Digital Radio

Digital Radio Standards

- Several standards for digital radio have been agreed:
  - Digital Audio Broadcasting (DAB):
    - currently most widely used
  - Extended DAB (DAB+):
    - additional codec (AAC), higher compression, more programmes
    - agreed in October 2006; ETSI standard in February 2007
  - Digital Multimedia Broadcasting (DMB):
    - extension of the DAB standard; includes audio and video
  - Digital Radio Mondiale (DRM):
    - European standard for broadcasting since 2001
    - intended for digital short- and medium-wave use
    - based on COFDM, but uses MPEG-4 AAC audio coding
  - Improved DRM (DRM+)

DAB Terminologies

- DAB – Digital Audio Broadcasting
- DMB – Digital Multimedia Broadcasting
- Multiplex / Virtual Sub-Channel / Ensemble
  - Ensemble or multiplex = multiplexed data stream
- Channel – a single audio program with (or without) associated data (e.g., music artist info)
- ETI – Ensemble Transport Interface = TS for DAB
- FIC – Fast Information Channel
- MSC – Main Service Channel: where services are multiplexed
- PDH – Plesichronous Digital Hierarchy
- SDH – Synchronous Digital Hierarchy
- CIF – Common Interleaved Frame

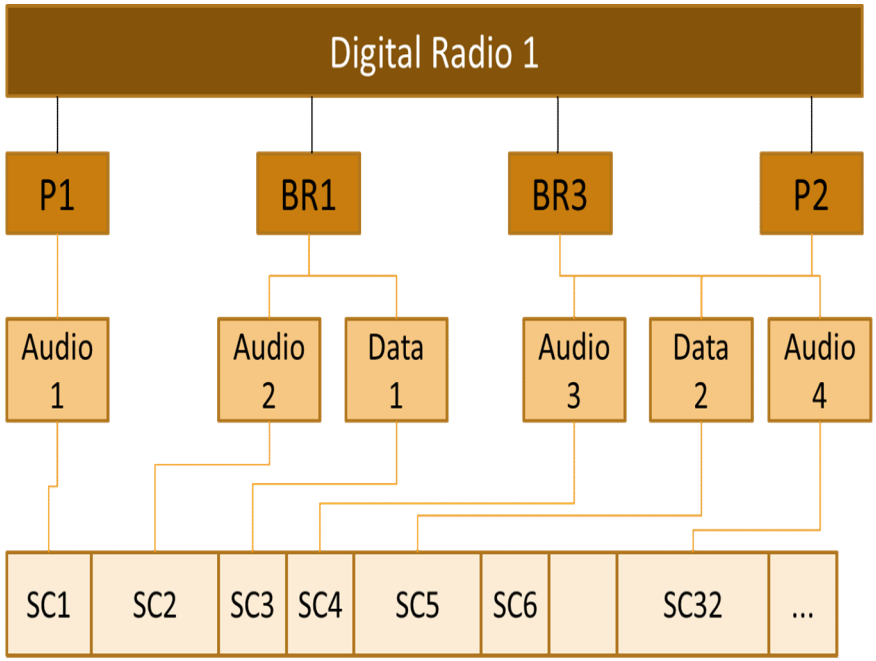
DAB Structure

- Ensemble > Services > Service components
  - i.e., bundle or TS > radio programmes > audio, data
- DAB ensemble is called ETI (Ensemble Transport Interface)
  - It contains all the actual payload data, plus metadata about level of FEC per subchannel
  - = output from DAB mux, input to DAB modulator
  - unprotected stream w.r.t. errors
  - contains info on level of protection for individual subchannels
  - 2.048 Mbps

DAB Structure

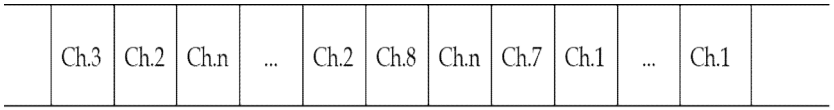
- Each service component is in one subchannel (SC)
  - Max. 64 subchannels per ETI
  - Rate: 8*n* kbps (*n*=1,2, …); synchronous system
  - Each subchannel has its own level of forward error correction (FEC); this level is listed in the ETI
    - FEC is done in DAB modulator, not in DAB mux
    - FEC in DAB = scrambling + convolutional coding + time interleaving

Example of ensemble: “Digital Radio 1”

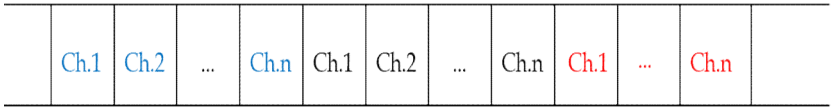


- 4 programmes (called services): P1, BR1, BR3 and P2.
- Each service (program, ‘station’) can be composed of a number of **service components** (audio, data).
- A service component can be e.g. an audio stream or a data stream. E.g. service P1 contains an audio stream. This service is physically transmitted in **subchannel** SC1.
- A subchannel is a section of the data stream dedicated to a specific channel.
- BR1 is composed of an audio stream and a data stream which are broadcast in subchannels SC2 and SC3. Each subchannel has a capacity of n*8 kbits/s (n depends on number of service components in particular subschannel).
- Service components can be shared with a number of services, as in the Data 2 example.
- All subchannels together – up to a maximum of 64 - result in the **Common Interleaved Frame (CIF)**.
- Note: SC means subchannel, not service component; Audio2 is a service component

DAB vs. DVB: Synchronicity



Asynchronous transfer mode (DVB)



Synchronous transfer mode (DAB)

- DAB is a completely synchronous system, a completely synchronous data stream being produced in the playout centre
- The data rates of the individual contents are constant (variable for asynchronous) and are always a multiple of 8 kbits; zero padding when not in use
- The time slots in which the contents from the individual sources are transmitted are permanently allocated (no fixed allocation for asynchronous)and vary only when there is a complete change in the virtual sub-channel.

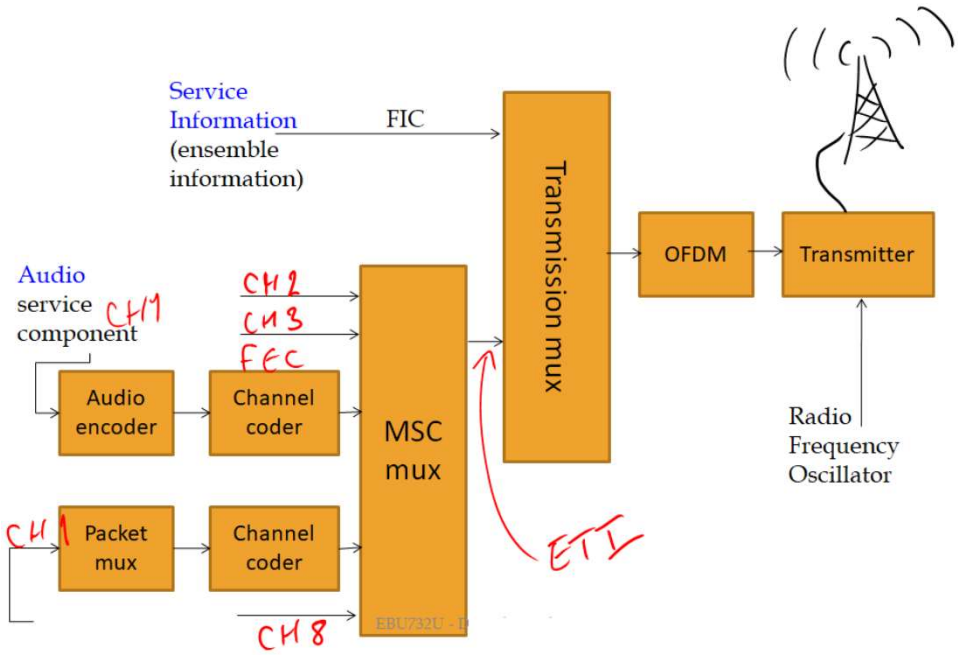
DAB Modes

- 4 different selectable modes in DAB
  - Mode I is used in the VHF band (Band III)
  - Mode II, III and IV are used in the L-band (for local programmes)
- Number of subcarriers (OFDM) is between 192 and 1536, depending on selected mode
  - Difference between modes is the symbol length and the number of subcarriers used
- DAB signal bandwidth is always 1.536 MHz

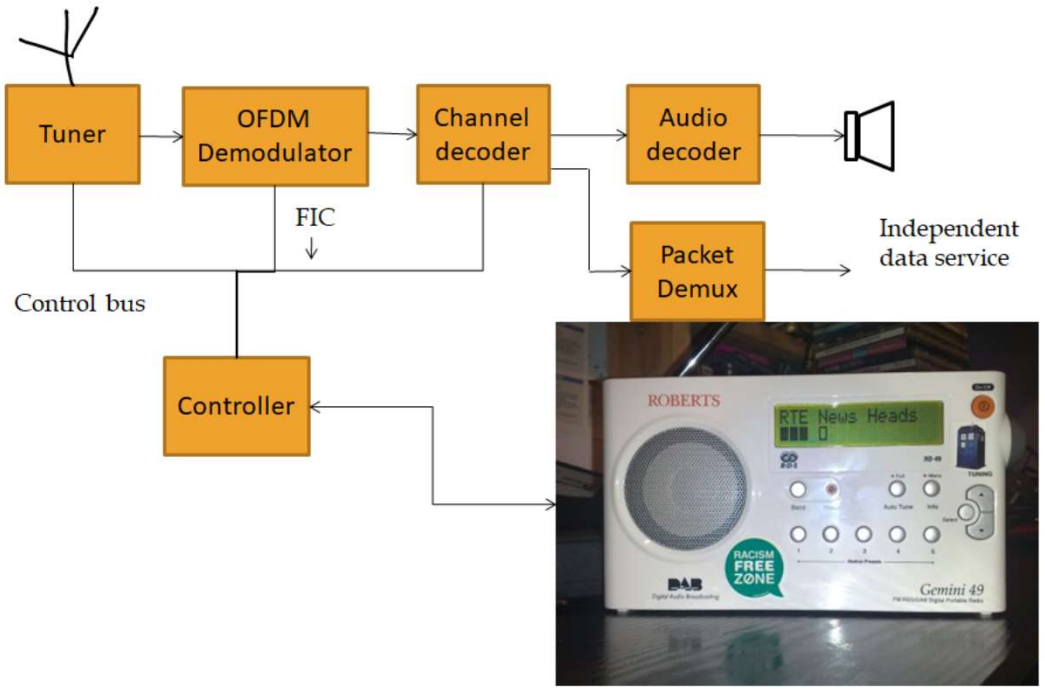
Mode	Frequency range (kHz)	Subcarrier spacing (MHz)	No. of COFDM carriers	Symbol duration (μs)	Guard Interval (μs)
I	Band III VHF	1	1536	1000	246
II	L band (< 1.5 GHz)	4	384	250	62
III	L band (> 1.5 GHz)	8	192	125	31
IV	L band (< 1.5 GHz)	2	768	500	123

DAB Signal Generation and Transmission

- Signals are individually coded at source level, error protected and time interleaved in the channel coder for each individual service
- The services are multiplexed together in the Main Service Channel (MSC)
- Multiplexer output is combined with Multiplex Control and Service Information, which travel in the Fast Information Channel (FIC), to form the transmission frames in the Transmission MUX
- COFDM is applied; the signal is modulated (shifted to the appropriate radio carrier frequency), amplified and transmitted



DAB Receiver

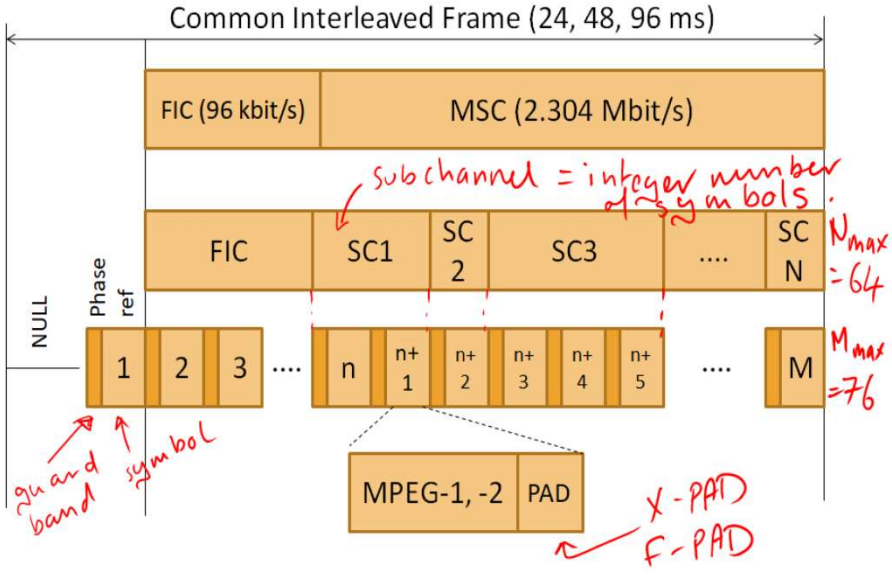


DAB Frames

- The frame-based DAB ensemble comprises three distinct elements:
  - **Synchronisation Channel**: conveys *reference* frequency and timing information, to allow receivers to synchronise to and decode the received DAB signals
  - **Fast Information Channel** (FIC): carries information describing the *composition* of the ensemble; informs receivers how to extract and decode the information for individual services
  - **Main Service Channel** (MSC): contains the *audio frames or data packets* corresponding to the different services within the ensemble (service = 1 complete radio programme)

DAB Frame Structure

- Symbol 0 is the NULL symbol.
- The RF carrier is off.
- Starts the DAB frame and is used to detect the start of each frame.
- Next is the time-frequency phase reference symbol, used for frequency and phase synchronisation. It does not contain any data.
- The actual data transmission starts with the second symbol.
- The length of the FIC is dependent on the DAB mode.



Additional Features

Program Associated Data (PAD)

- Embedded in the audio bit-stream
- F-PAD – Fixed-Length Program Associated Data
  - Identifier for music/voice
  - Identifier for type of service (jazz, rock, news)
  - Program related text (song title, channel name)
- X-PAD – Extended PAD (dynamic length)
  - Supplementary program data
  - E-mail addresses, competition questions, URLs, phone numbers etc.

Independent Data Services (IDS)

- Additional to PAD, General data transmitted as separate service, e.g.:
  - Continuous stream segmented in 24ms logical frames
  - Packet mode carry Independent Data Services is as a part of the FIC
  - Typical examples of IDS: Traffic Message Channel, correction data for Differential GPS, paging, electronic newspaper, RDS, etc.

Additional Features

- Conditional Access (CA):
  - applicable to each individual service or packet
  - ensemble transports CA information and provides the actual signal scrambling mechanisms

- Service Information (SI):
  - for operation and control of receivers
  - to provide information for program selection to the user
  - also establishes links between different services in the ensemble, links to services in other DAB ensembles, and even links to FM/AM broadcasts

DAB and Codecs, DAB+

- MPEG layer 2 (MP2) codec as used in original DAB specification has been overtaken by more recent developments
- Before 2002, the BBC used 192 kbit/s on music channels. Now, they use the lower 128 kbit/s, except for Radio 3 (classical).
- DAB+: in 2006, the DAB standards body recommended that AAC was included as an alternative codec within DAB
  - Subjective tests show the same quality rating for AAC at 96 kbit/s as for MP2 at 192 kbit/s
  - Changing to AAC will be difficult in markets where MP2 is already in widespread use

Digital Radio Mondiale: DRM

- Aim: to design a digital broadcasting system suitable for all the AM broadcasting bands worldwide
- DRM is an open and non-proprietary system, allowing any manufacturer to design and manufacture equipment on an equitable basis
- Most regions of the world have access to at least basic AM radio services
- AM bands still provide an attractive and cost-effective way for the broadcaster to reach a large audience
- Broadcasters have made large investments in AM transmission equipment, which in many cases has many years of useful life remaining
  - The antennas and transmitters used for high powered AM services represent a significant investment, for which the possibility of modification to allow digital transmission presents an attractive proposition

Why Continue with AM?

- The AM broadcasting bands have unique propagation advantages not available in other parts of the spectrum:
  - In the **long-wave (LW)** band wide area coverage can be achieved from a single transmitter with very stable and reliable propagation characteristics
  - In the **medium-wave (MW)** band both local regional and international coverage can be obtained depending on the transmitter power and time of day (~ ionospheric F-layer)
  - The **short-wave (SW) bands** provide very wide area coverage at large distances from the transmitter
- Small low cost portable or mobile receivers can be used
- The transmission technology required to deliver these services is well established, reliable and has a long lifetime
- Transmitters are terrestrially based, hence easy to repair

DRM Broadcast & DRM+

- There is regular DRM broadcasting on the SW band by about 30 broadcasters in at least 14 languages
- Deutsche Welle and BBC World Service both broadcast 24 hours per day on DRM
  - Starting a joint venture to use DRM to broadcast to Europe using short wave.
- More than 100 regular broadcasting services worldwide use DRM
- DRM+
  - Addition to DRM standard for VHF
  - ETSI/ITU standardization in 2009
  - OFDM is used for single frequency networks

Other Audio Broadcasting Standards

- US Digital Radio
  - There is now a single subscription satellite radio system in the US called *Sirius XM Radio*. This is particularly aimed at in-car reception
  - 1800 HD radio stations in the US covering 85% of the US population
  - The system was adopted by the Federal Communications Commission (FCC)
- Japanese Digital Audio system
  - Japan uses a standard called Integrated Services Digital Broadcasting (ISDB) that covers both audio and TV broadcasting. The audio version is ISDB-Tsb.

DAB in China

- The Chinese regulator, SARFT, announced in May 2006 that DAB was chosen for the industrial standard.
- This means that to date DAB is the only European digital broadcasting standard that has been approved for commercial use in China.
- DMB on air in five cities across the country including: Beijing, Shanghai, Guangzhou, Dalian and Henan.
- Guangzhou launched commercial services in 2007