Chinese, USA and Japanese Standards

Does China Have the Best Digital Television Standard on the Planet?

- The United States established its national standard for terrestrial broadcasts of high-definition digital television, known as ATSC (for Advanced Television Systems Committee), in 1996.
- The European Union settled on its standard, Digital Video Broadcast-Terrestrial, or DVB-T, in 1997.
- Japan developed its Integrated Services Digital Broadcasting-Terrestrial (ISDB-T) in the 1980s and adopted it in 2003.
- But China just finalized its digital television standard in late 2006, beginning transmission with the 2008 Beijing Olympics.

Advantages

- Being late in this particular game is not necessarily a bad thing.
- It allowed China to take advantage of advances in information-coding technologies that make digital television in China—unlike that in the rest of the world—work well even in bad weather.
- These technologies mean that China's digital television can be viewed on the go; it won't break up even at 200 kilometers per hour—you can watch a broadcast on a cellphone while sitting on a high-speed train.

Advantages and Disadvantages of DTMB

- Supports both single and multi-frequency systems
  - More flexible
  - More complicated
- Does not define default video encoding standards
  - High chip cost ☹
  - Any video codec can be used ☺
    - MPEG-2, MPEG-4
    - AVC(H.264), HEVC(H.265)
    - AVS

AVS = Audio Video Standard

- Developed by the Audio Video Coding Standard Working Group of China (AVS for short)
- Aim was to reduce dependence on foreign intellectual property.
  - Save money.
  - Promote China’s electronics industry worldwide.
- Open source. Also codes audio.
- Designed to be backwards compatible with MPEG-2.
- Similar to H.264/MPEG-4

Key Improvements

- ¼ pixel search increment for motion vectors.
- P-frames
  - MPEG-2: 1 previous picture.
  - AVS: 2 previous pictures (I or P).
- B-frames
  - MPEG-2: both forward and backward motion vectors are coded in interpolation mode.
  - AVS: only forward motion vectors are coded, backwards motion vectors are derived from the correlation between backwards and forwards.

DTMB (GB20600-2006)

- Designed to deliver a consistent, high quality digital TV viewing experience to both handheld and stationary devices.
- Audio and video at greater than 24Mbps.
- Mobile reception is built into the standard.
  - Not an ‘add on’ so performance will be better.
- MPE can be laid on top.
- MPE system is capable of broadcasting 20 to 30 mobile programs in one 8MHz channel.

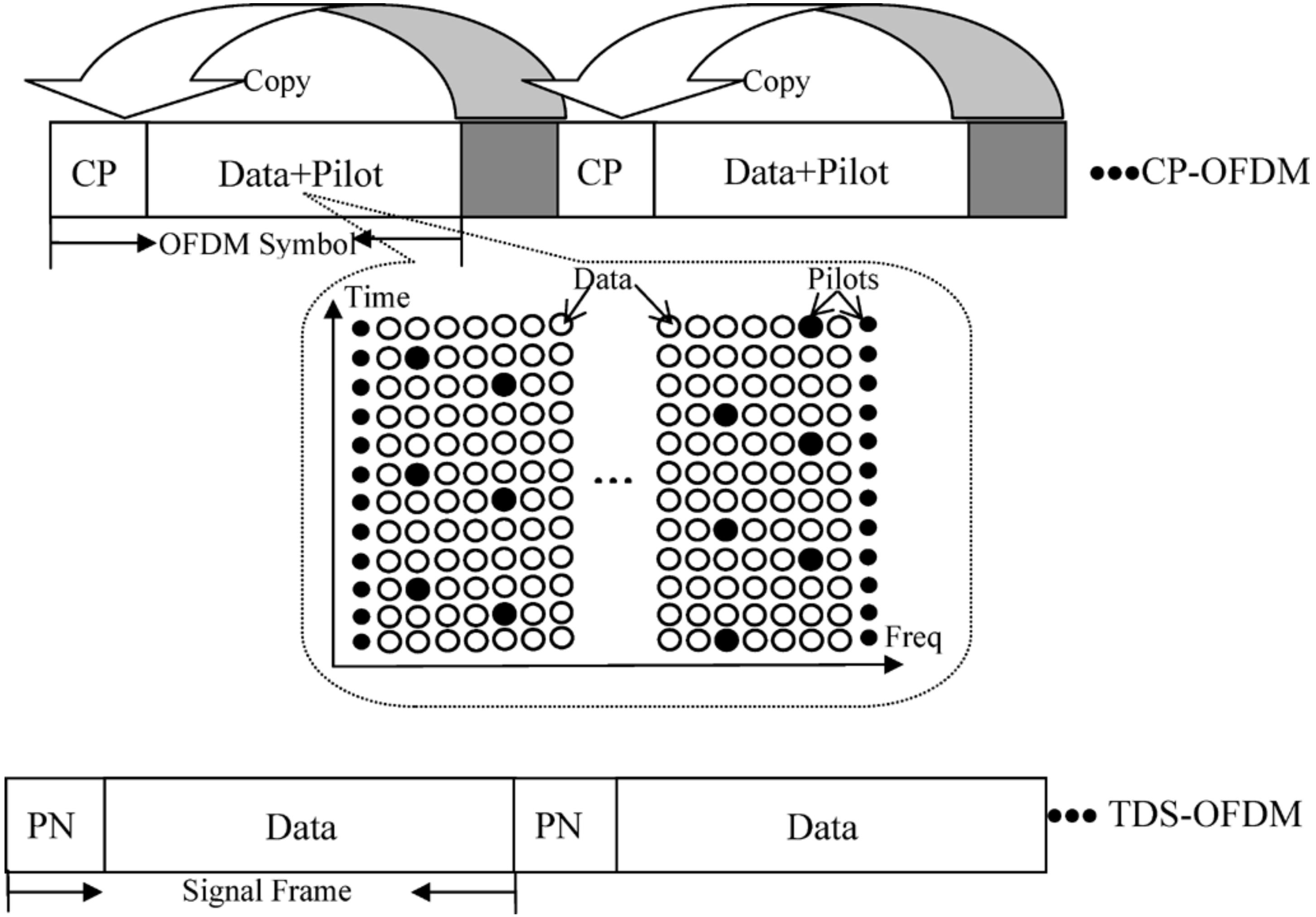
Mobile Devices

- Low power.
- Robust signal reception.
- Low resolution video.
- More complex signal processing due to Doppler shift.

Signal Acquisition

- On tune in, the signal must be ‘acquired’.
  - Use NULLS to locate frame positions.
  - Use synchronisation symbol to get phase reference.
  - Use pilot signals to get a ‘lock’ on all the subcarriers and to perform channel estimation.
  - Decode FIC.
  - Decode sub-channels.

Pilot Signals



Pilot Signals

- Used for channel estimation
  - Interference (phase and frequency) can be estimated by comparing the difference between several sets of pilot signals taken from several consecutive OFDM symbols.
  - Every OFDM symbol must be converted from the time to the frequency domain before the pilot signals can be detected.
  - Processing takes time.

Pilot Signals

- At high speeds the Doppler shift causes the channel characteristics to change so frequently that OFDM is unable to keep up!
- The signal is never acquired successfully!
  - The time taken to convert form time domain to the frequency domain is too long.
  - By the time we have processed enough OFDM symbols to get a good estimate of the channel characteristics, they have changed!

TDS-OFDM

- Time-Domain Synchronous OFDM.
- Main innovation of Chinese standard.
- Allows for
  - Fast channel acquisition.
  - High spectrum efficiency.
- How?
  - Guard interval is not a cyclic prefix.
  - Uses a PN (pseudo-random) sequence.

PN Guard Interval

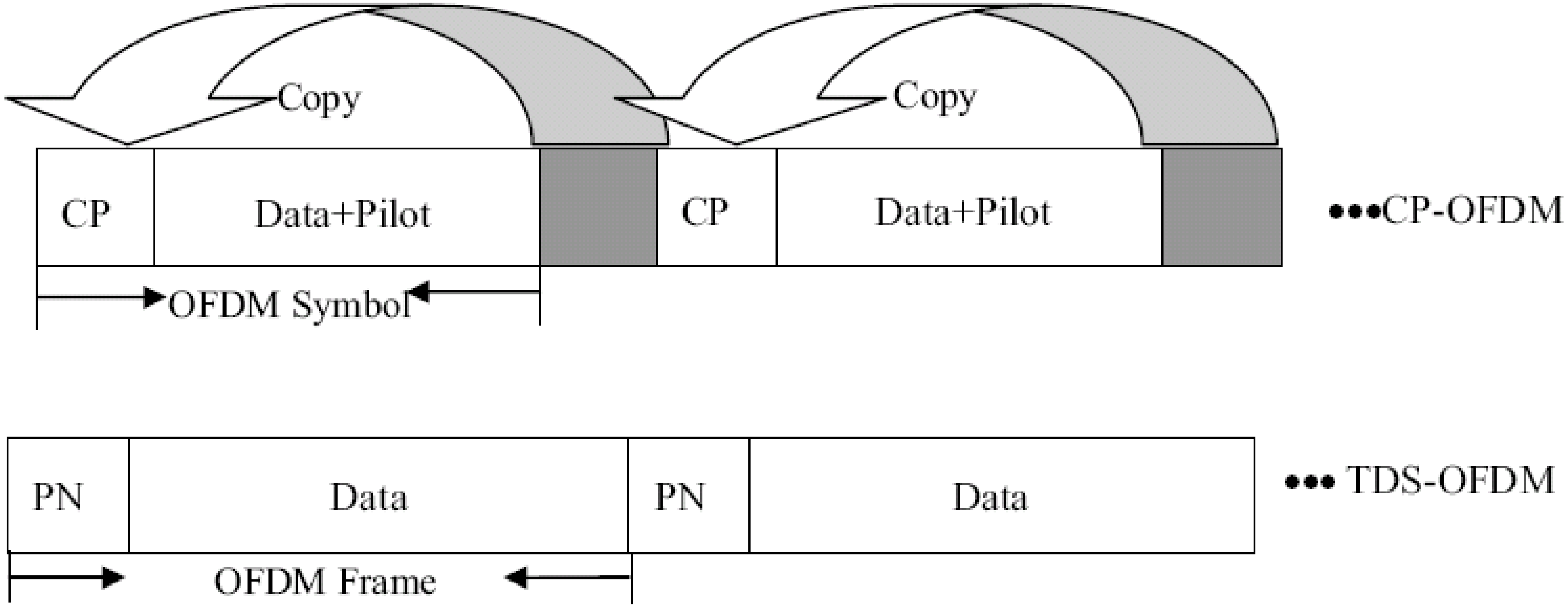


Figure 1. Difference between CP-OFDM and TDS-OFDM symbol in time domain.

PN Guard Interval

- Guard interval is a sequence that contains useful information (unlike cyclic prefix).
- Has cyclic characteristics so it can be identified but is not a repeat of information in the payload.
- Noise-like signal so, although is will not be orthogonal, the spectrum will be low power and distributed across the entire frequency range.
  - Easy to filter out.

Information in PN

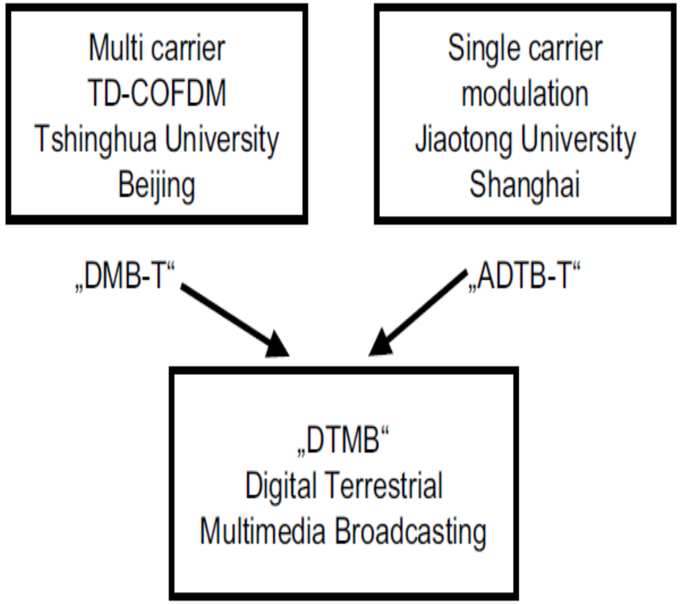
- Contains information for channel estimation and signal acquisition.
- Is in the time domain, not frequency domain (hence TDS).
- Very fast channel estimation and signal acquisition time (5% of time for DVB-T).
- Improved spectrum efficiency.

Improved Channel Estimation

- PN contains information that, in COFDM, was contained in the pilot signals.
  - No need for pilot signals, so better spectrum efficiency.
- Channel estimation is made from the PN portion of the signal.
  - PN is in time domain – no need for FFT so less delay.
  - Channel characteristics will not have changed (Doppler) before we can perform acquisition.
  - Immune to Doppler (below certain speeds).

DTMB: Further info.

- The following can be selected as modulation methods on the 3744 data carriers:
- 64QAM
- 32QAM
- 16QAM
- 4QAM
- 4QAM=NR

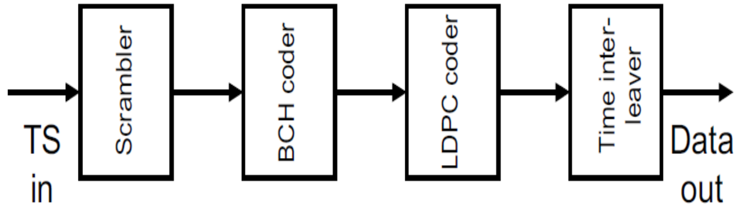


DTMB

DTMB FEC System

The error protection in DTMB consists of a

- Scrambler
- BCH coder
- LDPC coder
- Time interleaver

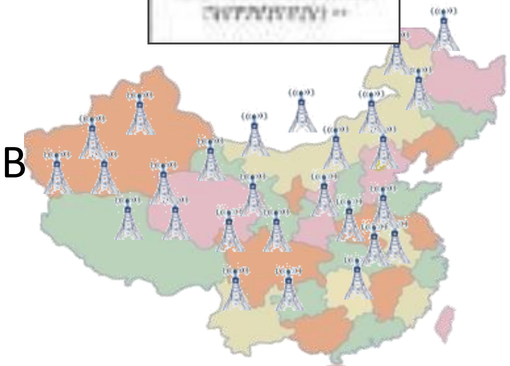


- The DMB-T signal is made up out of:
  - Signal frame (frame header + frame body = virtually guard +symbol)
  - Super frame = N1 • signal frame
  - Minute frame = N2 • super frame
  - Calendar day frame = N3 • minute frame
- Input signal of a DTMB transmitter is the MPEG-2 transport stream

DTMB Standard Deployment

- Broadcast 3-Step plan
  - By 2015, starts prefecture level HD/SD simulcast coverage
  - By 2018, analogue switch off in all big and medium cities
  - By 2020, analogue switch off in whole country

- Receiver must carry policy
  - By 2015.1.1, all the TV sets sold in China must carry DTMB receiving feature



Totals 15397 terrestrial TV tower

30082 TV transmitters

Analog switch off by 2020, deployment in 20+ provinces
337 cities and 2000 counties, 410 million subscribers

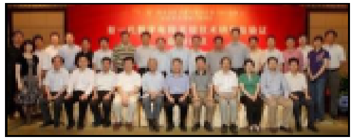
NGB-W Deployment Timeline

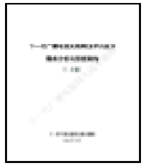
- 700MHz band will be fully kept to guarantee transition and new services

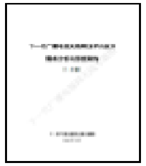
1st Generation Broadcast System

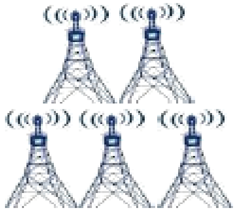
Major Cities	Receiver Mandatory	National Coverage	Big Cities ASO	Whole Country ASO
2012	2015	2016	2018	2020

Next Generation Broadcast System









2012
Next Generation
High Tech Project Starts

2014
NGB-W
Structure Drafts

2015
Prototype
Network Trial

2017
Next Gen.
Standardization

2019
Commercial
Broadcast

DTMB Standard Deployment

CCTV

2014.10 – 2016.10
0.8 Billion USD Terrestrial

12 CCTVs
1 Provincial
1 City
1 County

2562 TV Stations
6293 TXs
1 KW/300W/County

Targets of DTMB 2.0 / NGB-W System

Efficient, flexible, smart and interactive system with IP based open system

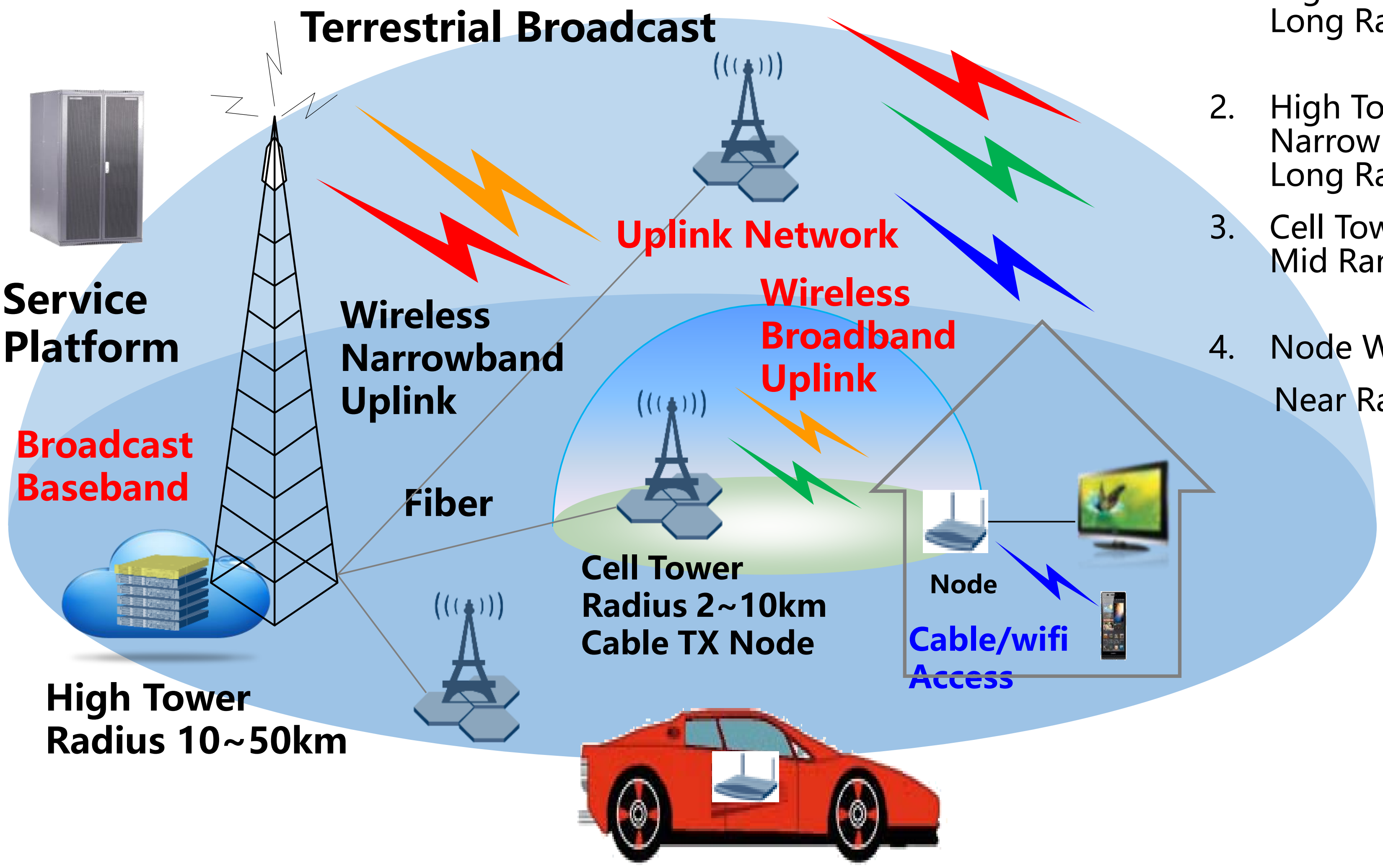
Much higher and more robust spectrum efficiency

Smart broadcasting transmission

Broadcast, multicast and unicast to support more services

Cost efficient and adaption to large scale deployment

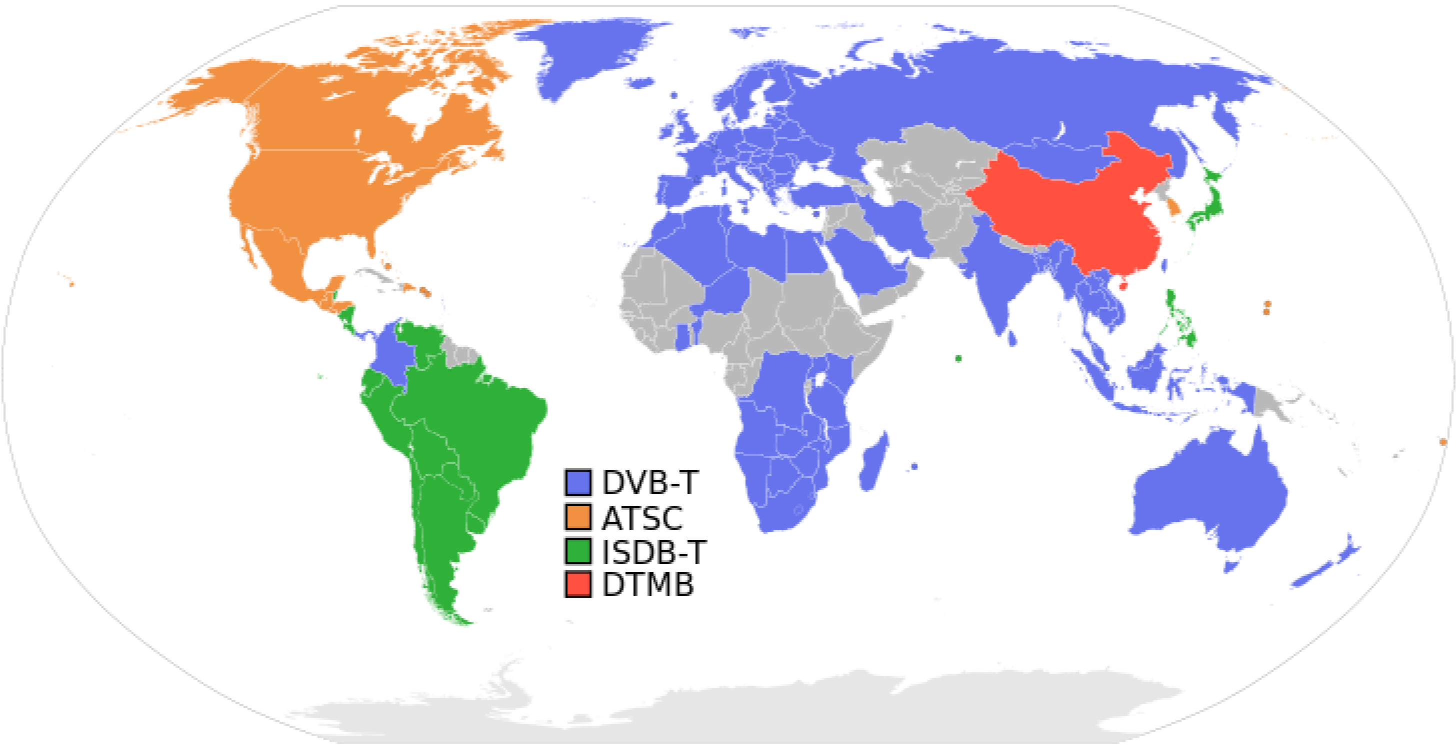
Targets of DTMB 2.0 / NGB-W System



1. High Tower Broadcast
   Long Range, High Frequency
2. High Tower Wireless
   Narrowband Uplink
   Long Range, Less Investment
3. Cell Tower Broadband Uplink
   Mid Range, Medium Investment
4. Node Wifi Access
   Near Range, More Terminals

US and Japanese Standards

World use of TV standards



The ATSC digital TV System

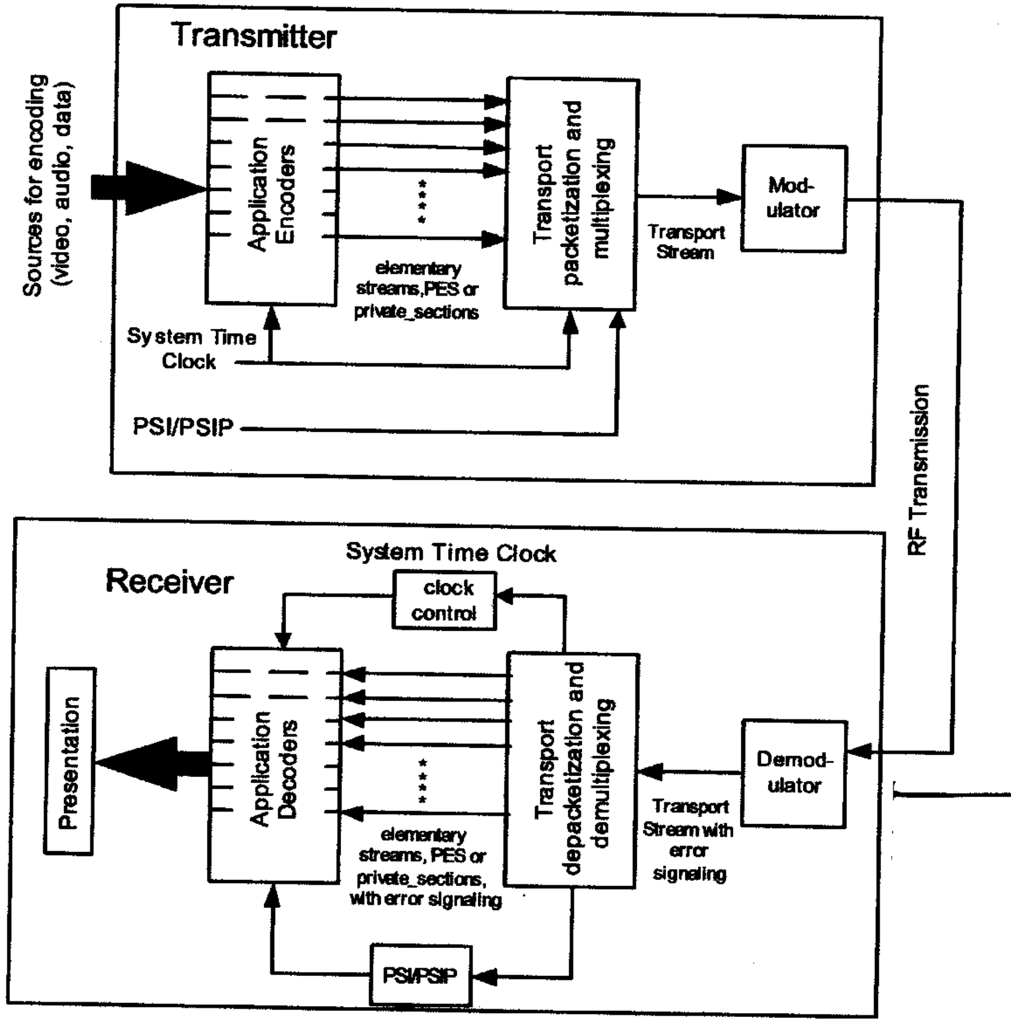
Background

- This is the standard of the Advanced Television Systems Committee based in Washington, USA
- The official designation is A/53 and the latest version is dated 2009 with some sections revised in 2010 and 2011
- ATSC Digital TV Standards include digital high definition television (HDTV), standard definition television (SDTV), data broadcasting, multichannel surround-sound audio, and satellite direct-to-home broadcasting.
- The ATSC digital standard superseded the NTSC standard in US in 2009 and in Canada in 2011

More Background

- The Advanced Television Systems Committee develops voluntary standards for digital television. The ATSC member organizations represent the broadcast, broadcast equipment, motion picture, consumer electronics, computer, cable, satellite, and semiconductor industries.
- There are 140 members but ATSC standards are mainly used in the Americas. The digital TV standard has been adopted by Canada, Mexico and South Korea. There is a standards battle underway for South American countries
- The Federal Communications Commission decided that A/53 should be the standard for broadcast transmission in the US

The ATSC system



- PSI is programme specific information
- The system is very similar to DVB in principle
- The application encoders perform the compression of the audio, video and data
  - Video encoding is MPEG-2 but an associated standard A/72 defines how to use H.264
  - Audio encoding is AC-3 (ATSC standard A/52, also known as Dolby digital 5.1)

AC-3 audio coding

- The input to an AC-3 encoder will be six 48 kbit/s audio streams (left, right, centre, left surround, right surround and low frequency effects) – total 6x48kHz x 18 bits = 5.184 Mbps
- This is compressed to a single 384kb/s bit stream
- Often only two channels are encoded
- The first step is to transform the representation of audio from a sequence of time samples into a sequence of blocks of frequency coefficients. This is done in the analysis filter bank.

Transmission

- The transport stream uses the MPEG-2 standard as for DVB
- Reed-Solomon coding, interleaving and energy equalisation are similar to DVB, although a trellis encoder is used after the interleaver
- The interleaver is complex, operating to a depth of 52 segments and handling noise bursts up to 192 ms
- The encoder divides a byte into 4 two-bit words and then adds an extra bit to indicate what the transition was from the previous word. The two bits hence become three, so there are 8 possible values and this is effectively a 2/3 convolution coder. These are the 8 levels in 8-VSB.

VSB

- The modulation is vestigial sideband modulation (VSB) instead of OFDM
- The terrestrial version is 8-VSB that gives a useable data rate of 19.39 Mbit/s for a 6 MHz channel
- For digital cable QAM is used in the US as in Europe
- The MPEG-2 packet has 197 bytes. Reed-Solomon coding adds 20 bytes giving 207 bytes.

Extra Audio services

- A service, to convey a narrative description of the picture content for use by the visually impaired.
- A service, to convey dialogue that has been processed for increased intelligibility for the hearing impaired.
- An emergency message service, which is given priority in reproduction. If this service type appears in the transport multiplex, it is routed to the audio decoder while muting the main service.
- Voice-Over. A service to be decoded and added into the center loudspeaker channel.

Recent additions

- A new standard to support television to mobile devices A/153 was adopted in 2013
- A new standard to support non real-time content delivery A/103 was adopted in 2012
- ATSC 2.0, soon to be adopted, will allow interactive and hybrid television Other features include advanced video compression, audience measurement and targeted advertising
- A more advanced standard ATSC 3.0 is also under development

The Japanese ARIB standard

Background

- ARIB is the *Association of Radio Industries and Businesses* and is the Japanese standardisation body
- The standard is titled Data Coding and Transmission Standard for Digital Broadcasting (ARIB standard B.24) and is in three volumes
  - Data Coding
  - XML-based multimedia coding scheme
  - Data Transmission

More background

- The standard covers
  - Digital satellite broadcasting in the 11.7 to 12.2 GHz band
  - Broadband satellite broadcasting within the digital satellite broadcasting
  - Digital terrestrial TV broadcasting
  - Digital terrestrial sound broadcasting
  - Digital satellite sound broadcasting
- The standard is supported by government regulations

Video

- The video coding is identical to MPEG-2
- The standard allows 525 lines (483 active) progressive or interlaced, 750 lines (720 active) progressive, 1125 lines (1080 active) interlaced and 4:3 or 16:9 aspect ratio for 525 interlaced, but only 16:9 otherwise
- The appendix of *operating guidelines* is longer than the body of the standard and it deals with issues such as
  - how to ensure that channel hopping time does not exceed 500ms
  - seamless switching between different video formats (e.g. standard definition to high definition)
  - How to convert 24 frames/s film to 30 frames/s TV

Audio

- The audio coding is according to the MPEG-2 AAC coding scheme, with support for mono, stereo, 3 front and one rear speakers, 3 front and 2 rear speakers or the 5.1 speaker arrangement
- The version of AAC required is the low complexity version. Several sampling frequencies are permitted between 16 kHz and 48 kHz
- The receiver is required to down-mix if 5.1 audio or another multi-channel transmission if the receiver only has stereo capability

Multiplexing

- The transport stream is constructed in accordance with the MPEG-2 standard
- There is a special emergency alarm signal configuration
- There is support for the MPEG-2 conditional access descrambling system (ECM and EMM)

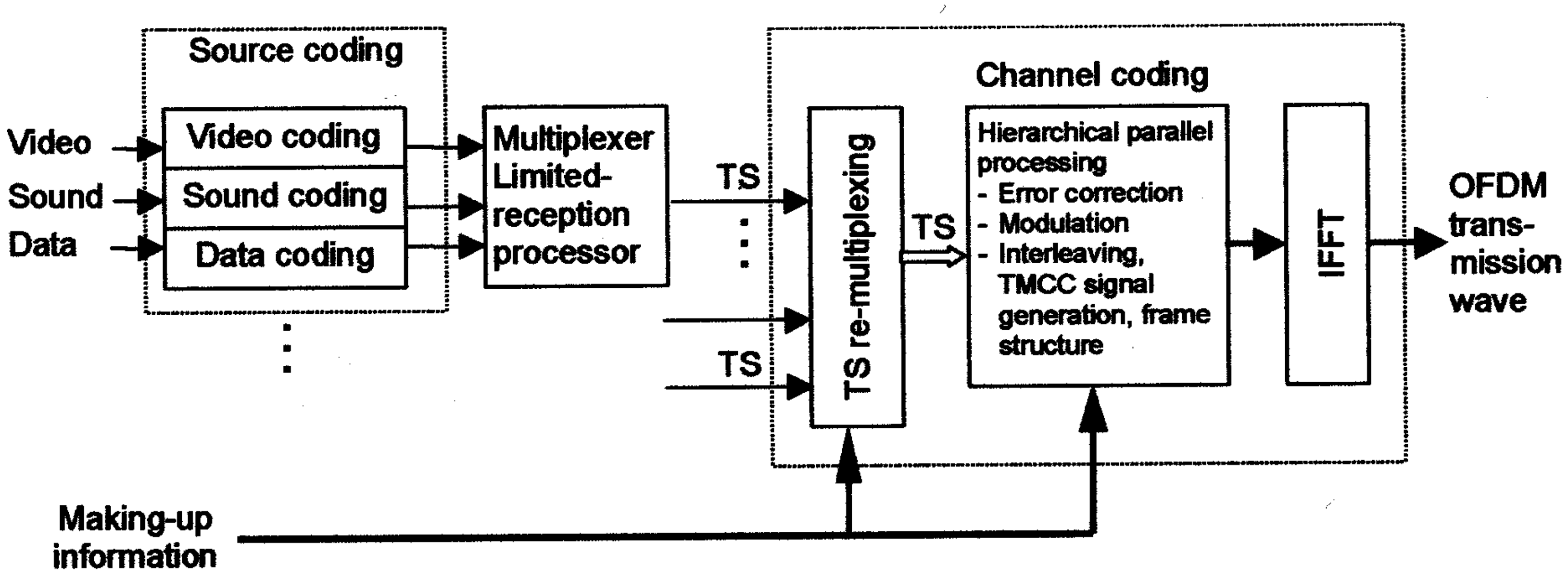
System Information

- This follows the MPEG-2 systems standard
- A Near Video on Demand reference descriptor is designed to transfer information efficiently for services that have the same sequence of events, but timeshifted from each other
- There is a parental rating descriptor that gives the minimum age in years for a service
- There is a digital copy control descriptor that specifies uncontrolled copying, one generation of copying is permitted or copying is forbidden
- A local time offset descriptor supports operation across different timezones

Data support for extra functions

- Electronic Programme Guide
- An index with programme titles and categories
- Subtitles
- Audio commentary for visually impaired
- Programme information (e.g cast, product information or station news)
- Multiple camera angle views
- Participation such as shopping or questionnaires
- Independent information such as news, weather and traffic
- Software and games downloads
- Automatic reception of emergency information
- Bug fix and updates of receiver software

Transmission

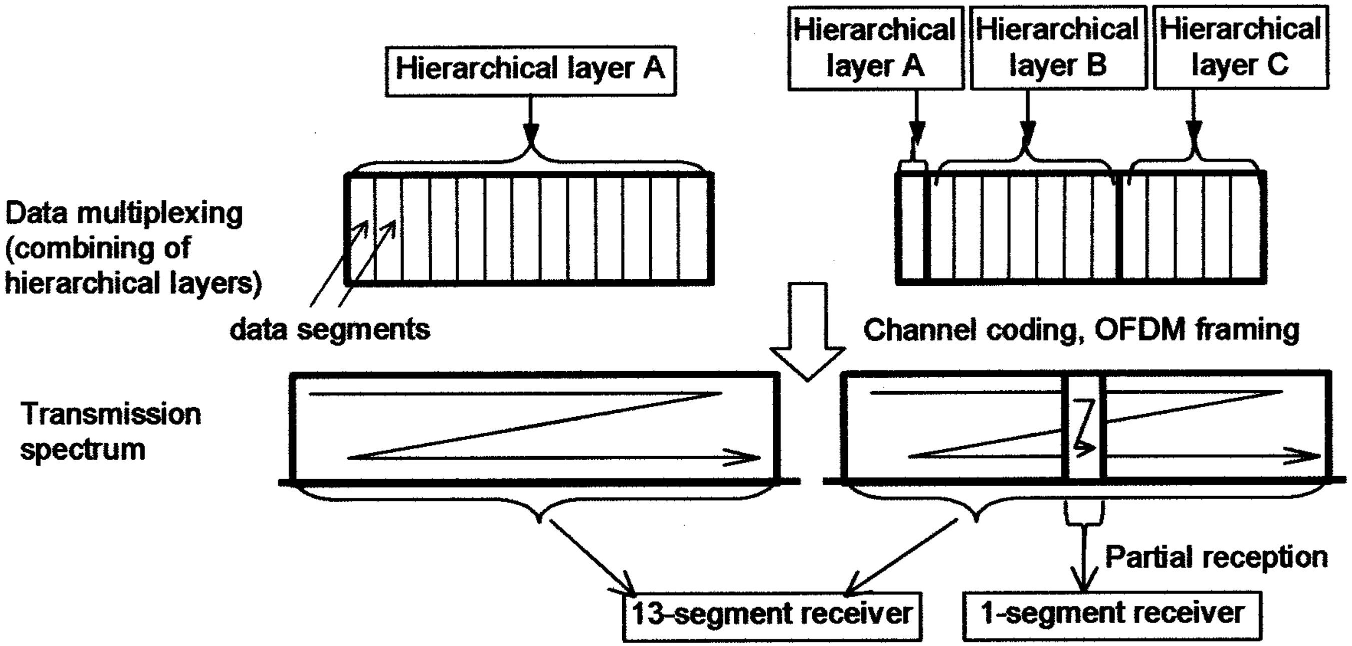


- IFFT = Inverse Fast Fourier Transform
- TMCC = transmission and multiplexing configuration control
- The hierarchical transmission is so that part of the channel can be used for a fixed reception service and part for mobile reception service

Transmission parameters

- Three transmission modes with different frequency spacing between OFDM carriers : 4kHz, 2kHz and 1kHz denoted as modes 1, 2 and 3
- A number of different modulation schemes are supported: QPSK, 16QAM and 64QAM and differential quadrature phase shift keying (DQPSK)

Hierarchical transmission



- Up to 3 layers of hierarchy are possible
- Some receivers will make use of all three layers, but other might only receive one layer
- For example 64QAM may be used for most of the bandwidth, but DQPSK with much stronger error protection for part of the bandwidth to support mobile receivers

Comparison between various standards

	ATSC	DVB-T	ISDB-T	DTMB
Applicable Standard	A.52/A.53	EN 300 744	ARIB STD-B31	GB 20600-2006
System Bandwidth	6 MHz	6, 7, and 8 MHz		
Source Coding	MPEG-2 transport stream			
Transmission Scheme	Single Carrier	Coded OFDM with 2k and 8k FFT size	BST-OFDM with 2k, 4k and 8k FFT size	TDS-OFDM with 3780 FFT size + Single Carrier
Guard Interval	—	1/32, 1/16, 1/8 and 1/4		1/4 (PN945), 1/7 (PN595), 1/9 (PN420)
Channel Coding	Rate 2/3 trellis code + RS(207,187, t = 10)	Punctured convolutional codes with code rate	1/2, 2/3, 3/4, 5/6, 7/8 + RS(204,188, t = 8)	LDPC(7488, 3008/4512/6016) + BCH(762, 752)
Modulation Scheme	8-VSB	QPSK, 16QAM and 64QAM	DQPSK, QPSK,16QAM, and 64QAM	QPSK, 4QAM-NR,16QAM,32QAM and 64QAM
Interleaver	12 to 1 trellis code Interleaver	Bit-wise interleaver+ symbol interleaver	Bit-wise interleaver + time and frequency interleaver	Convolutional interleaver
Data Rate	19.39 Mb/s	4.98–31.67 Mb/s	3.65–23.23 Mb/s	4.81–32.49 Mb/s

Table 1. *Main system parameters of DTTB standards.*

TFT-OFDM: Future technology for transmission

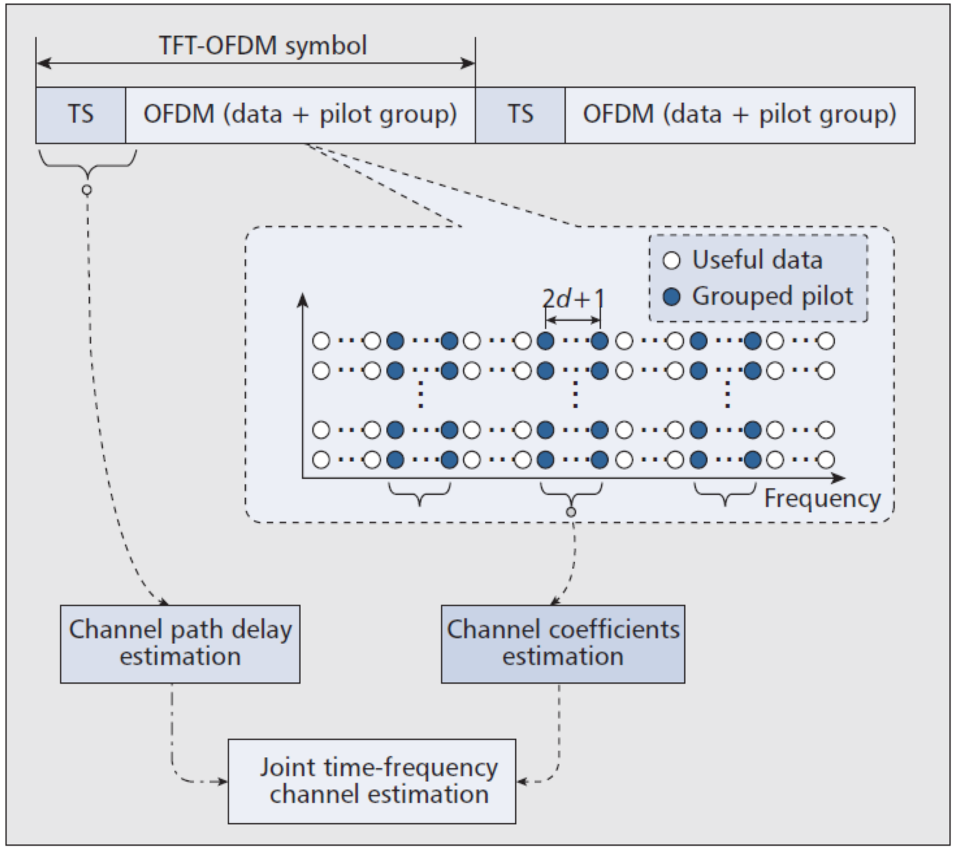


Figure 2. *Signal structure and the corresponding time-frequency joint channel estimation of the TFT-OFDM scheme.*

- Every TFT-OFDM symbol has time-frequency training information composed of the <u>time domain TS</u> and a very small number of <u>frequency-domain grouped pilots</u>.
- With the joint time-frequency channel estimation, the received TS without interference cancellation is directly utilized to merely acquire the path delay information of the channel, while the path coefficients are estimated by the frequency-domain pilots.
- TFT-OFDM could provide the best solution to achieve high spectral efficiency, fast yet reliable synchronization, accurate channel estimation, and improved bit error rate (BER) performance.

DTTB and Wireless Network Convergence

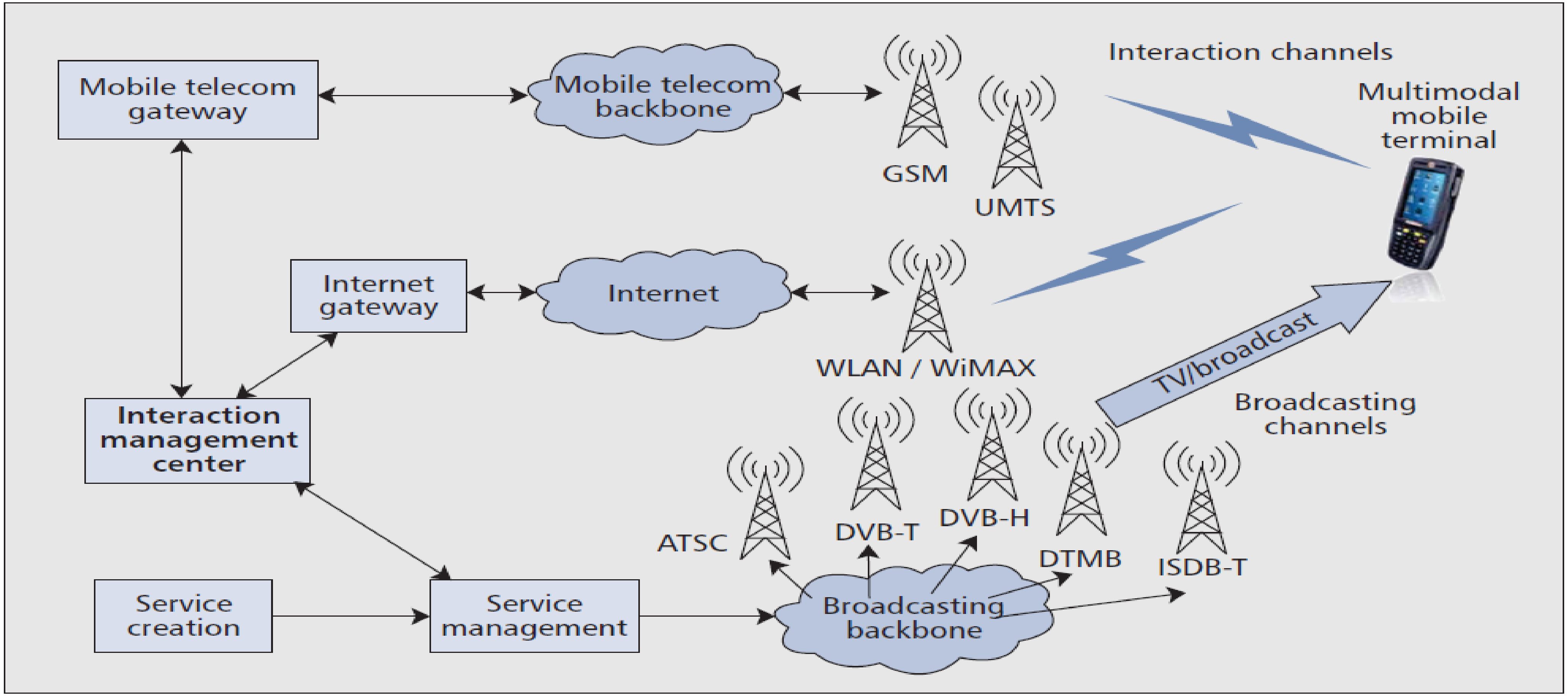


Figure 5. *The convergence between DTTB systems and wireless communications networks in MINT-T project.*