Mobile TV

Opzioni per le architetture di rete

Convegno nazionale 23-24/11/05

Summary

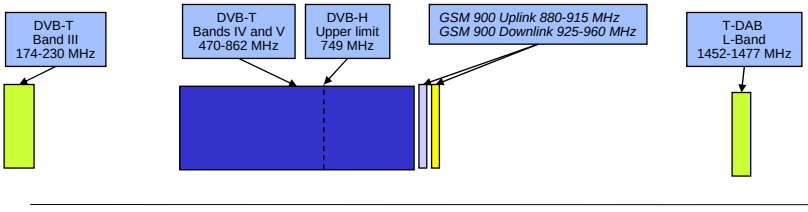
- Why DVB-H ?
- DVB-H frequencies
- High level planning criteria
- Network topology, MFN vs k-SFN
- Network architecture solutions

Why DVB-H ?

- Target to have portable, mobile and indoor reception
- Reduced power consumption (time slicing)
- Improved error tolerance and robustness (MPE-FEC)
- Improved speed performance (MPE-FEC)
- Scalability capacity in theory up to 30 Mobile TV programs per channel/frequency (in practice up to 15 with QPSK modulation)

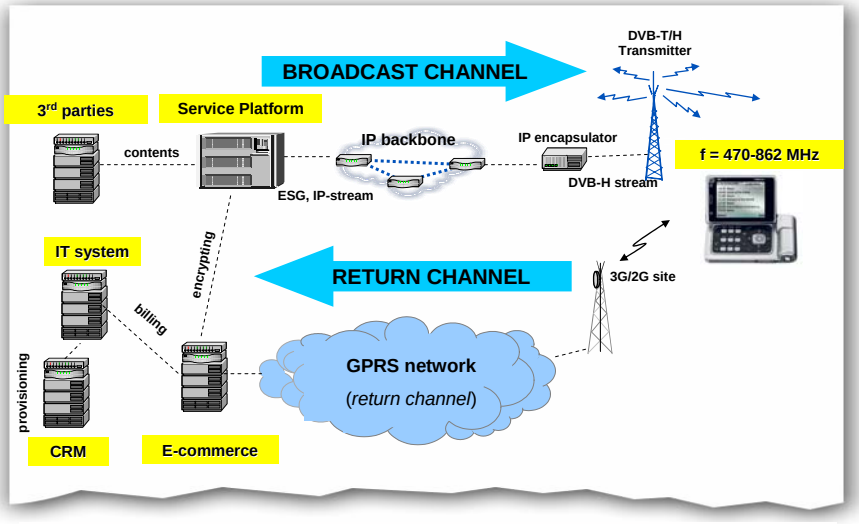
- DVB-H adds planning constrains:
  - Path loss enlarged by Building Loss & Receiver Loss
  - TV Towers only are not able to guarantee a good service quality level especially for indoor in Urban area. As consequence Gap-fillers need to be introduced

What about the DVB-H frequencies ?



- DVB-H is intended for integration into mobile phones so the need for an integrated antenna or to limit the antenna size is clearly an addition factor of importance
- The optimum frequency range falls within the current UHF broadcasting allocations.
- The use of broadcasting bands IV and V (470-862 MHz) is limited by terminal interoperability issues with GSM system. So, practical receivers reduce the available DVB-H frequency range and the upper limit of the band used for DVB-H to around 749 MHz– up to and including TV-channel 55.
- Adjacent frequencies dedicated ot DVB-H services would be a requirement to guarantee seamless handover especially in MFN network.
- L-Band spectrum has been proposed for DVB-H services but it require several transmitters and therefore would be much more expensive than at UHF.

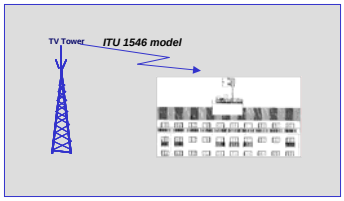
High level architecture



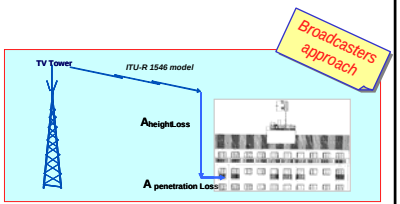
Focus on Radio Broadcast architectures

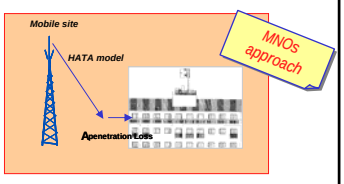
DVB-T vs DVB-H planning criteria

- DVB-T scenario
  - ITU-R 1546 model suggested by DVB community.



- DVB-H scenario
  - Mobile Operators suggest Hata model
  - Broadcasters are confident on DVB-T approach plus additional correction factors
  - Results from DVB-H trials will validate the right model to be used
  - System parameters (building loss, location probability, minimum C/N for mobile usage) need further investigations
  - DVB-H trials are mandatory to launch high quality TV mobile services and tune the investments





DVB-T/H Networks Topologies

- Which topology has to be used ?
  - MFN - Multi Frequency Network
  - SFN – Single Frequency Network

Transmitters do not use the same set of carrier frequencies

PROS

- ✓ No need for content and timing to be synchronized
- ✓ National and local contents
- ✓ Deploy can be immediately started without waiting for DVB-H frequencies assignment

CONS

- ✓ Require several channels/frequencies for national deploy
- ✓ Require frequency Planning
- ✓ No SFN gain – number of transmitters higher than SFN network

MFN - Multi frequency network

Transmitters use the same set of carrier frequencies

PROS

- ✓ Only one frequency for national deploy
- ✓ No frequency Planning required
- ✓ SFN gain – reduced number of transmitters compared to MFN case

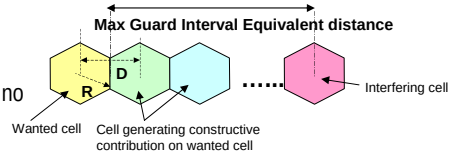
CONS

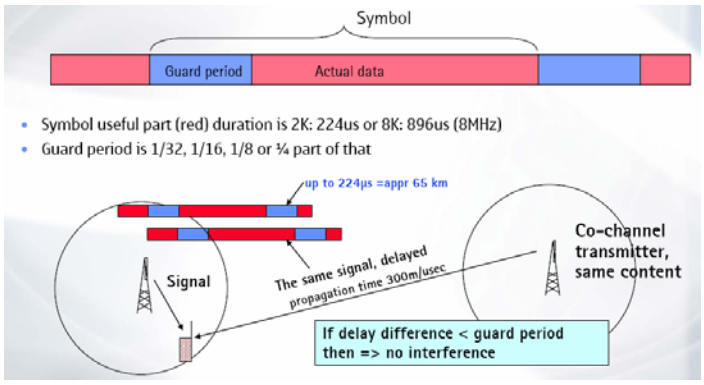
- ✓ Frequency has to be free all over the country
- ✓ Need to synchronize all transmitters in both timing and content
- ✓ National network only
- ✓ SFN size limited by Guard interval

SFN - Single frequency network

How large can be a SFN ?

- Generally the size is function of 'guard interval'
- If the signal falls into the Guard Interval there is no interference





How to solve SFN size limitation ?

MFN network with SFN sub-networks (k-SFN)
Transmitters which belong to a sub-network use the same frequency

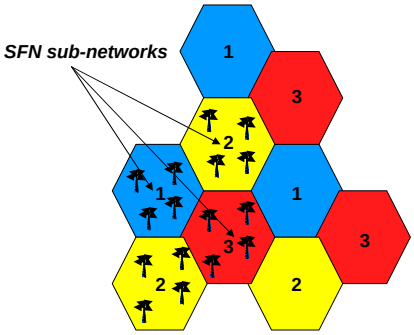
PROS

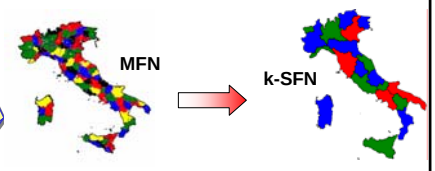
- ✓ Few frequencies (k=3) for national deploy
- ✓ SFN gain within a sub-network – reduced number of transmitters compared to pure MFN case
- ✓ National and local contents.

CONS

- ✓ Frequency Planning required – reuse concept introduced
- ✓ Frequencies (k=3) have to be free all over the country (wait for DVB-H frequencies assignment)
- ✓ Need to synchronize all transmitters in both timing and content within SFN sub-network
- ✓ SFN sub-network size limited by Guard interval

k-SFN

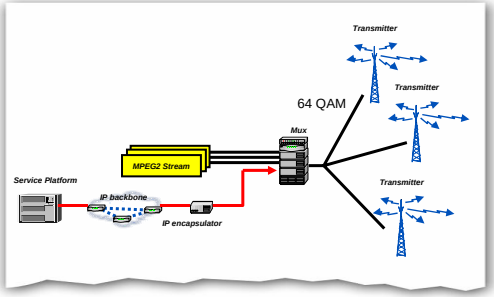




DVB-H architecture solutions

- DVB-T & DVB-H sharing infrastructure
  - *Scenario 1*: *DVB-T/DVB-H MUX sharing*
  - *Scenario 2*: *DVB-T/DVB-H Hierarchical Modulation*
- DVB-H stand alone
  - *Scenario 3*: *DVB-H dedicated network*

Scenario 1- DVB-T / DVB-H MUX sharing



Pros

- *DVB-H service does not need new and dedicated frequencies*
- *DVB-H network can be build in parallel with DVB-T*
- *DVB-T & DVB-H share the same transport and transmission infrastructure*

		Required C/N for BER = 2 × 10^{-4} after Viterbi QEF after Reed-Solomon			Bitrate (Mbit/s)			
Modulation	Code rate	Gaussian channel	Ricean channel (F_1)	Rayleigh channel (P_1)	ΔT_U = 1/4	ΔT_U = 1/8	ΔT_U = 1/16	ΔT_U = 1/32
QPSK	1/2	3,1	3,6	5,4	4,98	5,53	5,85	6,03
QPSK	2/3	4,9	5,7	8,4	6,64	7,37	7,81	8,04
QPSK	3/4	5,9	6,8	10,7	7,46	8,29	8,78	9,05
QPSK	5/6	6,9	8,0	13,1	8,29	9,22	9,76	10,05
QPSK	7/8	7,7	8,7	16,3	8,71	9,68	10,25	10,56
16-QAM	1/2	8,8	9,6	11,2	9,95	11,06	11,71	12,06
16-QAM	2/3	11,1	11,6	14,2	13,27	14,75	15,61	16,09
16-QAM	3/4	12,5	13,0	16,7	14,93	16,59	17,56	18,10
16-QAM	5/6	13,5	14,4	19,3	16,59	18,43	19,52	20,11
16-QAM	7/8	13,9	15,0	22,8	17,42	19,35	20,49	21,11
64-QAM	1/2	14,4	14,7	16,0	14,93	16,59	17,56	18,10
64-QAM	2/3	16,5	17,1	19,3	19,91	22,12	23,42	24,13
64-QAM	3/4	18,0	18,6	21,7	22,39	24,88	26,35	27,14
64-QAM	5/6	19,3	20,0	25,3	24,88	27,65	29,27	30,16
64-QAM	7/8	20,1	21,0	27,9	26,13	29,03	30,74	31,67

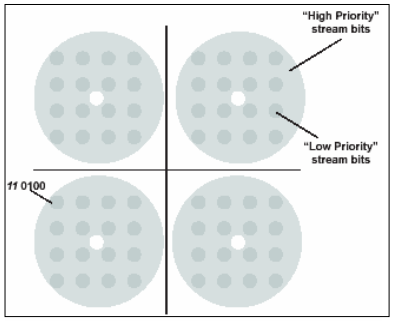
Cons

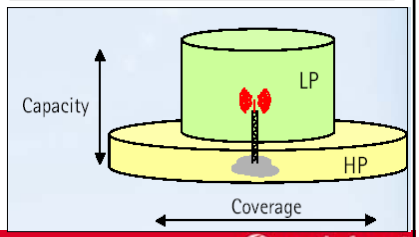
- *DVB-T drives the modulation scheme*
  - *High level modulation required (64-QAM)*
- *DVB-H network planning requires a lot number of sites*
- *Total bit rate is shared between DVB-T & DVB-H service*
- *Tx mode is 8k. DVB-H suggests 4k as tradeoff between 2 and 8K.*

Scenario 2 - DVB-T/H Hierarchical Modulation 1/2

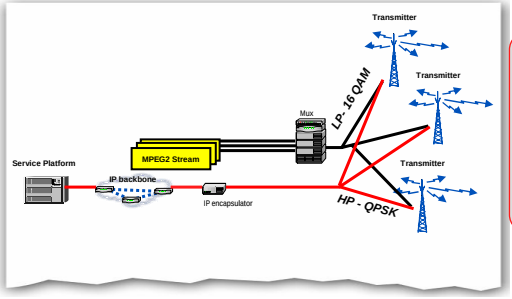
➢ *Make a single RF channel able to address two services with different QOS and targeted to different receivers.*

- ❑ Two separate streams are modulated onto a single DVB-T stream
- ❑ One stream called the “High priority” (HP) is embedded within a “Low priority” (LP) stream
  - ✓ The HP stream uses a QPSK modulation and defines the quadrant of the sub-carriers
  - ✓ The LP stream uses 16-QAM to define the position inside the quadrant of the sub-carriers
- ❑ The LP stream is of higher bit rate but lower robustness than the HP one





Scenario 2- DVB-T/H Hierarchical Modulation 2/2



Pros

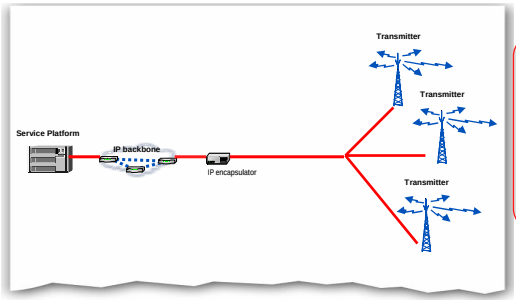
- *DVB-H service does not need new frequencies*
- *DVB-T & DVB-H experience different modulation scheme (HP & LP)*
- *The same transport infrastructure can be use to carry simultaneously HP & LP*

Modulation	Code Rate	α	Required C/N for BER = 2 x 10^{-4} after Viterbi QEF after Reed-Solomon: Gaussian Channel	Ricean Channel (F_1)	Rayleigh Channel (P_1)	Bitrate (Mbit/s): Δ/T_U = 1/4	Δ/T_U = 1/8	Δ/T_U = 1/16	Δ/T_U = 1/32
QPSK	1/2	1	8,9	9,5	11,4	4,98	5,52	5,85	6,03
	2/3		12,1	12,7	14,8	6,64	7,37	7,81	8,04
	3/4		13,7	14,3	17,5	7,46	8,29	8,78	9,05
in uniform 64-QAM	1/2		14,6	14,9	16,4	9,95	11,06	11,71	12,06
	2/3		16,9	17,6	19,4	13,27	14,75	15,61	16,09
	3/4		18,6	19,1	22,2	14,93	16,59	17,56	18,10
	5/6		20,1	20,8	25,8	16,59	18,43	19,52	20,11
	7/8		21,1	22,2	27,6	17,42	19,35	20,49	21,11
QPSK	1/2	2	6,5	7,1	8,1	4,98	5,52	5,85	6,03
	2/3		9,0	9,9	11,1	6,64	7,37	7,81	8,04
	3/4		10,8	11,5	14,5	7,46	8,29	8,78	9,05
in non-uniform 64-QAM	1/2		16,3	16,7	18,2	9,95	11,06	11,71	12,06
	2/3		18,9	19,5	21,7	13,27	14,75	15,61	16,09
	3/4		21,0	21,8	24,5	14,93	16,59	17,56	18,10
	5/6		21,0	22,7	27,9	16,59	18,43	19,52	20,11
	7/8		22,9	23,8	29,6	17,42	19,35	20,49	21,11

Cons

- *Currently, DVB-T decoders do not support Hierarchical modulation features. So DVB-T receiver upgrade would be required*
- *It is applicable if DVB-T uses a modulation scheme different from 64-QAM (QPSK or 16-QAM). LP robustness is the one of the final constellation plus a penalty coming from the HP "over modulation". (e.g. QPSK+16-QAM=64-QAM)*
- *HP robustness suffers the penalty coming from the LP "over modulation"*

Scenario 3- DVB-H dedicated network



Pros

- *Provides the best solution in terms of coverage*
  - QPSK ½ modulation scheme seems to be the optimal choice to minimize the transmitters number
- The available bit rate dedicated only to DVB-H service
- 4 K mode can be used

Modulation	Code rate	Portable MPE-FEC CR = 3/4
QPSK	1/2	6,0
QPSK	2/3	9,0
QPSK	3/4	11,3
16-QAM	1/2	12,1
16-QAM	2/3	15,1
16-QAM	3/4	17,7
64-QAM	1/2	15,4
64-QAM	2/3	18,8
64-QAM	3/4	21,5

** Implementation margin included*

Increasing of minimum +2 dB required

Cons

- *DVB-H service need new and dedicated frequencies*

Comparative results – link budget (1/2)

Urban scenario

	Mux shared 16QAM	Mux shared 64QAM	Hierachical mod.	Stand alone DVB-H
Modulation	16 QAM 1/2	64QAM 1/2	LP 16-QAM / HP QPSK	QPSK 1/2
Throughput [Mbps]	10-12	15-18	**LP 15-18 / HP 5-6**	5-6
Frequency [MHz]	600	600	600	600
Bandwidth [MHz]	7,61	7,61	7,61	7,61
Therma noise density [dBm/Hz]	-174	-174	-174	-174
Receiver noise figure [dB]	6	6	6	6
Noise power[dBm]	-99,19	-99,19	-99,19	-99,19
SNR [dB]	11,2	16	11,4	5,4
Implementation margin [dB]	2,5	2,5	2,5	2,5
Receiver sensitivity thershold [dBm]	-85,49	-80,69	-85,29	-91,29
Shadowing standard variation [dB]	8,1	8,1	8,1	8,1
Coverage probability	75%	75%	75%	75%
Shadowing margin [dB]	5,5	5,5	5,5	5,5
Penetration loss [dB]	15	15	15	15
Required Signal Strenght [dBm]	-65,02	-60,22	-64,82	-70,82
Tx EIRP [dBm] (High Tower/Low site)	63 / 53	63 / 53	63 / 53	63 / 53
Reciver antenna gain [dB]	-8	-8	-8	-8
DVB-H cell radius [Km] (High Tower 150m)	1,8	1,25	1,75	2,75
DVB-H cell radius [Km] (Low site 30m)	0,45	0,3	0,45	0,65

QPSK hierarchical vs pure QPSK

Comparative results – link budget (2/2)

Suburban scenario

	Mux shared 16QAM	Mux shared 64 QAM	Hierachical mod.	Stand alone DVB-H
Modulation	16-QAM 1/2	64-QAM 1/2	LP 16-QAM /HP QPSK	QPSK 1/2
Throughput [Mbps]	10-12	15-18	LP 15-18 / HP 5-6	5-6
Frequency [MHz]	600	600	600	600
Bandwidth [MHz]	7,61	7,61	7,61	7,61
Therma noise density [dBm/Hz]	-174	-174	-174	-174
Receiver noise figure [dB]	6	6	6	6
Noise power[dBm]	-99,19	-99,19	-99,19	-99,19
SNR [dB]	11,2	16	11,4	5,4
Implementation margin [dB]	2,5	2,5	2,5	2,5
Receiver sensitivity thershold [dBm]	-85,49	-80,69	-85,29	-91,29
Shadowing standard variation [dB]	6,1	6,1	6,1	6,1
Coverage probability	75%	75%	75%	75%
Shadowing margin [dB]	4,1	4,1	4,1	4,1
Penetration loss [dB]	10	10	10	10
Required Signal Strenght [dBm]	-71,37	-66,57	-71,17	-77,17
Tx EIRP [dBm] (High Tower/Low site)	63 / 53	63 / 53	63 / 53	63 / 53
Reciver antenna gain [dB]	-8	-8	-8	-8
DVB-H cell radius [Km] (High Tower 150m)	3,9	2,70	3,85	6,05
DVB-H cell radius [Km] (Low site 30m)	0,9	0,65	0,85	1,3

QPSK hierarchical vs pure QPSK

Conclusions

- DVB-H need dedicated frequencies (DVB-H MUXs)
- k-SFN topology for national and regional DVB-H networks
- DVB-H system parameters need further investigations
- DVB-H technical trials need to:
  - validate or tune the radio propagation models
  - calibrate investment evaluation
  - test interference issues with existing transmitting technologies (e.g. GSM, DVB-T, analogue TV)
  - Tune the best video quality for mobile TV services
  - ….

THANK YOU

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BACK UP

Digital PNAF (DVB-T) – I level

- Coverage of 90% of Italian population using 3 frequencies for each network and 260 transmitting sites
- The operator uses 1 frequency for region (regional SFN). Neighbor regions use different frequencies
- Total available frequencies are 54. Each network uses 3 frequencies so the max number of networks are 18 (12 national and 6 regional)
- Network Capacity :
  - ✓ 12 national network x 5 programs (for MUX)=60 national programs
  - ✓ 6 regional network x 5 programs (for MUX)=30 regional programs

Digital PNAF (DVB-T) – II level

- The II level planning uses the “residual resources” to provide 18 provincial MUX (networks)
- More protection for provincial MUX (16-QAM) respect to regional MUX (64-QAM)
  - ✓ Provincial MUX able to carry 3 programs
- Network Capacity:
  - ✓ 18 Multiplexes X 3 programs (for MUX)=54 local programs

PNAF conclusions

- PNAF forces to evolve towards the ***Digital Transmission*** and ***3-SFN*** network ***topology***
- The target for Digital conversion (switch-over) is “more or less” set
- The target for the complete transition MFN to 3-SFN is not set
  - The complete transition will be necessary to free more frequencies
  - How much time will be necessary? A short time, a long time or a VERY LONG TIME ?

OFDM

- Multipath represents the main problem in the Radio Channel causing the Intersymbol interference (ISI)

How does we can mitigate this problem ?

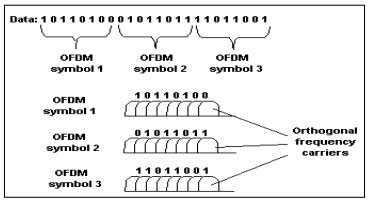
OFDM is a solution

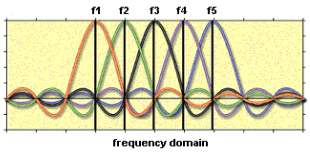
Converting single bit stream in *N* parallel bit streams

- ✓ Symbol duration is increased, so relative delay spread decreases
- ✓ Each parallel bit stream is modulated on one of *N orthogonal subcarriers (2K, 4K, 8K)*

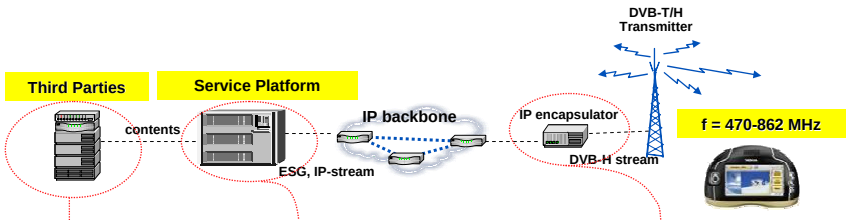
Adding a guard time to each OFDM symbol (Cyclic Prefix)

- ✓ Inter Symbol Interference (ISI) is avoided
- ✓ Inter Carrier Interference (ICI) is minimized





Elements Functionality



- ✓ Aggregates contents
- ✓ Creates ESG
- ✓ Manages Content/Service Protection

- ✓ Produces / Delivers contents and Data

- ✓ Creates Time-slicing
- ✓ Creates MPE-FEC
- ✓ Creates MPEG-TS
- ✓ Implements Content/Service Protection