Digital Broadcasting

Agenda

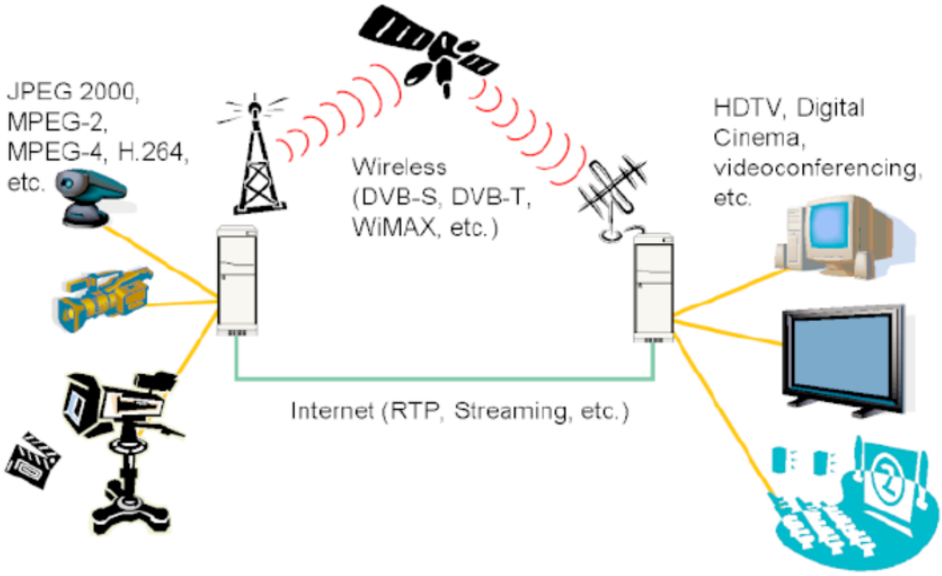
- What is broadcasting?
- Building blocks of a digital broadcasting system
- Major standards for digital broadcasting
- Digital Video Broadcasting - Satellite(DVB-S)

What is Broadcasting?

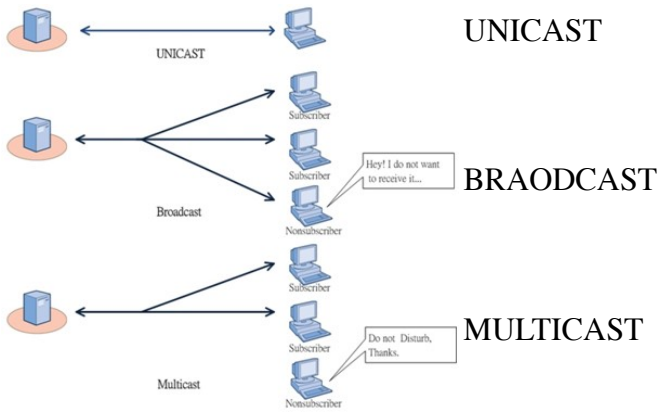
Broadcasting: a methods of transferring a message to all recipients simultaneously
Point-to-multipoint communication

- Simpler transmission scheme than uni-cast
- High transmission power

In principle: one-way communication
In practice: increasingly interactive



Transmission of different types of media/encodings/servers via communication channels for the benefit of various receivers



UNICAST

BRAODCAST

MULTICAST

Why Digital Broadcasting?

- Digital signals are more rugged (robust)
- Better quality: lossless data transmission
- More reliable
- Less expensive
- More flexible
- Time-vs.Frequency-Domain Multiplexing (signals can concurrently transmit over a single Datalink)
- Additional devices requiring digital data
- Commercial reasons: better spectral efficiency, more channels, more services (gaming, shopping, internet), mobile reception, data transmission

Benefits of Digital Switchover

Potential benefits to consumers:

- A greater choice of services
- Extra information on programmes and interactive features
- Easier tuning and new functions
- Less interference to pictures or sound

Potential benefits for the company

- Less cost due to no more need of simultaneous analogue/digital transmission
- Requires less spectrum and so saves huge capital expenditure
- Possibility of diversifying devices, services and applications

Potential benefit to government/regulatory body

- Wider coverage [reducing digital inequality]
- Freeing up spectrum which can be sold/offered for other services
- Better management/regulation

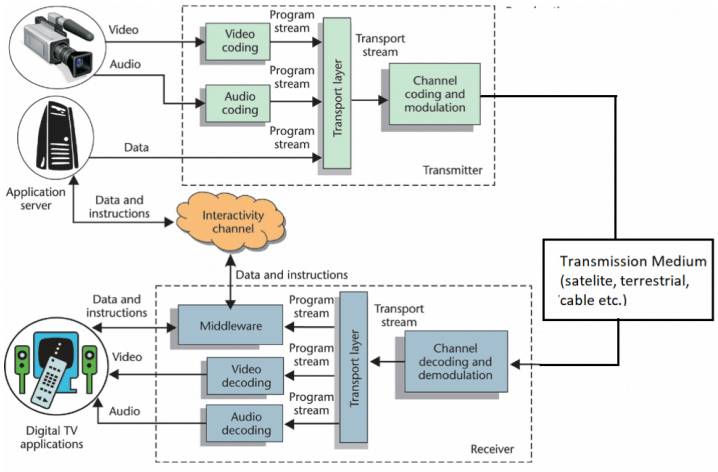
Summary:

Consumers: 1. More services 2.interactive features & more info. Programmes 3. Easier tunning(调整) & new functions 4. Less interference

Company: 1. Less cost 2. Less spectrum 3. Diversifying

Government/regulatory: 1. Wider coverage 2. Freeing up spectrum 3. Better management

Building blocks of a digital broadcasting system



Essential stages :

channel codding: error protection of bits

Modulation: for transmitting signal onto carrier

Other stages:

Source coding: data compression

Multiplexing: combining into single data stream

Signal processing

Involves video/audio and data

Fundamental components of DB

Audio,Visual, and Data

Transmitter:

Compression (source coding): e.g. **MPEG2**

Multiplexing: multiplexing information to single **Transport Stream (TS)**

Channel coding (**Forward error correction**) e.g. Reed-solomon

Modulation: e.g. **OFDM**: Orthogonal Frequency-Divsion Multiplexing

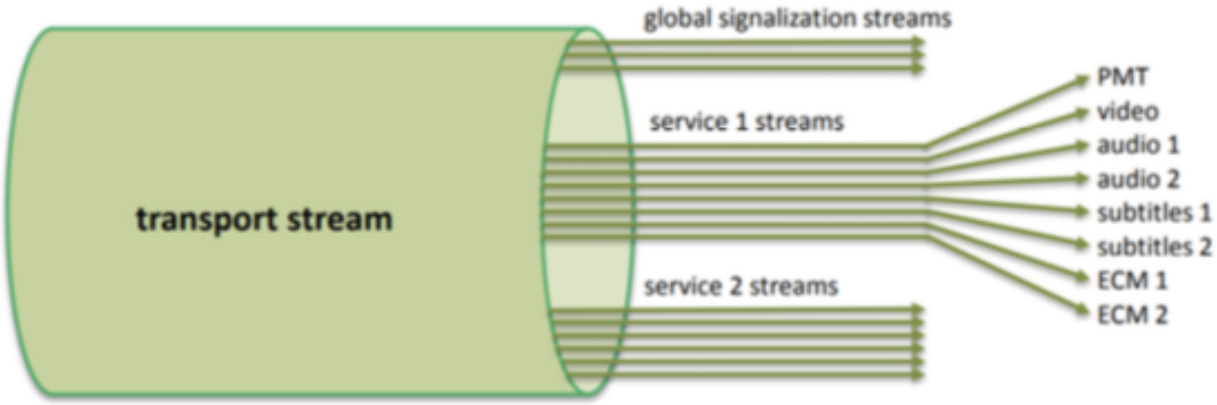
Transmission: (antenna or optical fibre)

Receiver: (Reverse Process)

Transport Stream (TS)

Transport stream: specifies a container format encapsulating packetised Elementary Streams (ES)

- Output of multiplexer
- Combining elementary streams into one single transport stream to the receiver



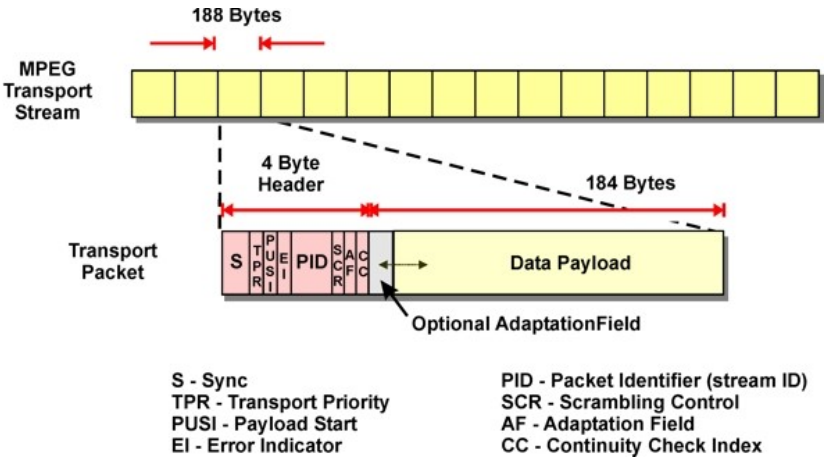
A transport stream is a multiplex of elementary streams

Elementary stream = sequence of TS packets with same PID (packet identifier) value in header

- One set of elementary streams for **global signalization**
- One set of elementary streams per service

E.g. MPEG-TS

- Structure of MPEG-2 TS defined in ISO/IEC 13818-1
- One operator uses several TS
- TS = synchronous stream of 188-byte TS packets
  - 4-byte header
  - optional « adaptation field », a kind of extended header
  - payload, up to 184 bytes
- Multiplex of up to 8192 independent elementary streams (ES)
  - each ES is identified by a Packet Identifier (PID)
  - each TS packet belongs to a PID, 13-bit PID in packet header
  - smooth muxing is complex, demuxing is trivial
- Two types of ES content
  - PES, Packetized Elementary Stream : audio, video, subtitles, teletext
  - sections : data structures



Channel Coding

Channel coding, also known as **forward error control coding (FECC)**, is a process of detecting and correcting bit errors in digital communication systems

Modulation

Digital Modulation uses discrete signals to modulate a carrier wave

The three main types of digital modulation:

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

Major standards for digital broadcasting

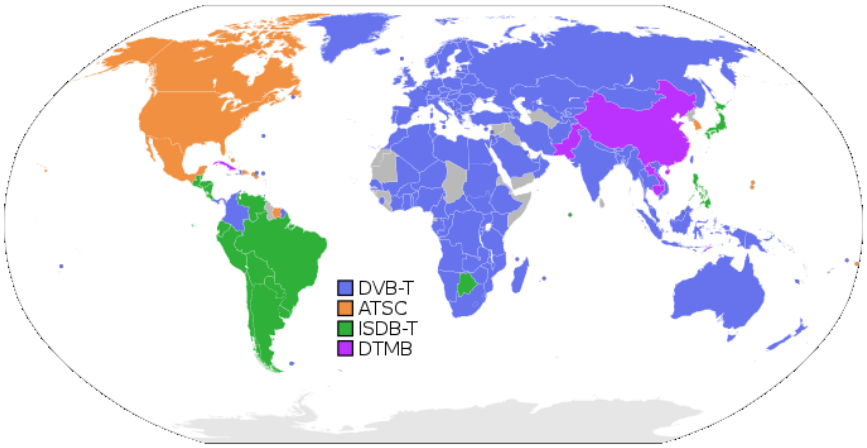
Why do we need standards?

Safety and reliability

Support of government policies and legislation

Interoperability (互用性) : The ability of devices to work together

Major Standards for Digital Brodcasting



- Digital Video Broadcasting (DVB)
- Advanced Televison System Committee (ATSC)
- Integrated Services Digital Broadcasting (ISDB)
- Digital Terrestrial Multimedia Broadcasting (DTMB)

DVB (Digital Video Broadcasting)

Set of standards that defines digital broadcasting using existing satellite, cable, and terrestrial infrastructures

Focus of digital television development

Based on MPEG2 source coding

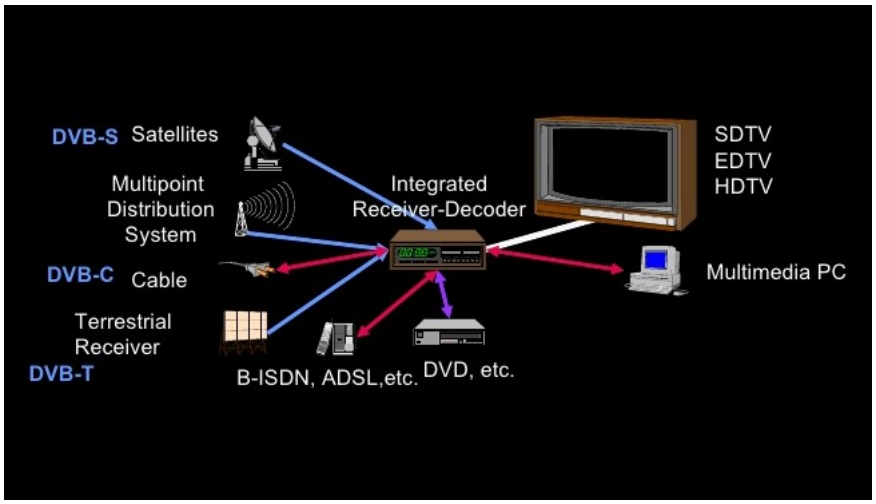
- DVB-S (1993), -C (1994), -T (1995), -SH, ...

DVB family of standards

Every DVB standard defines the **channel coding and modulation**, since every channel has a different set of characteristics

the system input and output signals are all **MPEG-2 Transport Streams**

- DVB-S and DVB-S2 for satellite broadcasting



ATSC (Advanced Television Systems Committee)

ATSC depends on numerous interwoven standards

Original specification for HDTV (**High Definition Television**)

- Uses Dolby, not MPEG for audio

ISDB (Integrated Services Digital Broadcasting)

Covers digital television (DTV) and digital radio

Main differences compared to DVB

– ISDB-S uses 8-PSK (Phase Shift Keying) and Trellis coding instead of QPSK in DVB-S (modulation)

– In ISDB-T, single 6 MHz TV channel can be split into 13 x 432 kHz subchannels for adaptive use

- digital audio (1 subchannel)
- SDTV (multiple subchannels)
- HDTV (all 13 subchannels)

DTMB (Digital Terrestrial Multimedia Broadcast)

CMMB: Chinese Mobile Multimedia Broadcasting

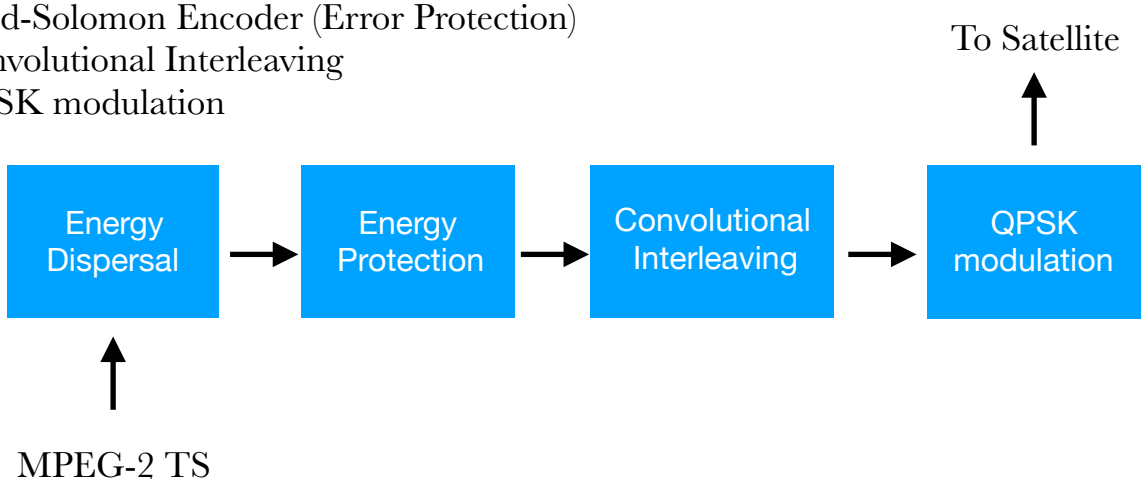
Digital Video Broadcasting - Satellite (DVB-S)

DVB-S: standard for Direct-to-home Broadcasting via Satellite (DBS)

DVB-S Encoding

After the data has been coded following the MPEG-2 standard, it needs to go through the next steps before being transmitted to the satellite:

- Multiplexing and randomisation for energy dispersion
- Reed-Solomon Encoder (Error Protection)
- Convolutional Interleaving
- QPSK modulation



Energy Dispersal

Energy Dispersal is carried out at the encoding end by **scrambling** with a pseudo random sequence

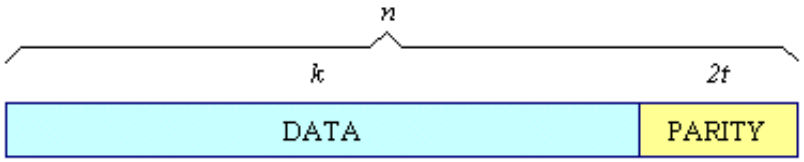
goal: in order to achieve a power-density spectrum of the modulated signal that is as even as possible

Error Protection

Error Protection scheme permitting various code rate

Reed-Solomon coding: RS(204, 188, t=8) is used, where 16 parity bytes are introduced in each transport packet. With this the decoder is able to correct up to 8 error bytes in each packet of 204 received bytes.

- The Reed-Solomon encoder takes a block of digital data and adds extra "redundant" bits



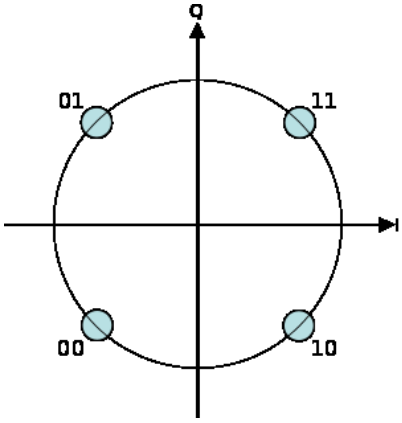
- The encoder takes *k* data symbols of *s* bits each and adds parity symbols to make an *n* symbol codeword.
- A Reed-Solomon decoder can correct up to *t* symbols that contain errors in a codeword, where $2t = n-k$.
- Example: RS(204,188) with 8-bit symbols. Each codeword contains 204 code word bytes, of which 188 bytes are data and 16 bytes are parity. For this code:
  n = 204, k = 188, s = 8, 2t = 16, t = 8
  Errors in up to 8 bytes anywhere in the codeword can be automatically corrected.

Interleaving

Interleaving: In order to avoid errors in consecutive packets, the packets are interleaved

Modulation

QPSK (Quadrature Phase Shift Keying) is used for modulation



With four phases, QPSK can encode two bits per symbol

Data Rate Calculation (example)

Symbol rate : 27.5 MS/s
QPSK offers 2 bits/Symbol

gross_data_rate = 2 bits/symbol X 27.5 Megasymbols/s = 55 Mbit/s

QPSK-modulated signal must first be provided with error protection before being fed into the actual modulator. Reed-Solomon code with rate (204, 188) is used.

net_data_rate Reed-Solomon

= gross_data_rate x 188/204
= 55 Mbit/s x 188/204
= 50.69 Mbit/s;

Further error protection in the form of convolutional coding is inserted after the Reed Solomen forward error correction

Code rate = $\frac{Input\ data\ rate}{Output\ data\ rate}$

In DVB-S, code rate can be selected with the range of : 1/2, 3/4, 2/3, …. 7/8
If the code rate = 3/4

net_data_rate 3/4

= net_data_rate Reed-Solomon x code rate
= 50.69 Mbit/s x 3/4
= 38.01 Mbit/s;

Observation on data rate

Code rate = 1/2: data stream is expanded by a factor of 2, error protection — maximum, net data rate — minimum
Code rate = 7/8: error protection — minimum, net data rate — maximum

The **code rate** can then be used to control the **error protection** and thus, as a **reciprocal** of this, also the **net data rate**

DVB-S2

Improved version of DVB-S standard
Broadcast Services for standard definition TV and HDTV
Improvements in channel coding
Improvements in channel modulation
offers 30% data rate increase under the same condition compared to DVB-S

Question in test

b) This question is about DVB-S.

[10 marks]

i) What compression standard is used for source coding in DVB-S?

(2 marks)

ii) What is the purpose of energy dispersal?

(2 marks)

iii) How does the Reed-Solomon Error Protection scheme work?

(2 marks)

iv) Assuming a symbol rate of 27.5 MS/s, QPSK modulation, Reed-Solomon code with rate (204, 188), and a code rate of ¾ are used, calculate the bit stream net data rate. Show your calculations.

(4 marks)

(1) MPEG-2
(2) To achieve the power-density spectrum of the modulated signal as even as possible
(3) The encoder takes k data symbols of s bits and adds 2t parity symbols to make an n symbol codeword. In this case, the decoder can correct up to t symbols.
(4) gross_data_rate = $27.5 \cdot 2 = 55$ Mbits/s

$$\text{net\_data\_rate} = 55 \cdot \frac{188}{204} = 50.69 \text{ Mbits/s}$$

$$\text{net\_data\_rate\_3/4} = 55 \cdot \frac{188}{204} \cdot \frac{3}{4} = 38.01 \text{ Mbis/s}$$