Mobile Communications
Chapter 6: Broadcast Systems

- Unidirectional distribution systems
- DAB
  - architecture
- DVB
  - Container
  - High-speed Internet
Unidirectional distribution systems

Asymmetric communication environments

- bandwidth limitations of the transmission medium
- depends on applications, type of information
- examples
  - wireless networks with base station and mobile terminals
  - client-server environments (diskless terminal)
  - cable TV with set-top box
  - information services (pager, SMS)

Special case: unidirectional distribution systems

- high bandwidth from server to client (downstream), but no bandwidth vice versa (upstream)
- problems of unidirectional broadcast systems
  - a sender can optimize transmitted information only for one group of users/terminals
  - functions needed to individualize personal requirements/applications
Unidirectional distribution

- **Service Provider**: Sender
- **Service User**: Receiver

- Optimized for expected access pattern of all users
- Individual access pattern of one user

A → B → A

A → B → A

A → B → A

A → B → A

A → B → A

A → B → A

A → B → A
Structuring transmissions - broadcast disks

Sender

- cyclic repetition of data blocks
- different patterns possible (optimization possible only if the content is known)

<table>
<thead>
<tr>
<th>flat disk</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>skewed disk</th>
<th>A</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>A</th>
<th>A</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>multi-disk</th>
<th>A</th>
<th>B</th>
<th>A</th>
<th>C</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
</table>

Receiver

- use of caching
  - cost-based strategy: what are the costs for a user (waiting time) if a data block has been requested but is currently not cached
  - application and cache have to know content of data blocks and access patterns of user to optimize
DAB: Digital Audio Broadcasting

- Media access
  - COFDM (Coded Orthogonal Frequency Division Multiplex)
  - SFN (Single Frequency Network)
  - 192 to 1536 subcarriers within a 1.5 MHz frequency band

- Frequencies
  - First phase: one out of 32 frequency blocks for terrestrial TV channels 5 to 12 (174 - 230 MHz, 5A - 12D)
  - Second phase: one out of 9 frequency blocks in the L-band (1452-1467.5 MHz, LA - LI)

- Sending power: 6.1 kW (VHF, Ø 120 km) or 4 kW (L-band, Ø 30 km)

- Date-rates: 2.304 Mbit/s (net 1.2 to 1.536 Mbit/s)

- Modulation: Differential 4-phase modulation (D-QPSK)

- Audio channels per frequency block: typ. 6, max. 192 kbit/s

- Digital services: 0.6 - 16 kbit/s (PAD), 24 kbit/s (NPAD)
DAB transport mechanisms

**MSC (Main Service Channel)**
- carries all user data (audio, multimedia, ...)
- consists of CIF (Common Interleaved Frames)
- each CIF 55296 bit, every 24 ms (depends on transmission mode)
- CIF contains CU (Capacity Units), 64 bit each

**FIC (Fast Information Channel)**
- carries control information
- consists of FIB (Fast Information Block)
- each FIB 256 bit (incl. 16 bit checksum)
- defines configuration and content of MSC

**Stream mode**
- transparent data transmission with a fixed bit rate

**Packet mode**
- transfer addressable packets
Transmission frame

- **null symbol**
- **phase reference symbol**
- **data symbol**
- **data symbol**
- **data symbol**

- **synchronization channel** (SC)
- **fast information channel** (FIC)
- **main service channel** (MSC)

- Frame duration $T_F$
- Guard interval $T_d$

Symbols: $L$, $0$, $1$, $T_u$
DAB sender

Audio Services
- Audio Encoder
- Channel Coder
- MSC Multiplexer
- ODFM
- Transmitter
- Radio Frequency

Data Services
- Packet Mux
- Channel Coder

Service Information
- FIC: Fast Information Channel
- MSC: Main Service Channel
- OFDM: Orthogonal Frequency Division Multiplexing
DAB receiver

- Tuner
- ODFM Demodulator
- Channel Decoder
- Audio Decoder
- Packet Demux
- Controller
- Control Bus
- User Interface
- Audio Service
- Independent Data Service
- (partial) MSC
- FIC

Prof. Dr.-Ing. Jochen Schiller, http://www.jochenschiller.de/  MC SS02 6.9
Audio coding

- **Goal**
  - audio transmission almost with CD quality
  - robust against multipath propagation
  - minimal distortion of audio signals during signal fading

- **Mechanisms**
  - fully digital audio signals (PCM, 16 Bit, 48 kHz, stereo)
  - MPEG compression of audio signals, compression ratio 1:10
  - redundancy bits for error detection and correction
  - burst errors typical for radio transmissions, therefore signal interleaving - receivers can now correct single bit errors resulting from interference
  - low symbol-rate, many symbols
    - transmission of digital data using long symbol sequences, separated by guard spaces
    - delayed symbols, e.g., reflection, still remain within the guard space
Bit rate management

- A DAB ensemble combines audio programs and data services with different requirements for transmission quality and bit rates.
- The standard allows dynamic reconfiguration of the DAB multiplexing scheme (i.e., during transmission).
- Data rates can be variable, DAB can use free capacities for other services.
- The multiplexer performs this kind of bit rate management, therefore, additional services can come from different providers.
### Example of a reconfiguration

<table>
<thead>
<tr>
<th>DAB - Multiplex</th>
<th>DAB - Multiplex - reconfigured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio 1 192 kbit/s</td>
<td>Audio 1 192 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 2 192 kbit/s</td>
<td>Audio 2 128 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 3 192 kbit/s</td>
<td>Audio 3 192 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 4 160 kbit/s</td>
<td>Audio 4 160 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 5 160 kbit/s</td>
<td>Audio 5 160 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 6 128 kbit/s</td>
<td>Audio 7 96 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 7 96 kbit/s</td>
<td>Audio 8 96 kbit/s</td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
<tr>
<td>Audio 8 96 kbit/s</td>
<td></td>
</tr>
<tr>
<td>PAD</td>
<td>PAD</td>
</tr>
</tbody>
</table>

D1 D2 D3 D4 D5 D6 D7 D8 D9

D10 D11

D1 D2 D3 D4 D5 D6 D7 D8 D9
Multimedia Object Transfer Protocol (MOT)

Problem

- broad range of receiver capabilities
  audio-only devices with single/multiple line text display, additional color graphic display, PC adapters etc.
- different types of receivers should at least be able to recognize all kinds of program associated and program independent data and process some of it

Solution

- common standard for data transmission: MOT
- important for MOT is the support of data formats used in other multimedia systems (e.g., online services, Internet, CD-ROM)
- DAB can therefore transmit HTML documents from the WWW with very little additional effort
MOT structure

MOT formats
- MHEG, Java, JPEG, ASCII, MPEG, HTML, HTTP, BMP, GIF, ...

Header core
- size of header and body, content type

Header extension
- handling information, e.g., repetition distance, segmentation, priority
- information supports caching mechanisms

Body
- arbitrary data

7 byte

| header core | header extension | body |

DAB allows for many repetition schemes
- objects, segments, headers
Digital Video Broadcasting

- 1991 foundation of the ELG (European Launching Group)
  goal: development of digital television in Europe
- 1993 renaming into DVB (Digital Video Broadcasting)
  goal: introduction of digital television based on
  - satellite transmission
  - cable network technology
  - later also terrestrial transmission
DVB Container

DVB transmits MPEG-2 container

- high flexibility for the transmission of digital data
- no restrictions regarding the type of information
- DVB Service Information specifies the content of a container
  - NIT (Network Information Table): lists the services of a provider, contains additional information for set-top boxes
  - SDT (Service Description Table): list of names and parameters for each service within a MPEG multiplex channel
  - EIT (Event Information Table): status information about the current transmission, additional information for set-top boxes
  - TDT (Time and Date Table): Update information for set-top boxes

![Diagram of MPEG-2/DVB container with HDTV, SDTV, and multimedia data broadcasting examples]
Example: high-speed Internet access

Asymmetric data exchange

- downlink: DVB receiver, data rate per user 6-38 Mbit/s
- return channel from user to service provider: e.g., modem with 33 kbit/s, ISDN with 64 kbit/s, DSL with several 100 kbit/s etc.
Convergence of broadcasting and mobile comm.

Definition of interaction channels

- Interacting/controlling broadcast via GSM, UMTS, DECT, PSTN, ...

Example: mobile Internet services using IP over GSM/GPRS or UMTS as interaction channel for DAB/DVB
## Comparison of UMTS, DAB and DVB

<table>
<thead>
<tr>
<th></th>
<th>UMTS</th>
<th>DAB</th>
<th>DVB</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spectrum bands</strong></td>
<td>2000 (terrestrial), 2500 (satellite)</td>
<td>1140-1504, 220-228 (UK)</td>
<td>130-260, 430-862 (UK)</td>
</tr>
<tr>
<td>(depends on national regulations) [MHz]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Regulation</strong></td>
<td>Telecom, licensed</td>
<td>Broadcast, licensed</td>
<td>Broadcast, licensed</td>
</tr>
<tr>
<td><strong>Bandwidth</strong></td>
<td>5 MHz</td>
<td>1.5 MHz</td>
<td>8 MHz</td>
</tr>
<tr>
<td><strong>Effective throughput</strong></td>
<td>30-300 kbit/s (per user)</td>
<td>1.5 Mbit/s (shared)</td>
<td>5-30 Mbit/s (shared)</td>
</tr>
<tr>
<td><strong>Mobility support</strong></td>
<td>Low to high</td>
<td>Very high</td>
<td>Low to high</td>
</tr>
<tr>
<td><strong>Application</strong></td>
<td>Voice, data</td>
<td>Audio, push Internet, images, low res. video</td>
<td>High res. video, audio, push Internet</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Local to wide</td>
<td>Wide</td>
<td>Wide</td>
</tr>
<tr>
<td><strong>Deployment cost for wide coverage</strong></td>
<td>Very high</td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>