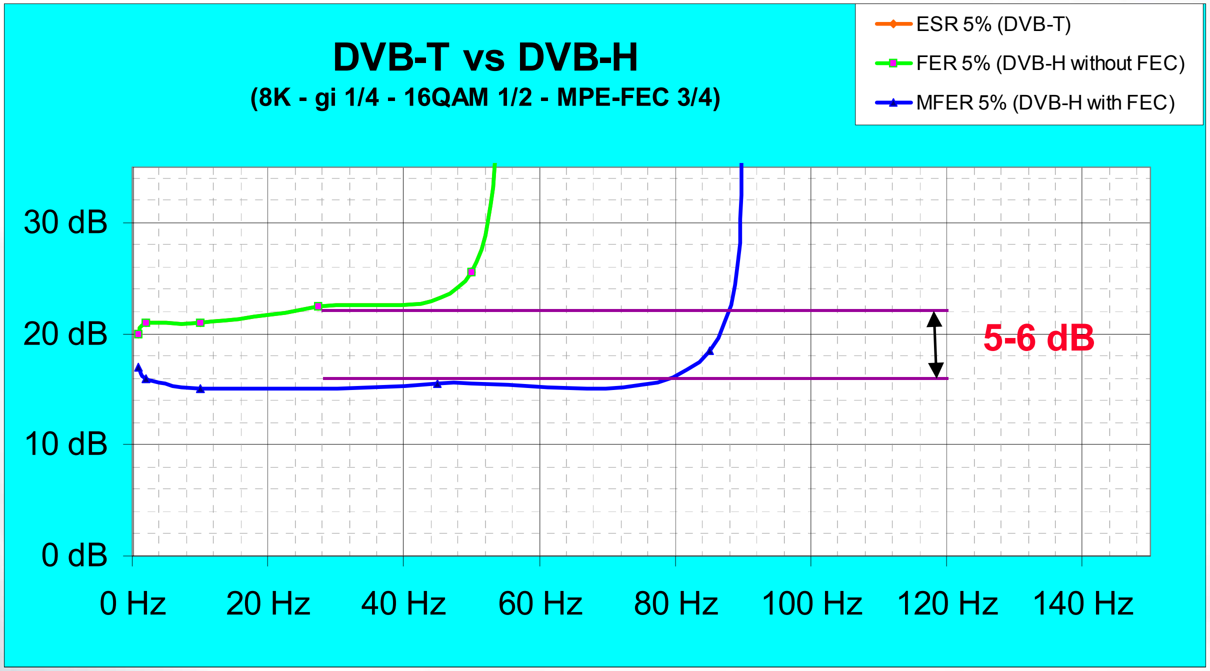
MPE-FEC

- IP-Data is filled in vertical direction
- RS-Code words are calculated in horizontal direction
- Data is transmitted in vertical direction
- The number of rows K selectable, max 1024
- The code may be punctured or shortened => selectable robustness



Performance of DVB-H

- 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
- General improvement in tolerance to noise.



Notice the flatness from low mobility to high mobility!

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Why a new standard?
DVB-T2
Why & how?

Motivation & background

- HDTV is a new service that is coming – already via satellite
  - More capacity needed in terrestrial network
- Technology progress in semiconductors
  - More complexity can be allowed for receiver
- Technology progress in theory & algorithms
  - MISO , MIMO
  - Coding
  - Etc
- DVB had developed second generation DVB-S2 standard with extreme efficiency
  - Wish to repeat the same in terrestrial
- **Capacity increase, robustness and flexibility** were the main drivers

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T2 work

- Starting point for T2 work was to take as much as reasonable from existing DVB-T
  - OFDM with guard intervals
  - QAM modulated carriers
  - …

- But many things were changed
  - TDM structure with synch symbols
  - Possibility of time slicing
  - Service specific robustness
  - LDPC coding
  - Extended modulation
    - => 256QAM
    - Rotated constallations
  - Interleaving
  - etc

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Closer Summary of Techniques (1)

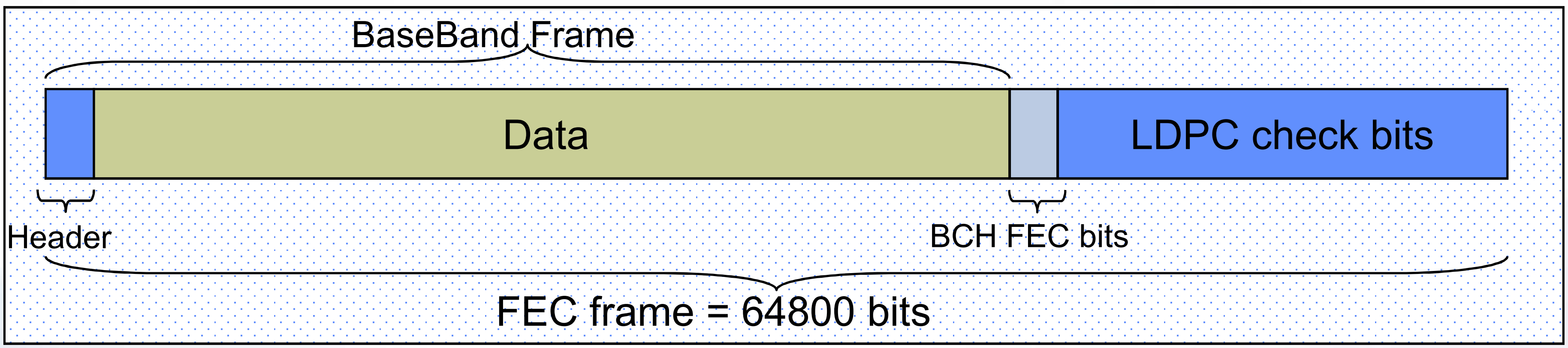
- S2 LDPC (Rates: ½, 3/5, 2/3, ¾, 4/5, 5/6)
- Compatible S2 system layer (Baseband Frames)
- Classical GI-OFDM
  - FFT sizes: 1K, 2K, 4K, 8K, 16K, 32K
  - GI sizes: 1/128, 1/32, 1/16, 19/256, 1/8, 19/128, ¼
  - Bandwidths 1.7, 5, 6, 7, 8,10 MHz
- 8 Scattered Pilot patterns
- Time interleaving at physical layer to improve impulse noise robustness
- Time slicing at physical layer
  - Different PLPs can have different levels of robustness
  - Enables power saving
- Sub-slicing within frame
  - Increases time diversity/interleaving depth without increasing de-interleaver memory

Closer Summary of Techniques (2)

- P1 symbol for frame sync. and for rapid T2 signal detection
- P2 symbol carrying frame construction data and PSI/SI information
- Three main levels of interleaving
  - Bit interleaving, Time interleaving and Frequency interleaving
- Rotated constellations
- MISO capability (Alamouti-based transmit diversity)
- Peak-to-average-power reduction via tone reservation and constellation distortion
- Future Expansion Frames
- Signalling and compatibility with future implementations of Time Frequency Slicing

Key features: BB Frames and LDPC

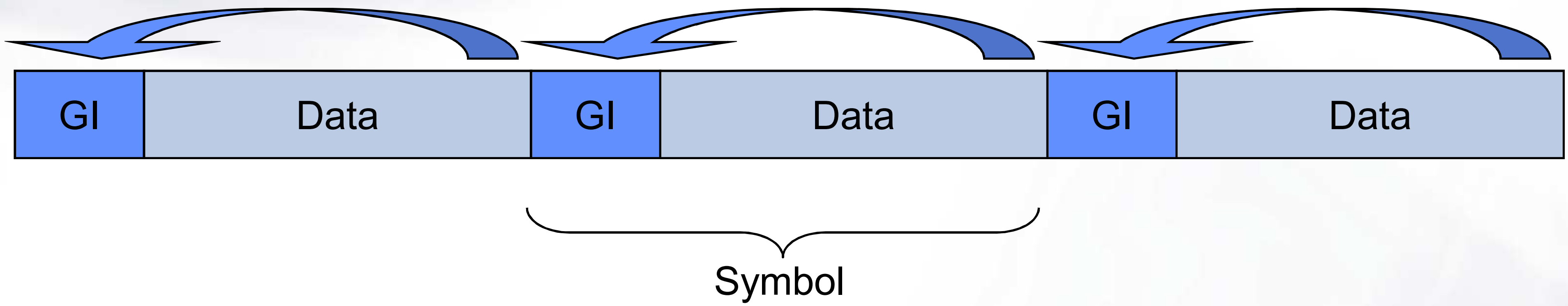
- Data packaged into BaseBand Frames
- BaseBand Frames protected by the S2 LDPC FEC
  - With an additional small BCH code to mop up any residual errors after LDPC decoding



- This FEC frame, of length 64800 bits, is a fundamental unit within T2
  - Code rates: 1/2, 3/5, 2/3, 3/4, 4/5, 5/6
  - A shorter FEC frame of 16200 bits also provided for low data rate services

Key Features: Modulation (1)

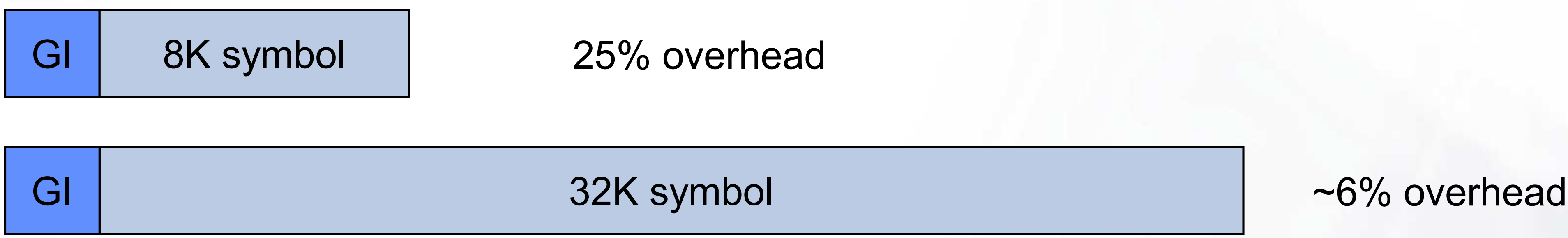
- T2 uses conventional Guard-Interval OFDM (GI-OFDM)
  - as in DVB-T



- Each symbol carries data on a large number of separate carriers
  - 1K, 2K, 4K, 8K, 16K, 32K options are available in T2
    - 16K and 32K: to give improved SFN performance
    - 1K for bandwidth and frequency flexibility
  - Increasing the number of carriers increases the symbol period

Key Features: Modulation (2)

- Increasing the symbol period
  - Can reduce guard interval overhead for given size of SFN
  - Can increase SFN capability for a given fractional GI



- T2 extends guard interval range to allow reduced overhead and additional flexibility
  - GIs in T2: 1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4

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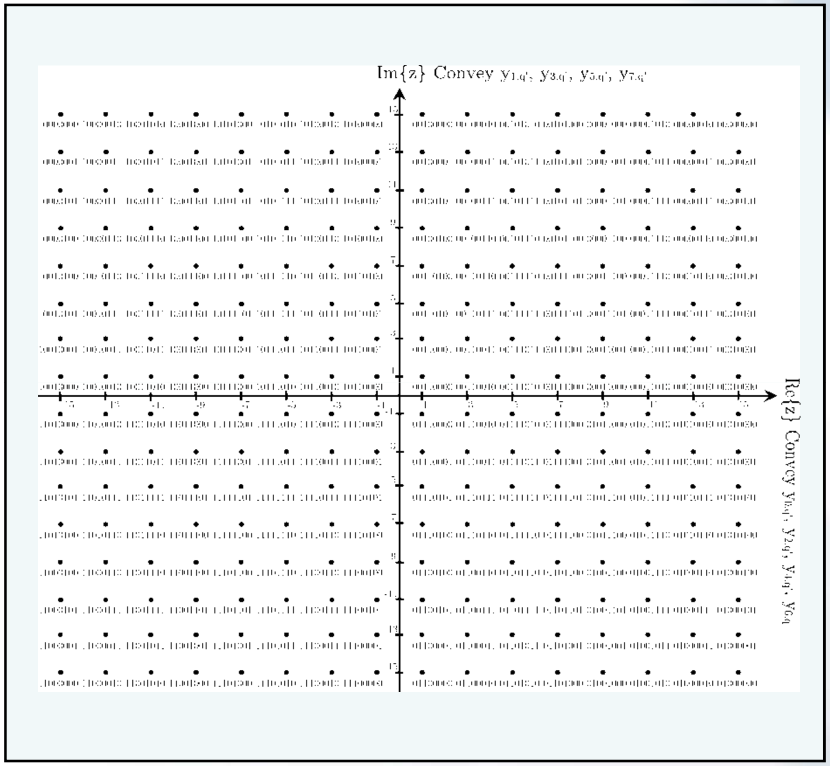
Key Features: Modulation (3)

- T2 includes 256 QAM mode
  - Carries 8 bits/ data cell
    - (c.f 6 bits / data cell for 64 QAM)
  - Enables greater capacity, exploiting improved FEC performance of LDPC
  - Studies show that typical tuner phase noise should not be a problem



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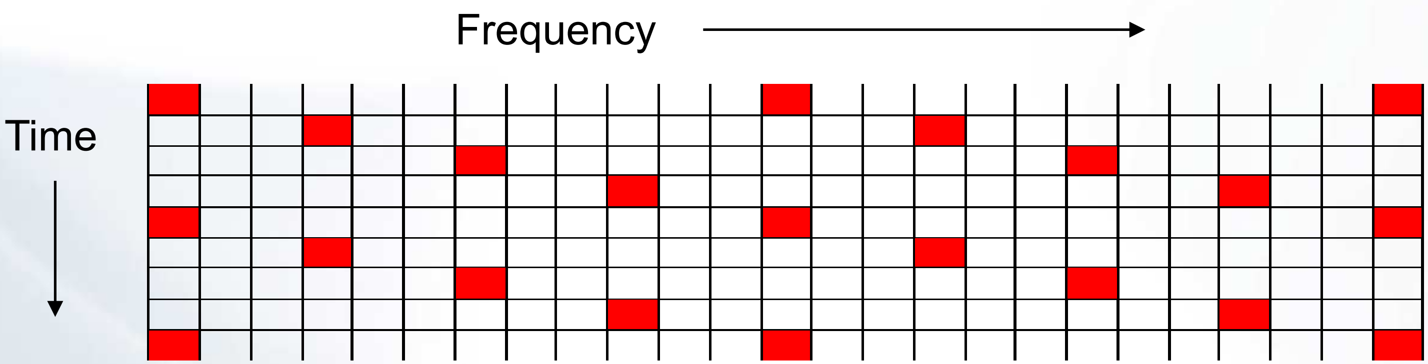
Scattered Pilot Patterns (1)

- Scattered pilots are OFDM cells of known amplitude and phase
  - Receiver uses these to compensate for effects of channel changing in frequency and time.
- In DVB-T, 1 in 12 OFDM cells is a scattered pilot
  - 8% overhead
  - Independent of guard-interval fraction



8%

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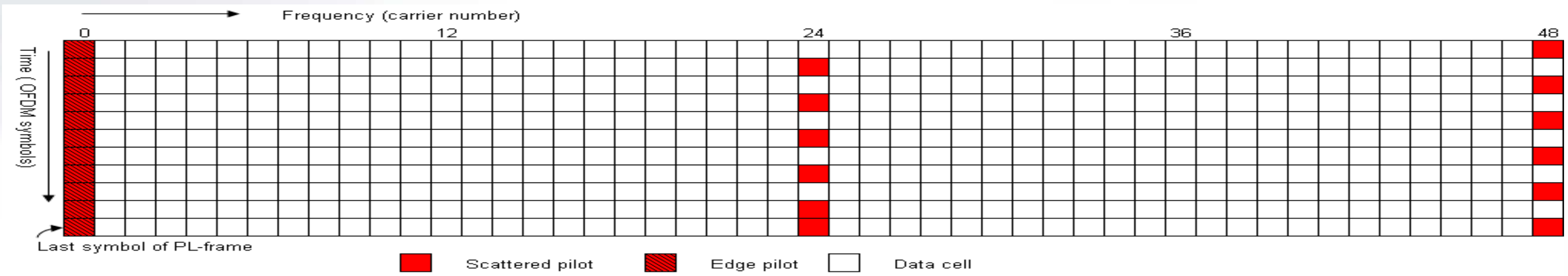
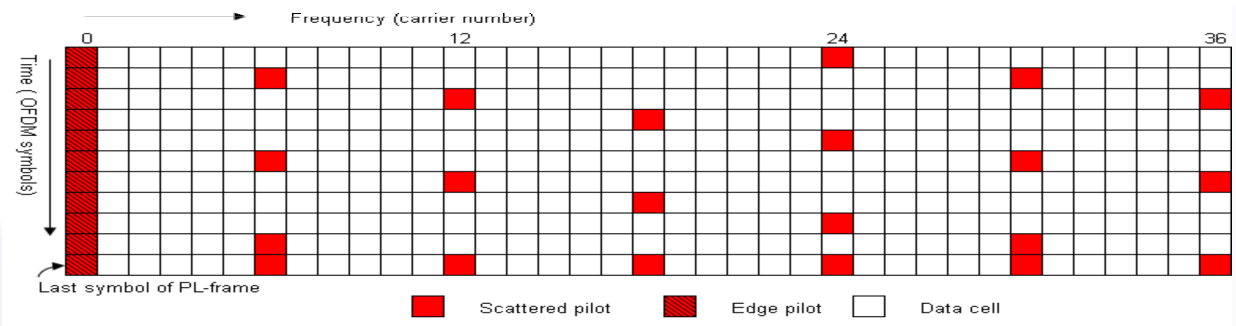
Scattered Pilot Patterns (2)

- T2 has 8 different scattered pilot pattern options
  - Aim: to minimise pilot pattern overhead for a given fractional guard interval; e.g. ….

Time



2%



4%

- Pilot cells are boosted by up to 7 dB depending on density
  - Improves signal to noise on channel estimate
- Pilot pattern modulated by pseudo-random sequence
  - Can be used for improved time synchronisation algorithms
- Pilot pattern modified for edge carriers and for last symbol of frame

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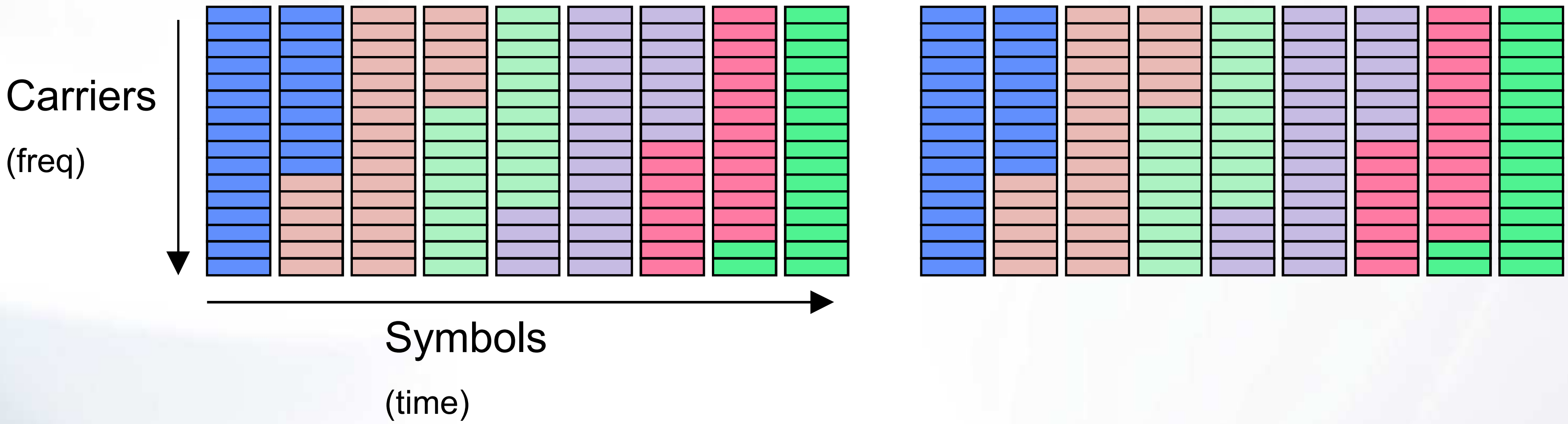
Key features: Service Specific Robustness

- Each service can be given its own modulation mode (e.g. 256QAM, 16 QAM) and FEC coding rate (e.g. rate 3/5, rate 3/4)
  - Different applications: roof-top reception/portables



- Each service is given a slice of data cells within a frame
  - Each slice is part of a *Physical Layer Pipe* for that service
  - Also enables power saving in the receiver
  - Slices can be sub-divided into sub-slices within frame in order to give more time diversity

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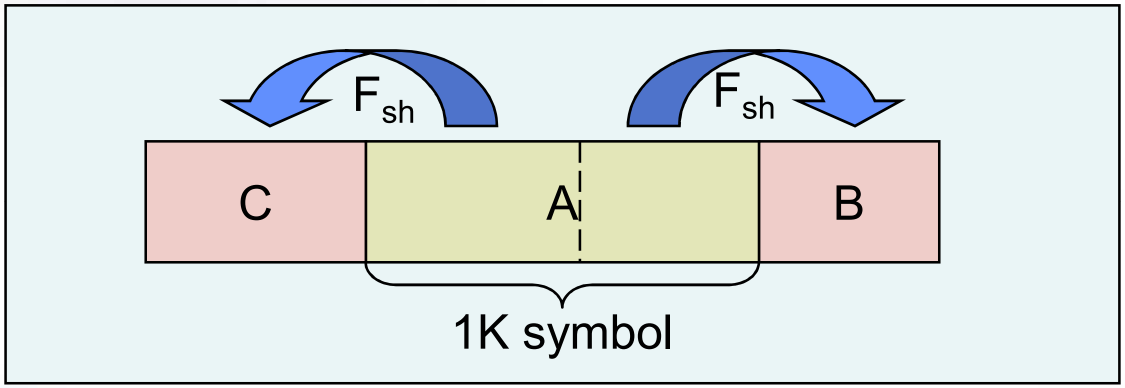
Key features: Frame Structure

- Start of frame is signalled by a short P1 symbol
  - Based on **1K OFDM** symbol with frequency shifted repeats at front and rear of symbol

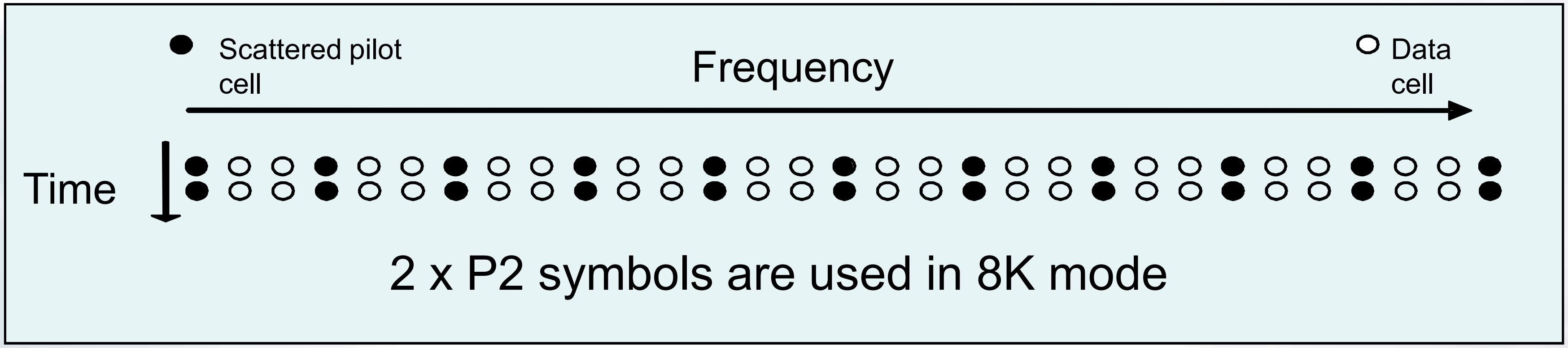


- Only a sparse proportion of 1K carriers occupied
  - Carrying carefully chosen data patterns
- Lengths of segments carefully chosen

- This format of P1 symbol provides
  - Simple and robust mechanism for rapid detection of T2 signal
  - Fast frequency lock mechanism
  - 7 bits of signalling (e.g. for FFT size in main frame)

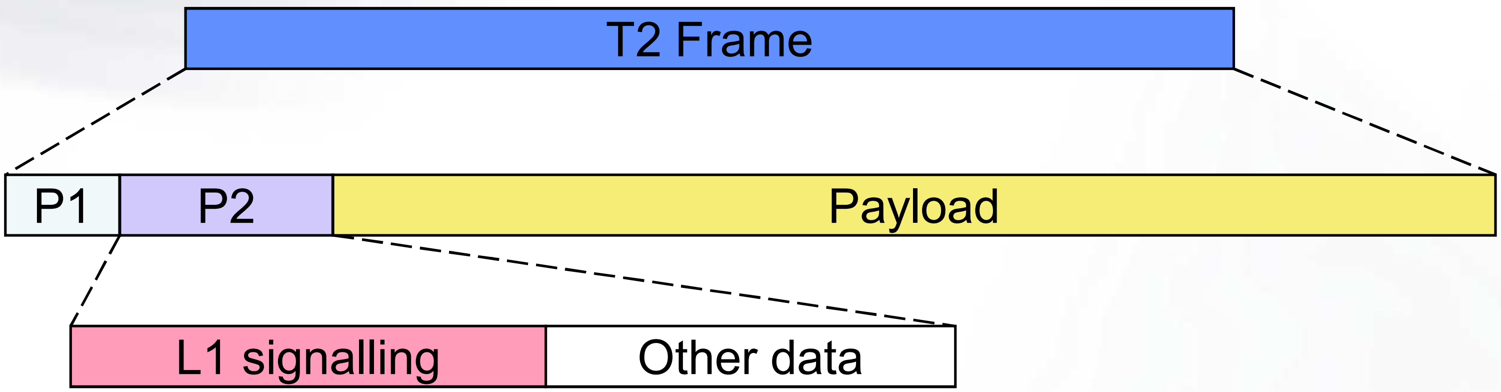
Frame Structure (2)

- Structure of frame must be signalled at beginning of frame
  - Start address and length of individual PLPs
  - This data is carried in P2 symbols which follow P1 symbol
    - Number of P2 symbols depends on FFT size
  - Frame structure data must be carried robustly
    - Use strong FEC and modulation modes within P2
  - Channel equalisation must be rapid and robust
    - Use a greater density of scattered pilots



Frame Structure (3)

- Typical frame duration: 150 -250 ms
  - P1 & P2 overhead typically less than 1%



- L1 signalling carries frame structure data
  - L1 data must be carried more robustly than payload data
  - L1 data split into 2 parts: L1-pre (very robust); L1-post (quite robust)
- Other data carried in P2 can include common PSI/SI data for services carried in payload

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Frame Structure (4)

- Typical use – single PLP
  - Complete transport stream is contained within single PLP
    - Including all PSI/SI

- Typical use – multiple PLP
  - Each PLP carries a transport stream

  - Frame structure for all PLPs is contained in L1 data - which is
    - carried in P2 symbols at beginning of frame
    - And normally carried 'in-band' with each PLP – for that PLP (to reduce need to decode P2 symbols)

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Interleaving

- LDPC works well only for randomly distributed bit errors
  - Must avoid regular patterns of errors and bursts of errors
  - Must randomise mapping of bits from FEC block into constellation points
- T2 uses three main interleavers – applied per PLP
  - Bit Interleaving within an FEC block
    - Randomises errors from single errored data cells
    - Based on a row/column block interleaver - with a ‘twist’
  - Time Interleaver
    - Disperses data cells from FEC blocks of a given service throughout slice (/subslices) for that service
  - Frequency Interleaving
    - Causes randomisation of possibly-damaged adjacent data cells within an OFDM symbol
    - Provides robustness against a frequency-selective channel
    - T2 uses twin interleavers (based on DVB-T interleaver)

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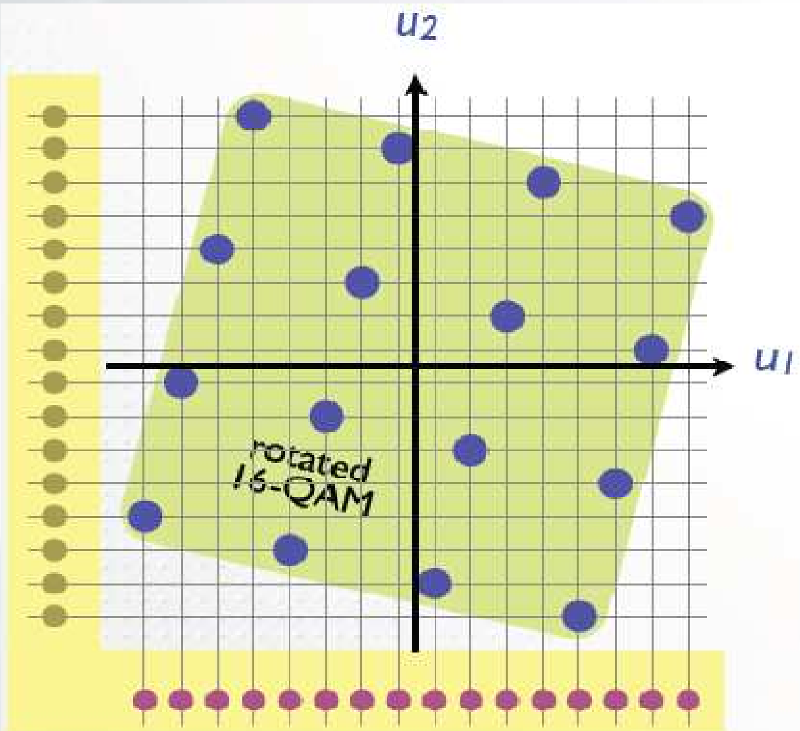
Rotated Constellations (1)



- Map data onto a normal QAM (x,y)
- Rotate constellation (axes now (u_1,u_2)
- Ensure u_1 and u_2 travel in different cells
  - So that they fade independently
  - Gather together in receiver

- Each of u_1,u_2 carries all of the info of original x,y
  - So can decode (less ruggedly) if one is erased completely

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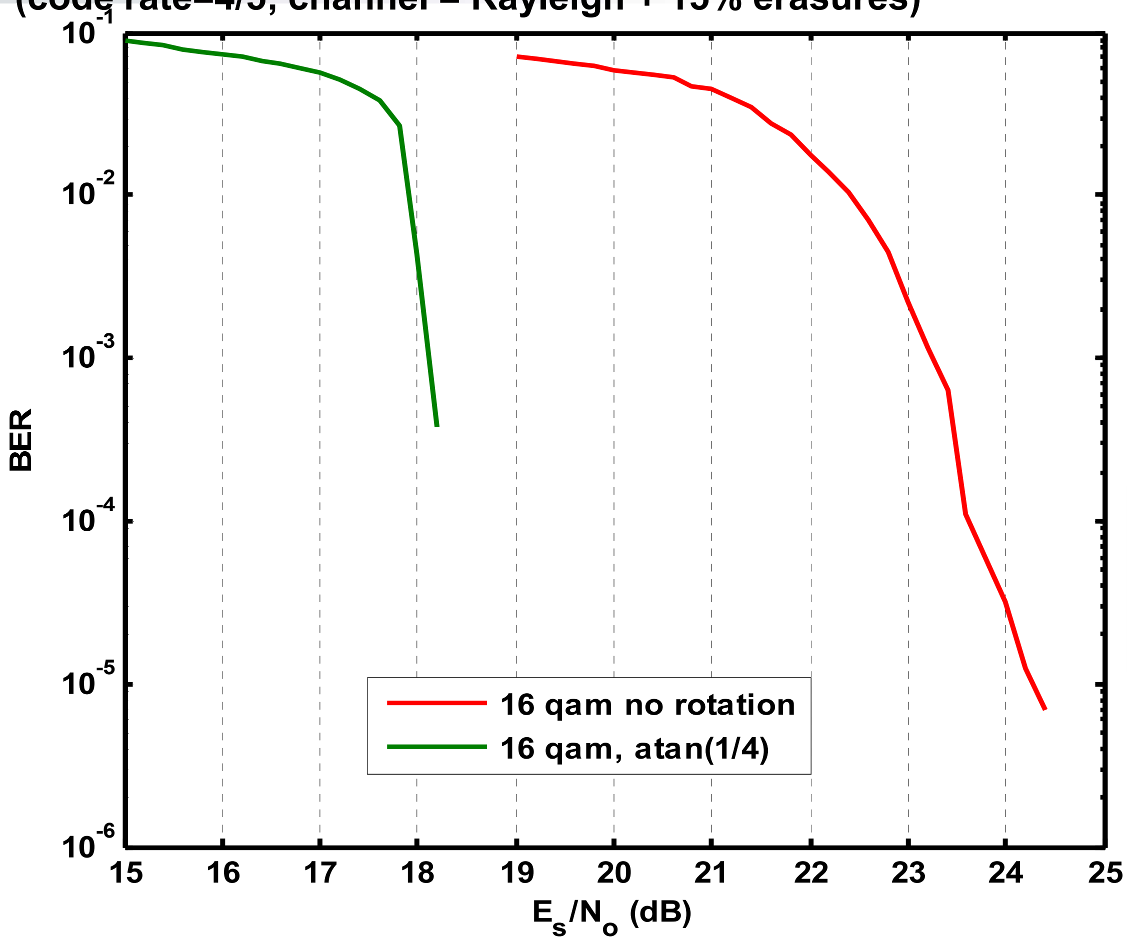
Rotated Constellations (2)

Comparison of performance for rotated/non-rotated constellations (code rate=4/5; channel = Rayleigh + 15% erasures)



- Rotated constellations provide significantly improved robustness against loss of data cells
  - Can achieve gains of up to 5 dB on difficult channels
    - e.g. 15% cell loss channel
  - Can translate into increased bit rate by choosing less robust FEC with lower overhead

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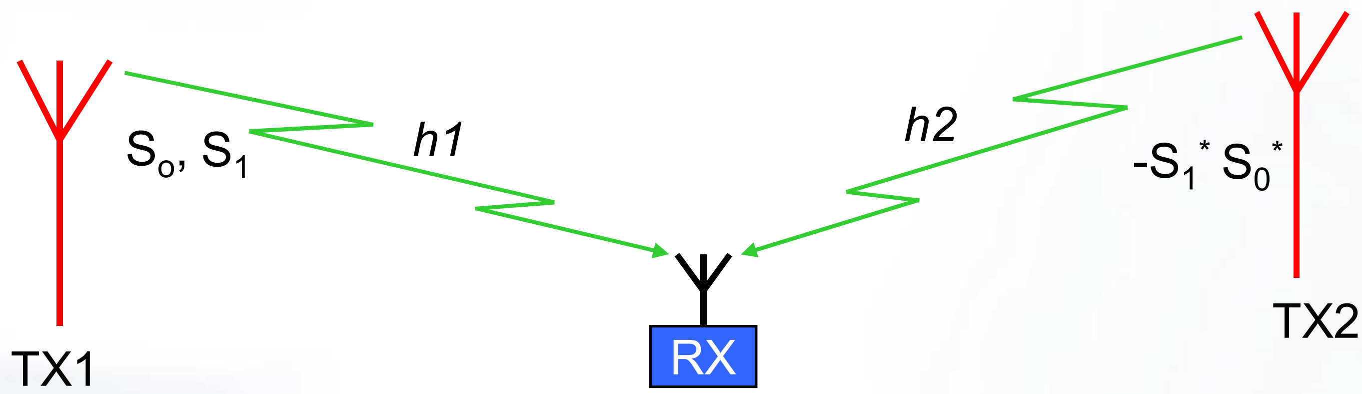
Transmit Diversity (1)

- T2 includes Alamouti coding mode for simple SFNs
  - While Tx1 transmits pair of data cells S_0,S_1, Tx2 transmits $-S_1^*$,S_0^*
  - Also involves modification of pilot patterns to measure *h1 and h2*
  - This prevents possibility of ‘flat fading’ at receiver

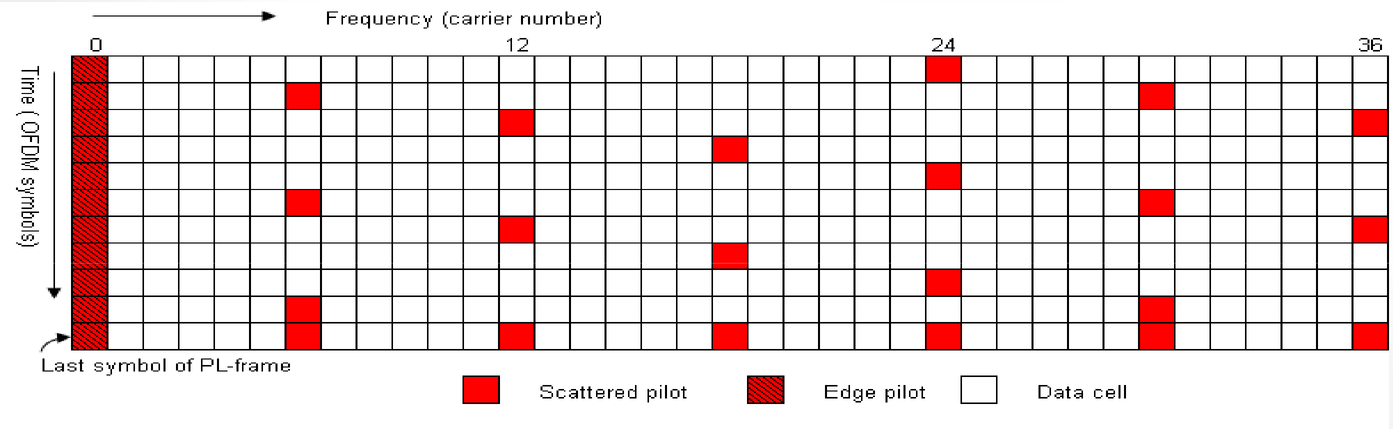


- Initial planning studies predict 30% increase in coverage area for simple SFNs

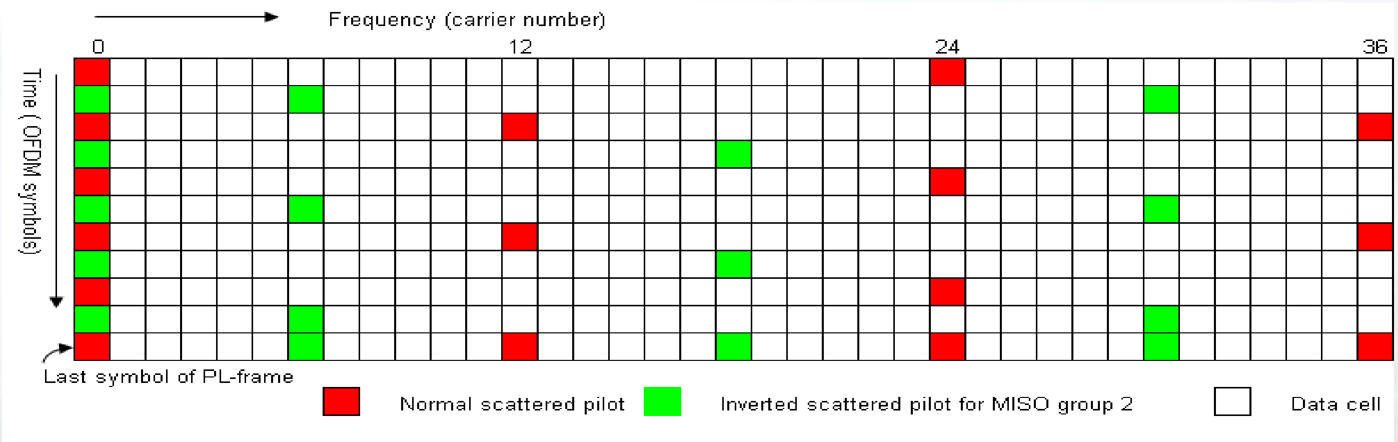
Transmit Diversity (2)

- Scattered pilot patterns are modified (for second transmitter) to enable measurement of channels h1 and h2; e.g. -

Transmitter 1

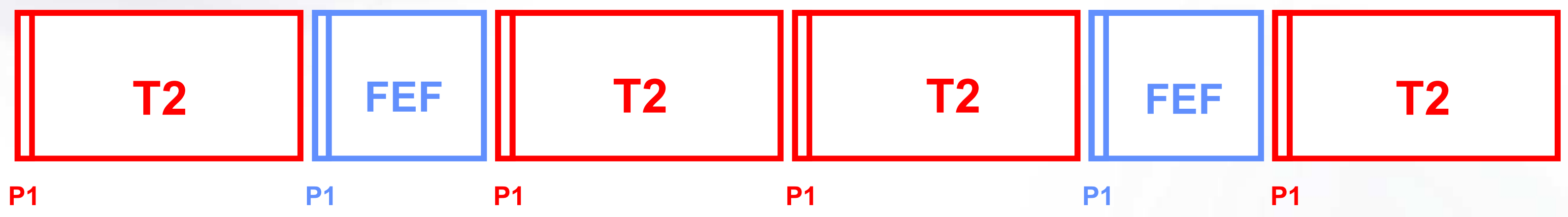


Transmitter 2



Additional Features

- Future Extension Frames (FEFs)
  - Provide a mechanism for future compatible enhancements – e.g. MIMO
  - Only requirement is for FEF to start with P1 symbol



- Time Frequency Slicing
  - Multiplex of signals is spread across several linked frequencies
    - Can give significant Stat Mux gain (20%) and frequency planning gain (5dB)
  - T2 signalling and system is compatible with Time Frequency Slicing system provided receivers have 2 tuners

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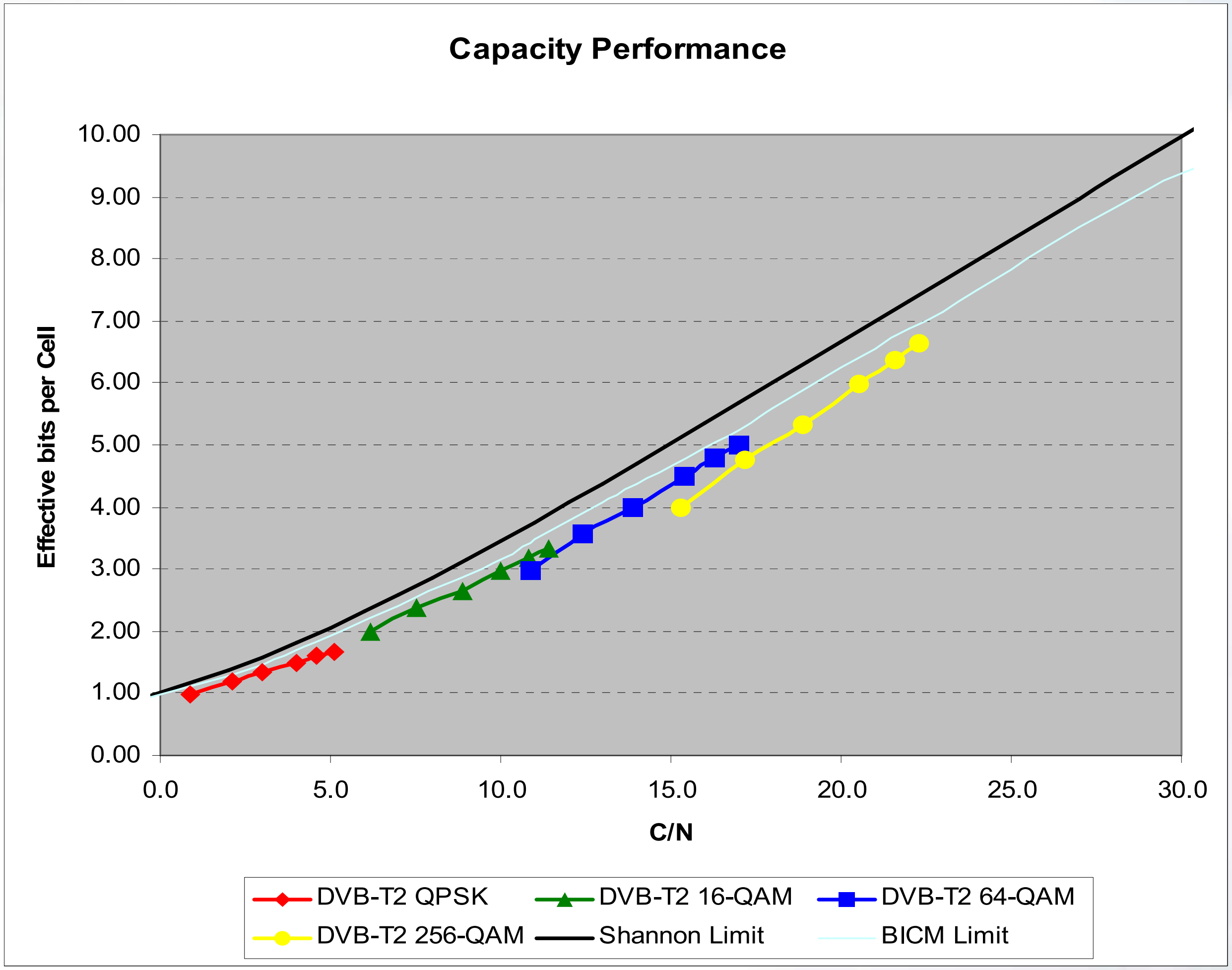
Modulation and Coding performance

- Capacity limits for simple Gaussian noise channel
  - With LDPC can get close to theoretical limit
- Typically 30% gain in capacity compared with DVB-T codes.



Why STILL a new standard?

Future NGH

Why & how?

Motivation & background

- Technology progress
  - Various new things possible
- Business environment changes
  - New standards competing with DVB-H or otherwise changing the situation
    - LTE, T2 etc
- Room for improvement
  - Robustness and indoor reception are the main points
  - There exists reasonable and realistic means to address this within a couple years time frame

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DVB study mission on NGH

- A study mission (NGH- next generation handheld) to probe these issues was launched in DVB June 2007

- SM Conclusions Spring 2008:
  - The new standard should address all relevant market segments (terrestrial, terrestrial-satellite hybrid) in order to avoid market fragmentation.

  - If significant capacity increase is needed, feasibility and available performance using multiantenna techniques (MIMO) in handheld terminals should be carefully assessed

  - The new standard NGH, among other things listed above, should be capable of using multiple bands of spectrum and have flexible spectrum use.

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2x2 MIMO promise vs. Alamouti 2x2

SIDSA, study mission have computed this capacity for a perfect MIMO 2x2 system, and for the Alamouti system used in diversity 2, which is a particular implementation of 2x2 MIMO.

	Capacity for Alamouti 2x2 (bit/cell)	Capacity for optimal MIMO 2x2 (bit/cell)
SNR = 0 dB	1.44	1.59 (+10.1 %)
SNR = 4 dB	2.36	2.73 (+15.6 %)
SNR = 8 dB	3.46	4.22 (+22.1 %)
SNR = 12 dB	4.68	5.04 (+29.2 %)
SNR = 16 dB	5.96	8.12 (+36.1 %)

Note: very preliminary, overview result

The result depends strongly on the channel model and actual implementation

"Real" MIMO seems to provide substantial benefit

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But is there REAL need?

- DVB set up **CM group CM-NGH** in 2008 to define commercial requirements
- The key findings
  - Technology has progressed and significant improvement in performance is available
  - ***Robustness and indoor reception*** are the main points
  - The business environment changes due to T2, LTE etc
- CM listed several general requirements (24.6.2009) like
  - NGH must be sufficiently flexible to deliver content types that match the varying amounts of attention a user might want to devote: e.g. radio, radio with slideshow, high quality (SD) TV
  - Must integrate with 'back channel' technologies to offer a truly immersive, two-way experience
  - Must be able to offer extended viewing sessions therefore extended ***battery life*** is important
  - Must offer fast access to services therefore ***fast start up and channel switching*** are important
  - Should be able to act as a 'second screen' by offering content that complements and synchronises with content on DVB-T(2) and other platforms
  - Should be possible to offer ***location specific content***

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Technology comments

- **Overhead reduction**
  - Changing the base code (like in DVB-T2) to LDPC (or equivalent), significant reduction is available
  - IP overhead can be reduced (e.g. header compression)

- **Performance increase**
  - Changing coding ; RS => LDPC (like in T2)
  - Additional low code rates for robustness (e.g. rate ¼ …)
  - Longer interleaving
  - Two tuner approach
    - Use 2x2 or (distributed) 4x2 MIMO (probably in crosspolarized form)
    - Use diversity (polarization or spatial?)
    - Or even TFS (time-frequency slicing)?!!
  - Rotated constellations (from T2)

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Technology comments 2

- **New bands**

  - MIMO probably not feasible in VHF, UHF still unclear
  - Above 1 GHz MIMO is feasible
    - However: No feedback info about the channel to the Tx is available => MIMO is not as efficient as in p-t-p connections
  - Satellite bands: Satellite option requires very long interleavers (ca 10 s!) => large memory needed

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Challenges for NGH system

- How to deal with MIMO & diversity question?
  - Obligatory for UHF and above or optional (e.g. in UHF)?
  - Receiver complexity and cost issue
- How to deal with long interleaver issue?
  - Zapping time & delay
  - Memory
  - Cost - how to support satellite services without unreasonable burden to all receivers?
- How to share T2 & NGH in one RF channel?
  - Using Future extension frames (FEF) of T2?
- How to handle upper layer issues?
  - TS, IP etc transport
  - Seamless/easy service handover via various bearers

How to simplify – not only adding features??!!

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What could it be?

Wild, (educated?) guess

- T2 based system with some additions/modifications
  - More (and less!) coding rates
  - Long time interleaving (at least as option)
  - At least some support for 2x2 and possibly 4x2 MIMO
  - Less overhead
  - Streamlined to allow various service handover
  - Allowing flexible use together with T2 and within T2
    - e.g. using future extension frames

Hope that this does not block anybody to make innovations!

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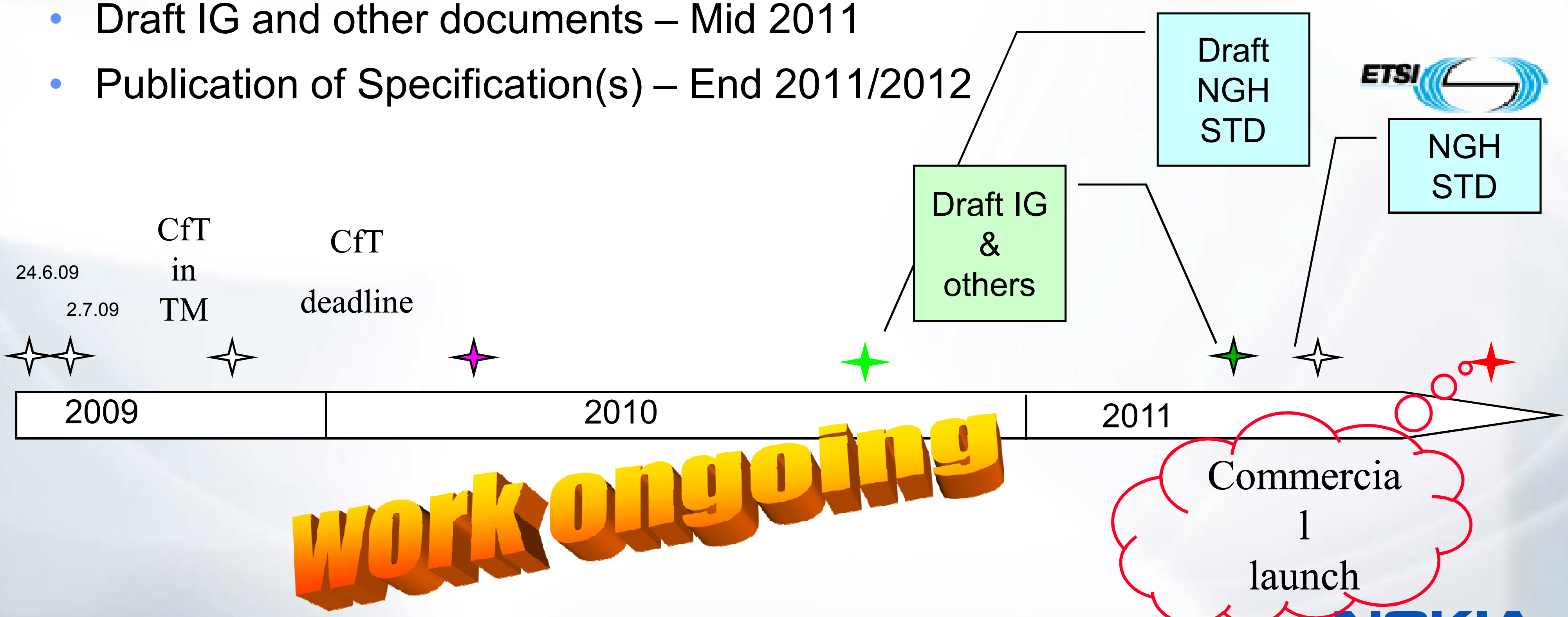
NGH work scheduling (draft)

- CM approval – 24. June 2009
- SB approval – 2 July 2009
- Start of technical work (CfT) – November 2009 (probably)
- Draft Specification – 2H 2010
- Draft IG and other documents – Mid 2011
- Publication of Specification(s) – End 2011/2012



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Conclusions

- DVB is a living organization that has been successful in creating broadcast standards over ten years
- DVB-T => DVB-H => DVB-T2 => DVB-NGH form a natural evolution path for fixed and mobile handheld broadcasting
- The future may provide more tightly knitted family of terrestrial broadcasting standards (T2-NGH)
  - Serving all segmets – home rooftop reception, portable, mobile (vehicular) and handheld receivers
- The performance is (will be) very close to Shannon limits
  - One cannot significantly improve spectral efficiency after this by defining a new physical layer standard
  - Other improvement might be possible
    - (e.g. areal/temporal etc spectral efficiency)
    - ???

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Thank You!

Special thanks for many slides to

several collegues

from Nokia and DVB community

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[6] ETSI TR 102 401 V1.1.1 (2005-04), Digital Video Broadcasting (DVB); Transmission to Handheld Terminals (DVB-H); Validation Task Force Report VTF

[7] ETSI TR 102 377 V1.2.1 (2005-11), Digital Video Broadcasting (DVB); DVB-H Implementation Guidelines

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[11] ETSI EN 302 755 V1.1.1 Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

http://www.dvb-h.org/

www.nokia.com/mobiletv

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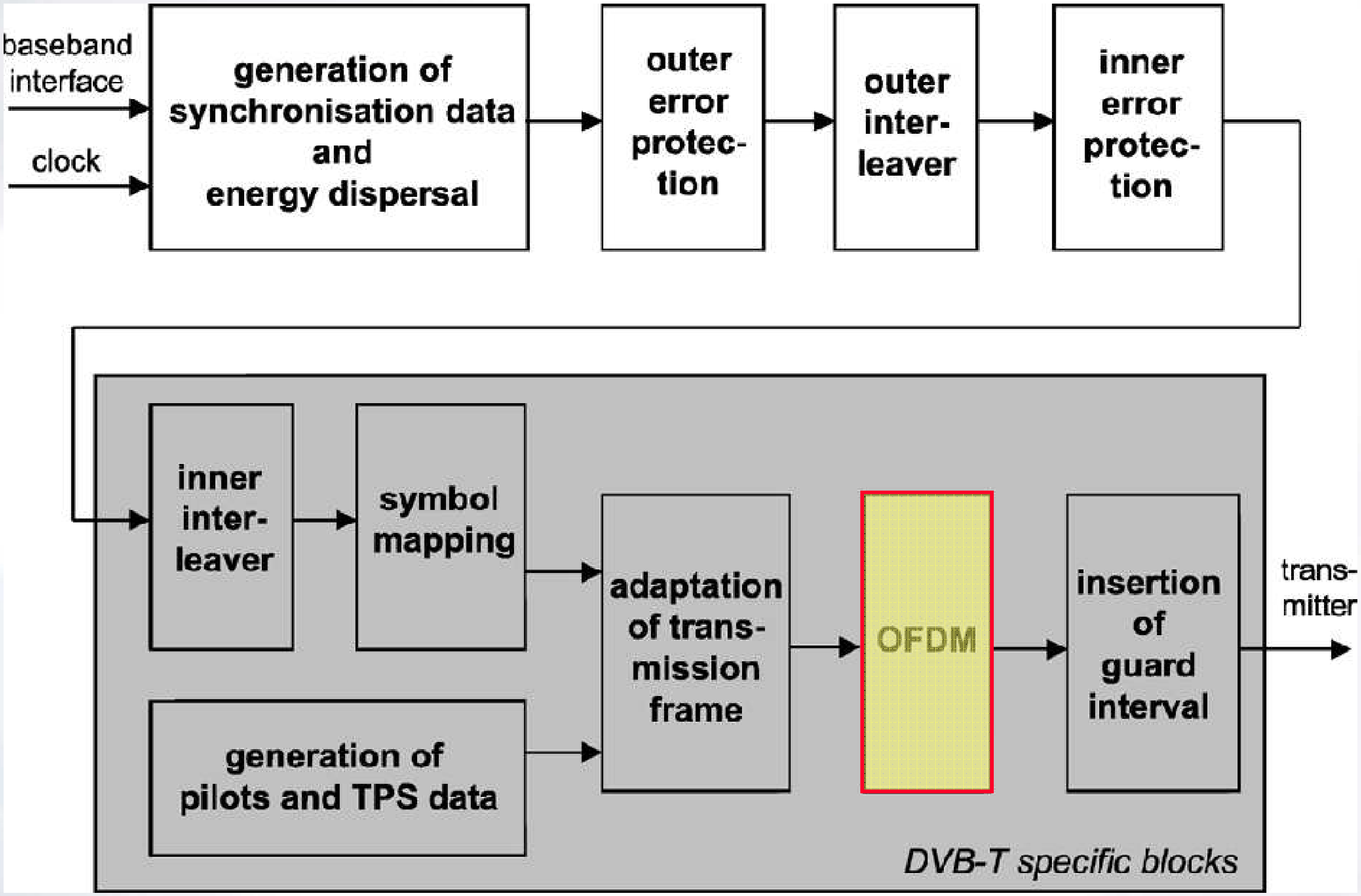
Competition & future

- Several competing standards exist
  - Japanese one segment ISDB-T
  - Korean DMB-T
  - Qualcomm MediaFlo
  - Chinese CMMB
  - (MBMS)

- New evolutions emerging
  - DVB-T2
  - US evolution of ATSC
  - Etc

Digital broadcast is strongly & rapidly evolving area

DVB-T encoding block diagram



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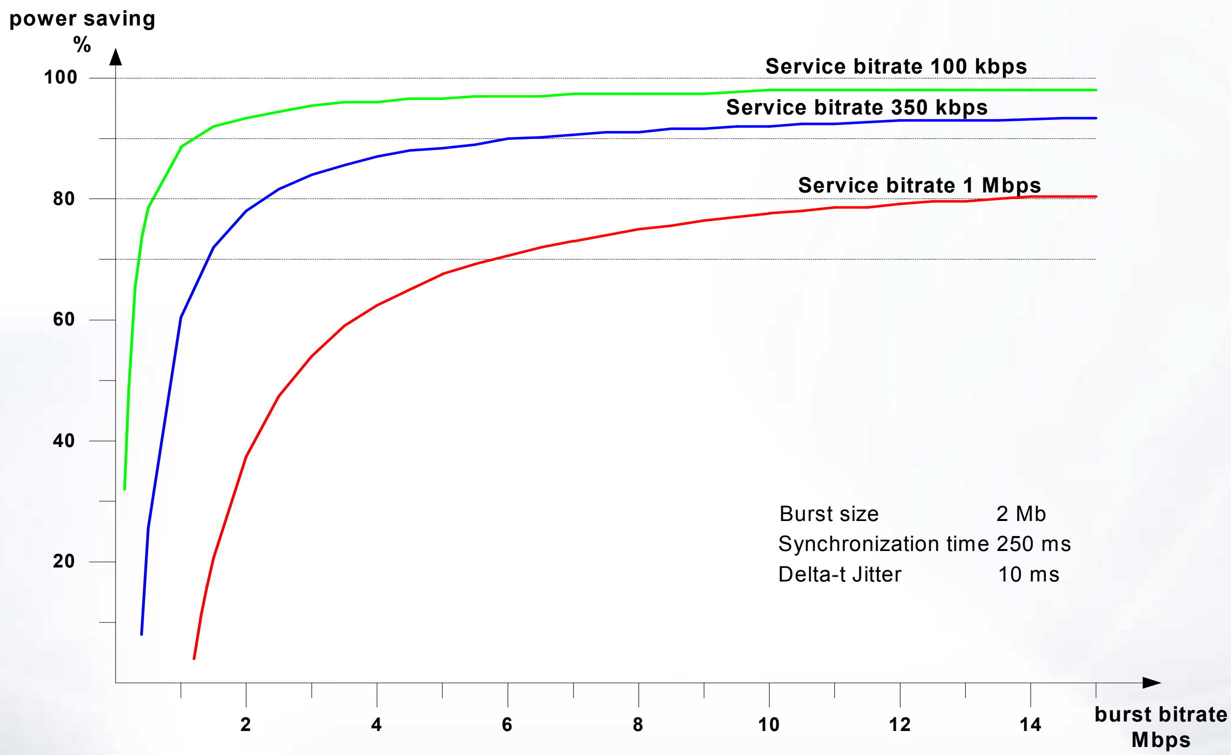
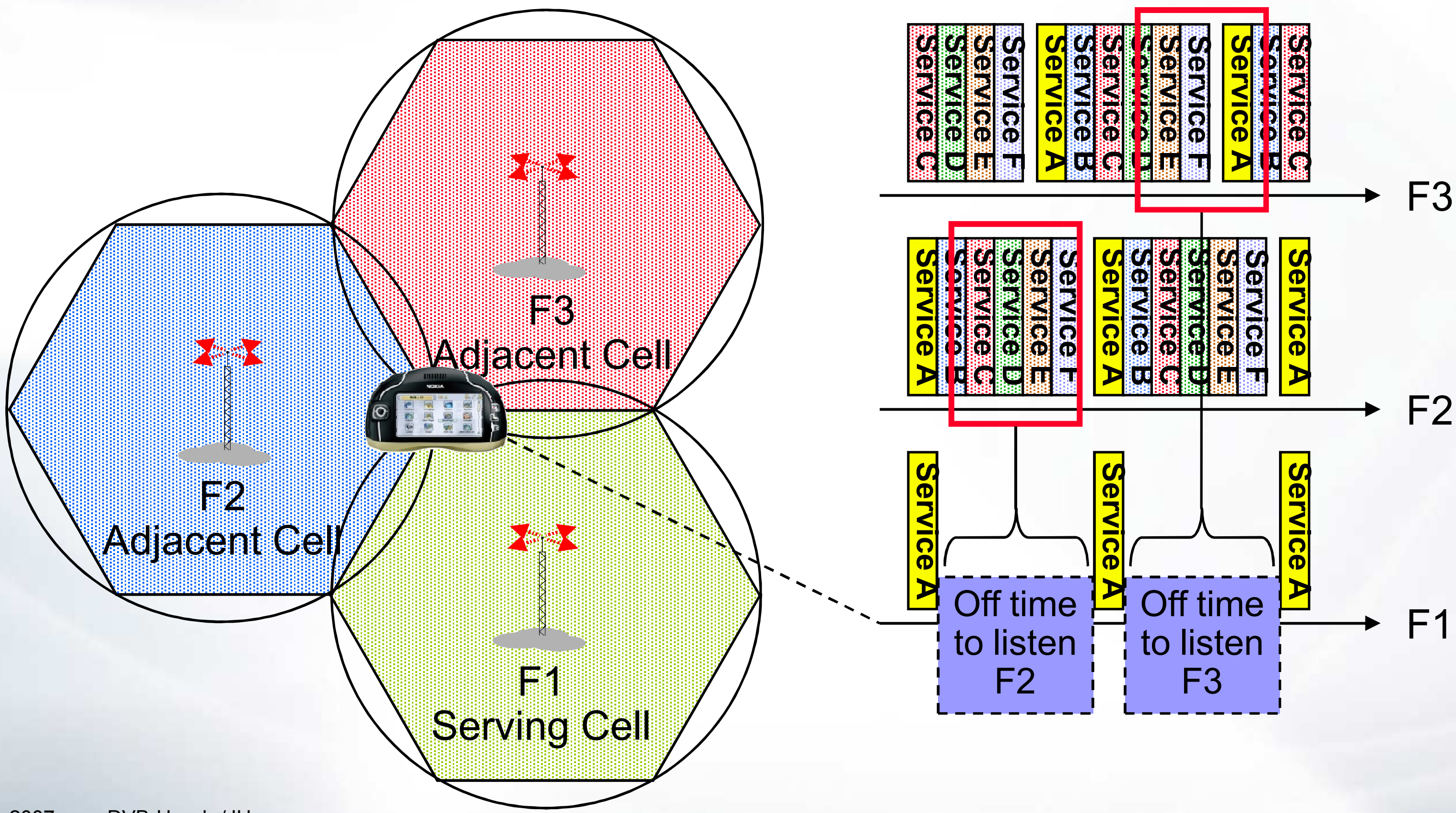
Power saving

- Assuming only two services available, same bitrate, both Time Sliced
  -> On Time is 50% of the Cycle Time
  -> Power Saving nearly 50% (Synchronization Time decreases the achieved level)
- Time Slicing always saves power on a receiver
- The greater the Off Time / On Time relation, the greater power saving achieved



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



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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

Conclusions on DVB-H

- 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
- DVB-H **can share DVB-T multiplex** with MPEG2 services

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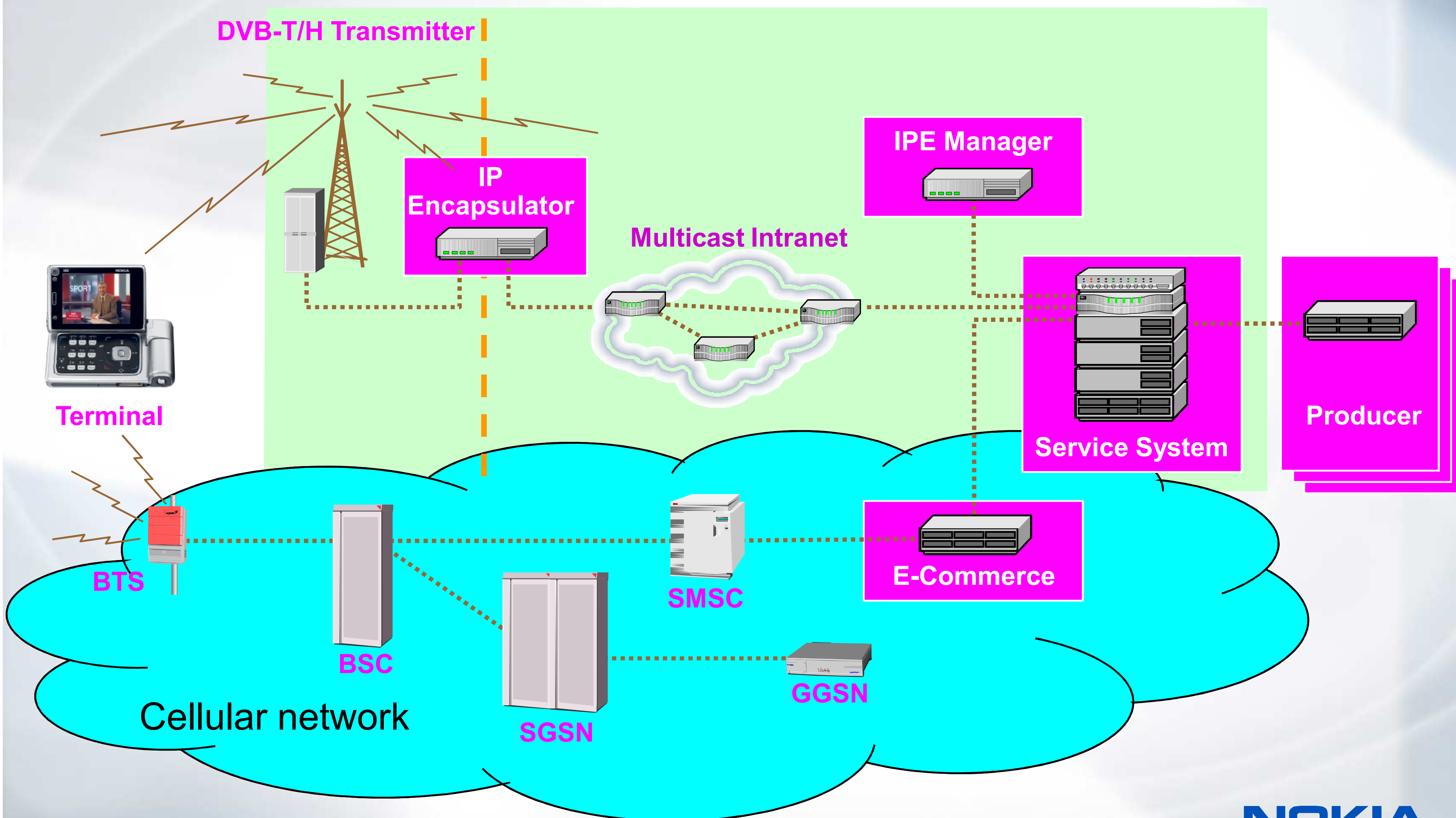
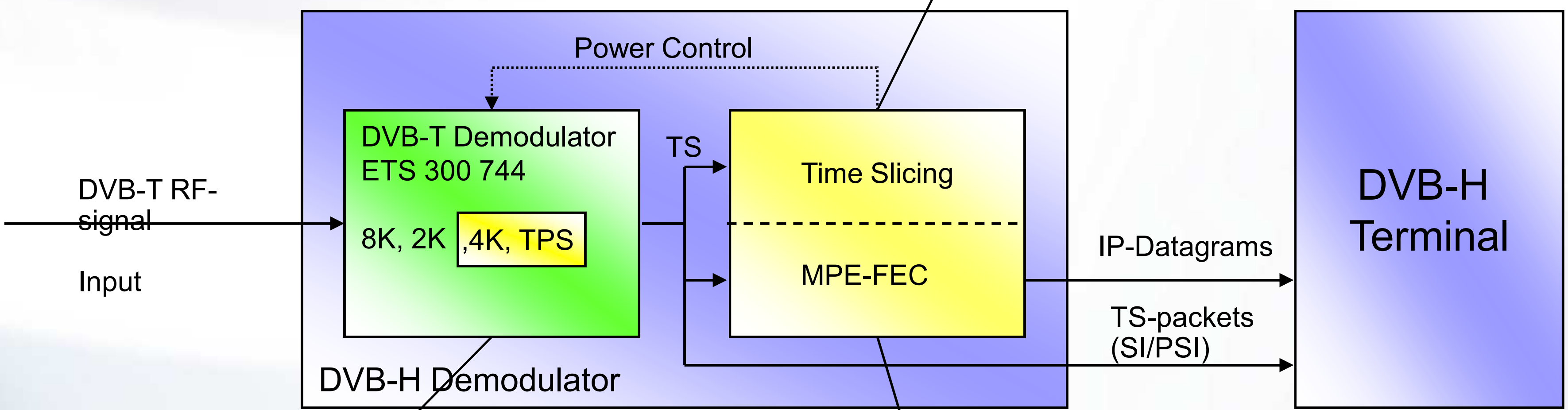
The System Architecture in a Nutshell



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.

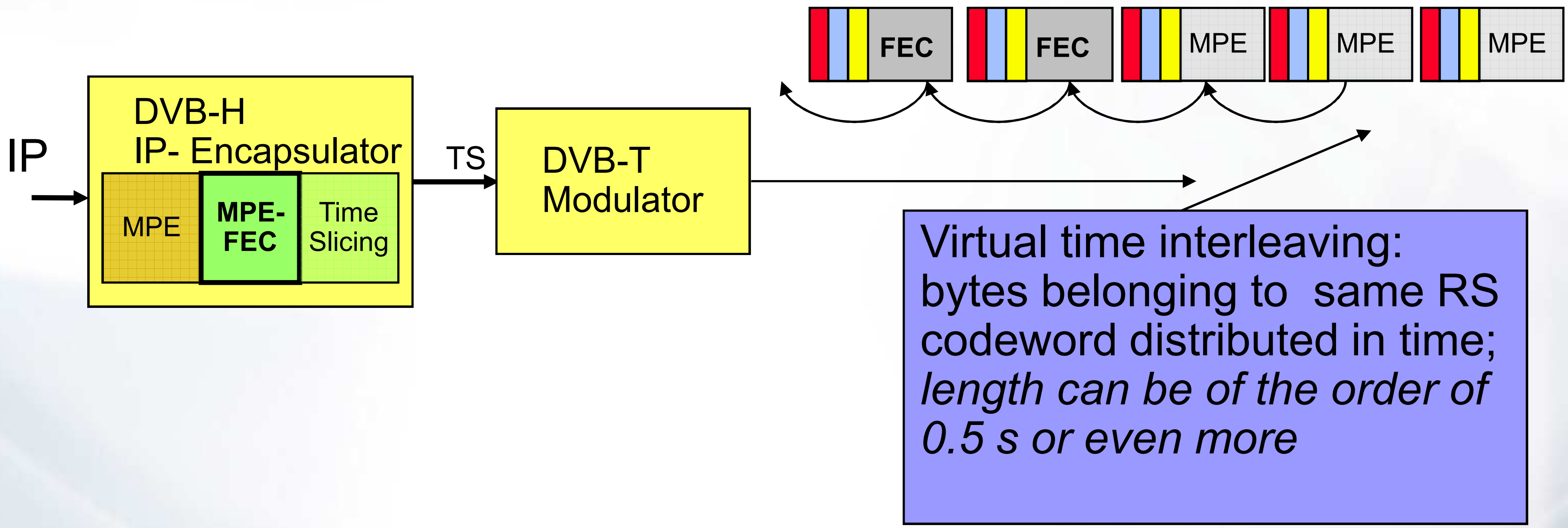


Network Design Flexibility and Signalling
-With 4k practical SFN is still possible with very good mobile performance.
-Flexible use of interleavers [8k in 4k or 2k].
-New TPS bits to signal Time Sl. and MPE-FEC.
-Cell id is mandatory.
-Very low additional complexity.

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.

MPE-FEC

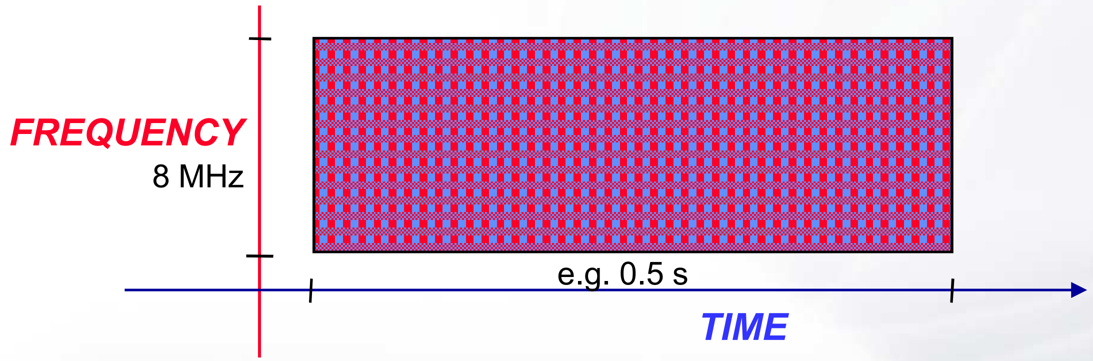
- Additional data link layer Reed-Solomon coding for IP datagrams
- RS data delivered in special FEC sections (***virtual interleaving***)
- Reuses Time Slicing buffer (max 2 Mbit)



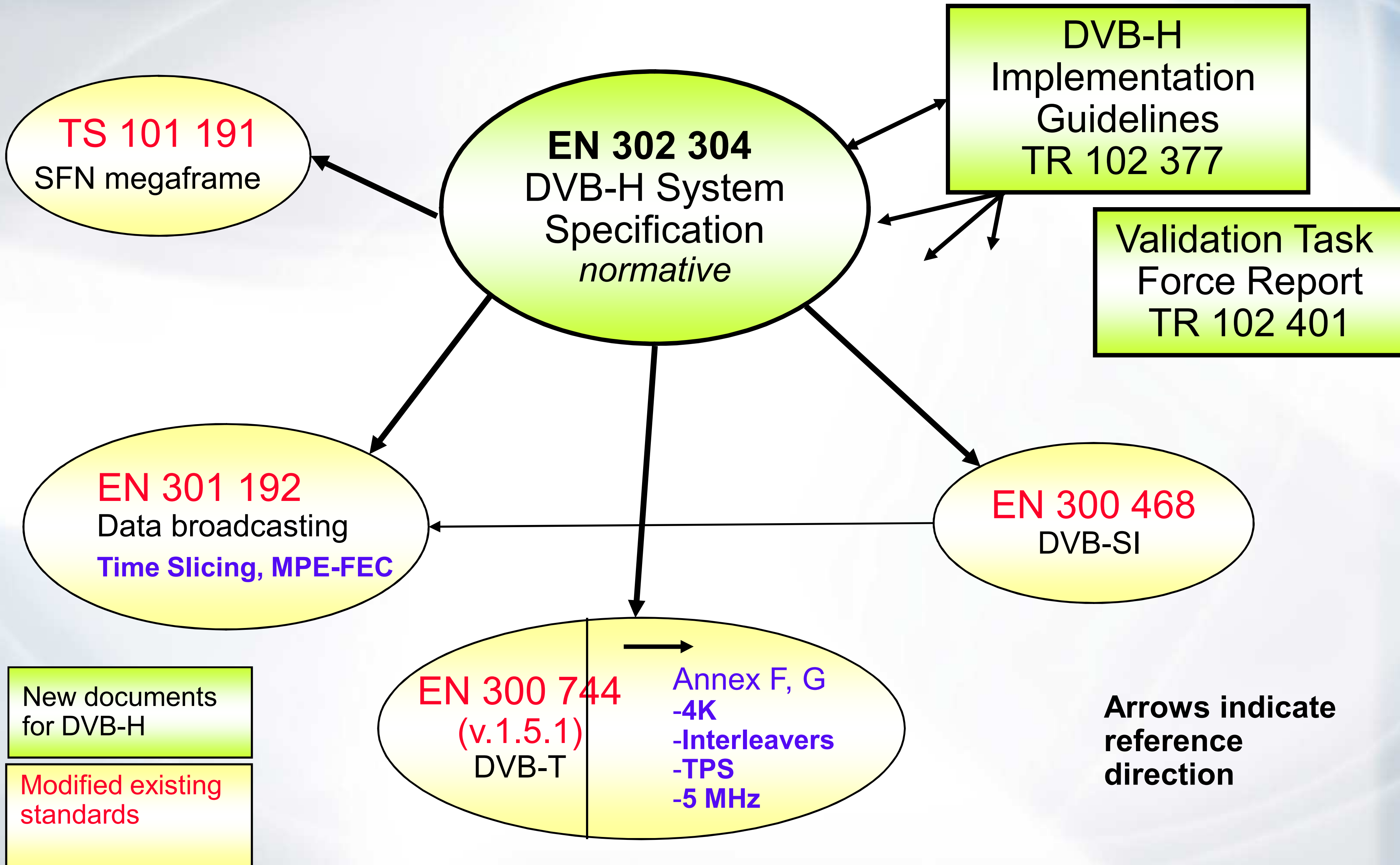
Time slicing 3

- 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!)



DVB-H Standards Family



Arrows indicate reference direction

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Highlights of the NGH commercial requirements

7	The DVB-NGH specification shall be optimized for outdoor and deep indoor portable and slow mobile reception (pedestrian ≤15 km/h).
8	The DVB-NGH specification shall also be optimized for in-vehicle and outdoor mobile vehicular reception (15 to 350 km/h).

Keep mobility

11	The DVB-NGH specification shall be designed to operate at least in the frequency bands III, IV and V, L-band and S-band.
12	DVB-NGH shall be designed to operate in RF channel bandwidths of **1.7**, 5, 6, 7,and 8, **10**, 15 and **20** MHz.

New bands & bandwidths

15	The system shall be designed for terrestrial use and it may also contain ***a satellite component.***

Avoid market fragmentation!

18	The system should support for the transport of the whole stream to transmitters over non synchronous networks such as **IP**.
19	**Individual quality for service components** should be possible.
22	The NGH standard should allow for a NGH service to be offered in different qualities. The lower quality being more robust, e.g. based on the use of **scalable video coding**.

IP support and individual & different service quality; possibly SVC

24	The video, audio or data **net throughput shall be maximized** for a given reception condition (e.g. C/N), i.e. overheads such as packet headers and metadata should be minimized, without losing functionality.

Reduce overheads!

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Highlights of the commercial requirements 2

28	**The preference, in terms of performance improvement, is on robustness and indoor coverage. Recognizing that capacity can be traded for robustness, the overall capacity improvement, for a given robustness, shall be at least 50% compared to DVB-H.**	Major motivation!
29	The DVB-NGH specification should allow for the re-use of DVB-H RF network structures mixing several sites profiles (e.g. from high power/high broadcast towers to low power/low sites similar to 3G sites) and distribution networks as far as possible.	Guard existing (and future) investments
30	**It shall be possible to combine DVB-NGH and DVB-T2 signals in one RF channel**	Could be major competitive edge!
31	The DVB Technical Module is requested to complete the DVB-NGH technical specification(s) by the end of 2011.	Commercial launch 2012

Notes & disclaimers:

1) based on draft document from CM

2) Selection of certain requirements here does not mean any preference or indication of importance; purely personal interest ☺

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Goals for channel modelling

- To obtain channel models representative of MIMO delivery to a handheld device (or laptop)
- Terrestrial and Satellite
- VHF,UHF, L-Band; dimensionality up to 4x2
- Probably cross-polar receive antennas (+ wired headset)

$$\begin{pmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{pmatrix}$$

$$\begin{pmatrix} \tilde{h}_{11} & \tilde{h}_{12} \\ \tilde{h}_{21} & \tilde{h}_{22} \end{pmatrix}$$

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Thank You!

Special thanks for many slides to

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