Chapter 7

Broadcast Systems

Introduction

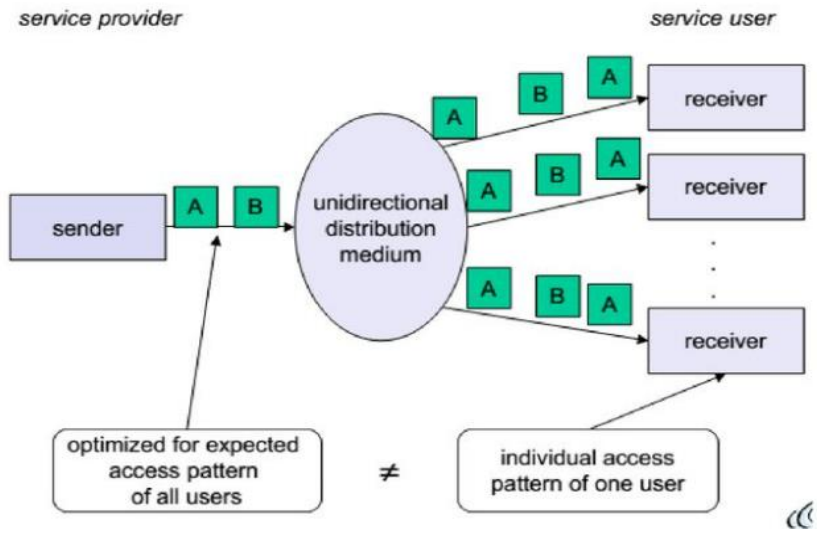
Broadcast can be defined as the delivery of a transmission to two or more stations at the same time, such as over a bus-type local network or by satellite. Examples are Analog audio radio (FM, AM) vs. Digital audio radio (HD Radio-HDR, Digital Audio Broadcasting (DAB), Satellite radio and Digital Radio Mondiale (DRM), Analog television vs Digital television, Wireless telephone networks etc.

Broadcasting license is necessary for transmission of radio or television programs from a radio or television station to home receivers by radio waves Over the Air (OTA).

- **Unidirectional** distribution systems or **broadcast** systems are an extreme version of **asymmetric** communication systems.
- Quite often, **bandwidth** limitations, differences in **transmission power**, or **cost** factors **prevent** a communication system from being **symmetrical**.
- Symmetrical communication systems offer the **same** transmission **capabilities** in **both** communication directions, i.e., the channel characteristics from A to B are the same as from B to A.
- This symmetry is necessary for a telephone service, but many other applications do not require the same characteristics for both directions of information transfer.

- Consider a typical **client/server** environment.
  - Typically, the client needs much more data from the server than the server needs from the client.
  - Today's most prominent example of this is the **world wide web**.
- A **television** with a set-top box represents a more extreme scenario.
  - While a high-resolution video stream requires several Mbit/s, a typical user returns some bytes from time to time to switch between channels or return some information for TV shopping.
- Finally, today's **pagers** and **radios** work completely one-way.
  - These devices can only receive information, and a user needs additional communication technology to send any information back to, e.g., the radio station.

- A special case of asymmetrical communication systems are unidirectional broadcast systems where typically a **high bandwidth** data stream exists from one sender to many receivers.
- Figure shows a simple broadcast scenario.



- The problem arising from this is that the sender can only **optimize** transmitted **data** for the **whole** group of **receivers** and not for an individual user.
- A sender tries to optimize the transmitted packet stream for the access patterns of all receivers without knowing their exact requirements.
- All packets are then transmitted via a broadcast to all receivers.
- Each receiver now picks up the packets needed and drops the others or stores them for future use respectively.
- These additional functions are needed to personalize distributed data depending on individual requirements and applications.
- A very simple example of this process could be a user-defined **filter function** that filters out all information which is not of interest to the user.

Cyclical repetition of data

- A broadcast sender of data does not know when a receiver starts to listen to the transmission.
- While for radio or television this is no problem, transmission of other important information, such as traffic or weather conditions, has to be repeated to give receivers a chance to receive this information after having listened for a certain amount of time.
- The **cyclical repetition** of data blocks sent via broadcast is often called a **broadcast disk** according to the DAB/DVB standards.
- Different patterns are possible.

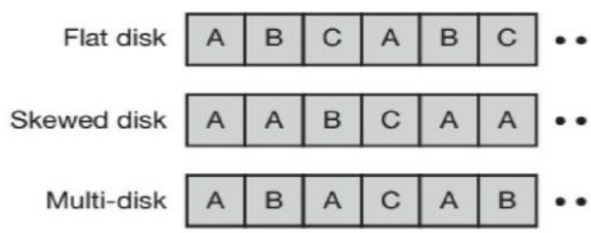


Figure 6.2
Different broadcast patterns

- The sender repeats the three data blocks A, B, and C in a cycle.
- Using a **flat disk**, all blocks are repeated one after another.
- Every block is transmitted for an **equal amount of time**, the average waiting time for receiving a block is the same for A, B, and C.
- **Skewed disks** favor one or more data blocks by repeating them once or several times.
- This raises the probability of receiving a repeated block (here A) if the block was corrupted the first time.
- Finally, **multi-disks** distribute blocks that are repeated more often than others evenly over the cyclic pattern.
- This minimizes the delay if a user wants to access, e.g., block A.
- It is only possible to optimize these patterns if the sender knows something about the content of the data blocks and the access patterns of all users.

Digital audio broadcasting

- Today's analog radio system still follows the basic principle of frequency modulation invented back in 1933.
- In addition to audio transmission, very limited information such as the **station identification** can accompany the program.
- Transmission **quality** varies greatly depending on **multi-path** effects and **interference**.
- The fully digital DAB system does not only offer sound in a CD-like quality, it is also practically immune to interference and multi-path propagation effects.
- DAB systems can use **single frequency networks** (SFN), i.e., all senders transmitting the same radio program operate at the same frequency.

- Today, different senders have to use different frequencies to avoid interference although they are transmitting the same radio program.
- Using an SFN is very frequency efficient, as a single radio station only needs one frequency throughout the whole country.
- Additionally, DAB **transmission power** per antenna is orders of magnitude lower compared to traditional FM stations.
- DAB uses **VHF** and **UHF** frequency bands, e.g., the terrestrial TV channels 5 to 12 (174–230 MHz) or the L-band (1452–1492 MHz).
- The modulation scheme used is **DQPSK**.
- DAB is one of the systems using **COFDM** with 192 to 1536 carriers (the so-called ensemble) within a DAB channel of 1.5 MHz.

- Additionally, DAB uses **FEC** to reduce the error rate and introduces **guard spaces** between single symbols during transmission.
- COFDM and the use of guard spaces reduce ISI to a minimum.
- DAB can even benefit from multipath propagation by recombining the signals from different paths.
- Within every frequency block of 1.5 MHz, DAB can transmit up to **six stereo audio** programs with a data rate of 192 kbit/s each.
- Depending on the redundancy coding, a data service with rates up to 1.5 Mbit/s is available as an alternative.
- For the DAB transmission system, audio is just another type of data.

- DAB uses two basic **transport mechanisms**:
- **Main service channel** (MSC):
  - The MSC carries all **user data**, e.g. audio, multimedia data.
  - The MSC consists of **common interleaved frames** (CIF), i.e., data fields of 55,296 bits that are sent every 24 ms.
  - This results in a data rate of 2.304 Mbit/s.
  - A CIF consists of **capacity units** (CU) with a size of 64 bits, which form the smallest addressable unit within a DAB system.
- **Fast information channel** (FIC):
  - The FIC contains **fast information blocks** (FIB) with 256 bits each (16 bit checksum).
  - An FIC carries all **control information** which is required for interpreting the configuration and content of the MSC.

- Figure gives a simplified overview of a DAB sender.

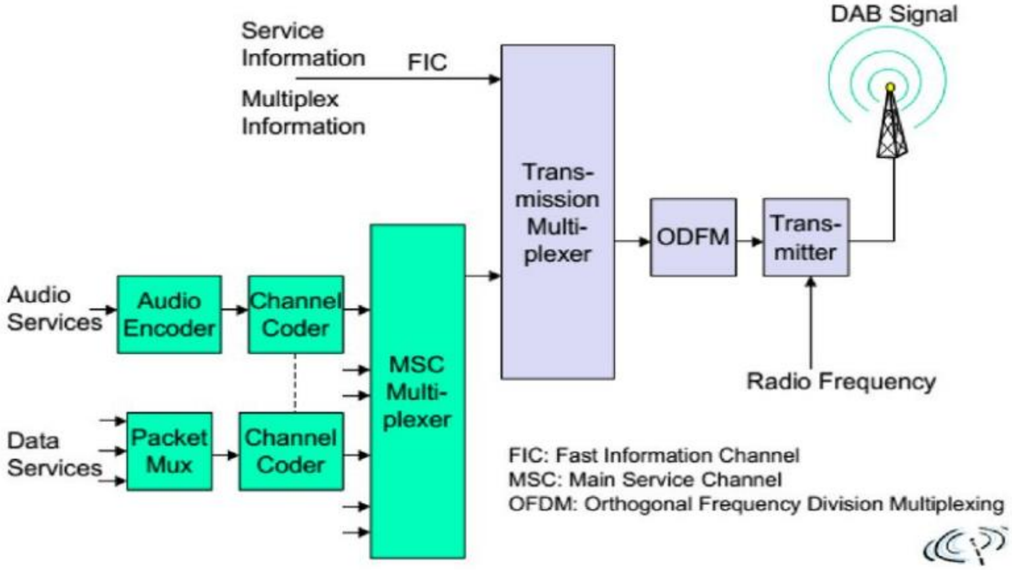
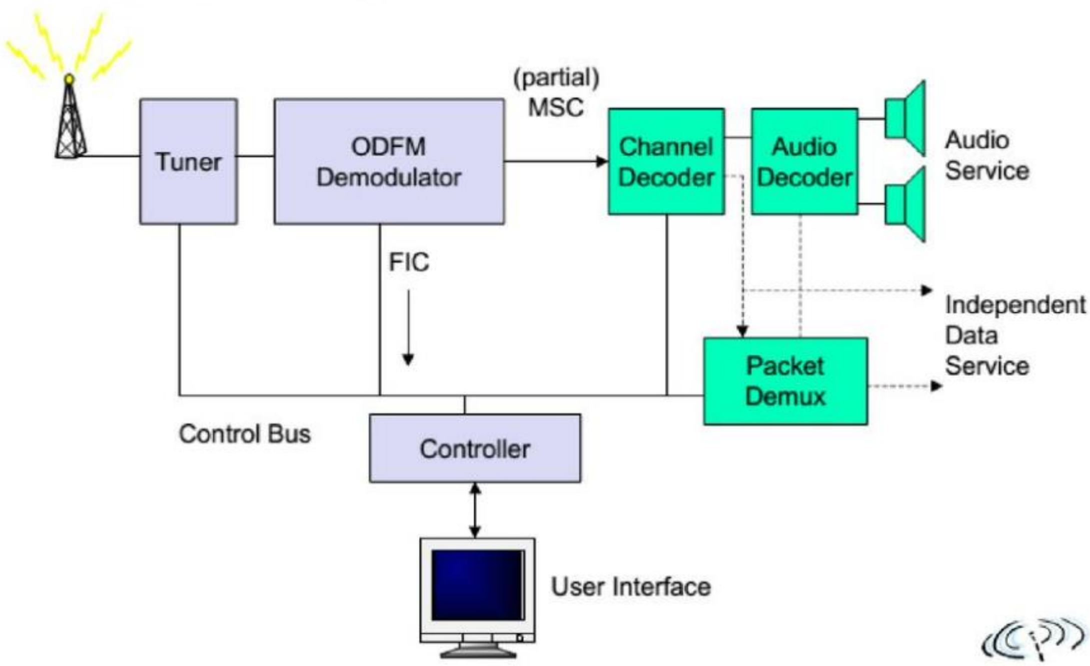


Figure gives a simplified overview of a DAB receiver.



Digital video broadcasting

- The logical consequence of applying digital technology to radio broadcasting is doing the same for the traditional television system.
- The analog system used today has basically remained unchanged for decades.
- The only invention worth mentioning was the introduction of color TV for the mass market back in the 1960s.
- Television still uses the low resolution of 625 lines for the European PAL system or only 525 lines for the US NTSC respectively.
- The display is interlaced with 25 or 30 frames per second respectively.
- So, compared with today's computer displays with resolutions of 1,280 $\times$1,024 and more than 75 Hz frame rate, non-interlaced, TV performance is not very impressive.

- After some national failures in introducing digital TV, the so-called **European Launching Group** was founded in **1991** with the aim of developing a common digital television system for Europe.
- In **1993** these common efforts were named digital video broadcasting (DVB).
- The goal of DVB is to introduce digital television broadcasting using
  - **satellite** transmission (DVB-S, (ETSI, 1997)),
  - **cable** technology (DVB-C, (ETSI, 1998)), and also
  - **terrestrial** transmission (DVB-T, (ETSI, 2001b)).

- Figure 6.7 shows components that should be integrated into the DVB architecture.

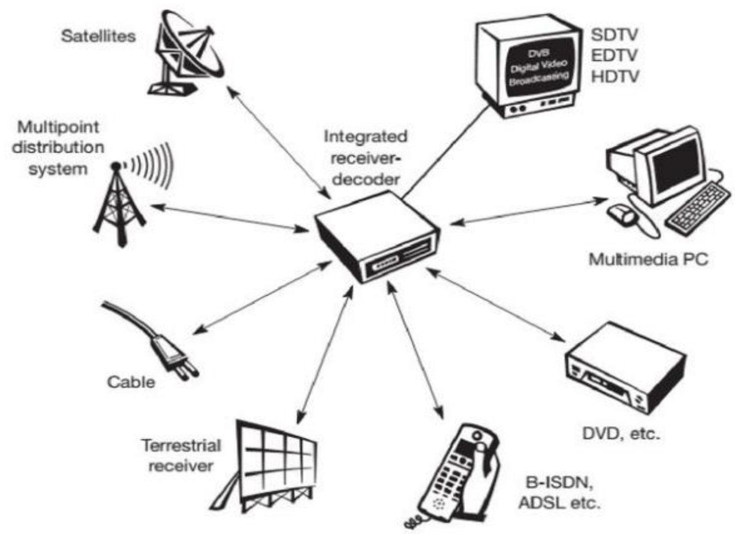


Figure 6.7
Digital video broadcasting scenario

- The center point is an **integrated receiver-decoder** (set-top box) connected to a high-resolution monitor.
- This set-top box can receive DVB signals via satellites, terrestrial local/regional senders (multi-point distribution systems, terrestrial receiver), cable, B-ISDN, ADSL, or other possible future technologies.
- Cable, ADSL, and B-ISDN connections also offer a **return channel**, i.e., a user can send data such as channel selection, authentication information, or a shopping list.
- Audio/video streams can be recorded, processed, and replayed using digital versatile disk (DVD) or multimedia PCs.

- Different levels of quality are envisaged:
  - **standard definition** TV (SDTV),
  - **enhanced definition** TV (EDTV), and
  - **high definition** TV (HDTV) with a resolution of up to 1,920 × 1,080 pixels.
- Similar to DAB, DVB also transmits data using flexible **containers**.
- These containers are basically **MPEG-2 frames** that do not restrict the type of information.
- DVB sends service information contained in its data stream, which specifies the content of a container.

DVB for high-speed Internet access

- Apart from this data/multi-media broadcasting, DVB can be also used for **high band width, asymmetrical Internet access**.
- An information provider, e.g., video store, offers its data to potential customers with the help of a service provider.
- If a customer wants to download high-volume information, the information provider transmits this information to a satellite provider via a service provider.
- The satellite provider now multiplexes this data stream together with other digital TV channels and transmits it to the customer via satellite and a satellite receiver.

Figure 6.10
Mobile Internet services using IP over GSM/GPRS or UMTS as interaction channel for DAB or DVB