Digital Audio Broadcasting (DAB) systems

Outline

- Introduction
- DAB species
- History of DAB
- DAB specification
- IBOC DAB
- OFDM
- CDMA
- Future work
- References

Introduction

- Replace the existing AM and FM audio broadcast services
- Very well suited for mobile reception
- High robustness against Multipath reception
- High quality digital audio services (near CD quality)

Introduction

- Ancillary data transmission (e.g. travel and traffic information, still and moving pictures, etc.)
- Larger coverage area than current FM and AM systems
- Efficient frequency spectrum use
- Low transmitting power

DAB species

- DAB (Eureka 147 project)
  - ETSI standard
- In Band On Channel (IBOC) DAB (High definition radio project)
  - NRSC standard
- ISDB
  - Japanese standard
  - Digital TV & audio

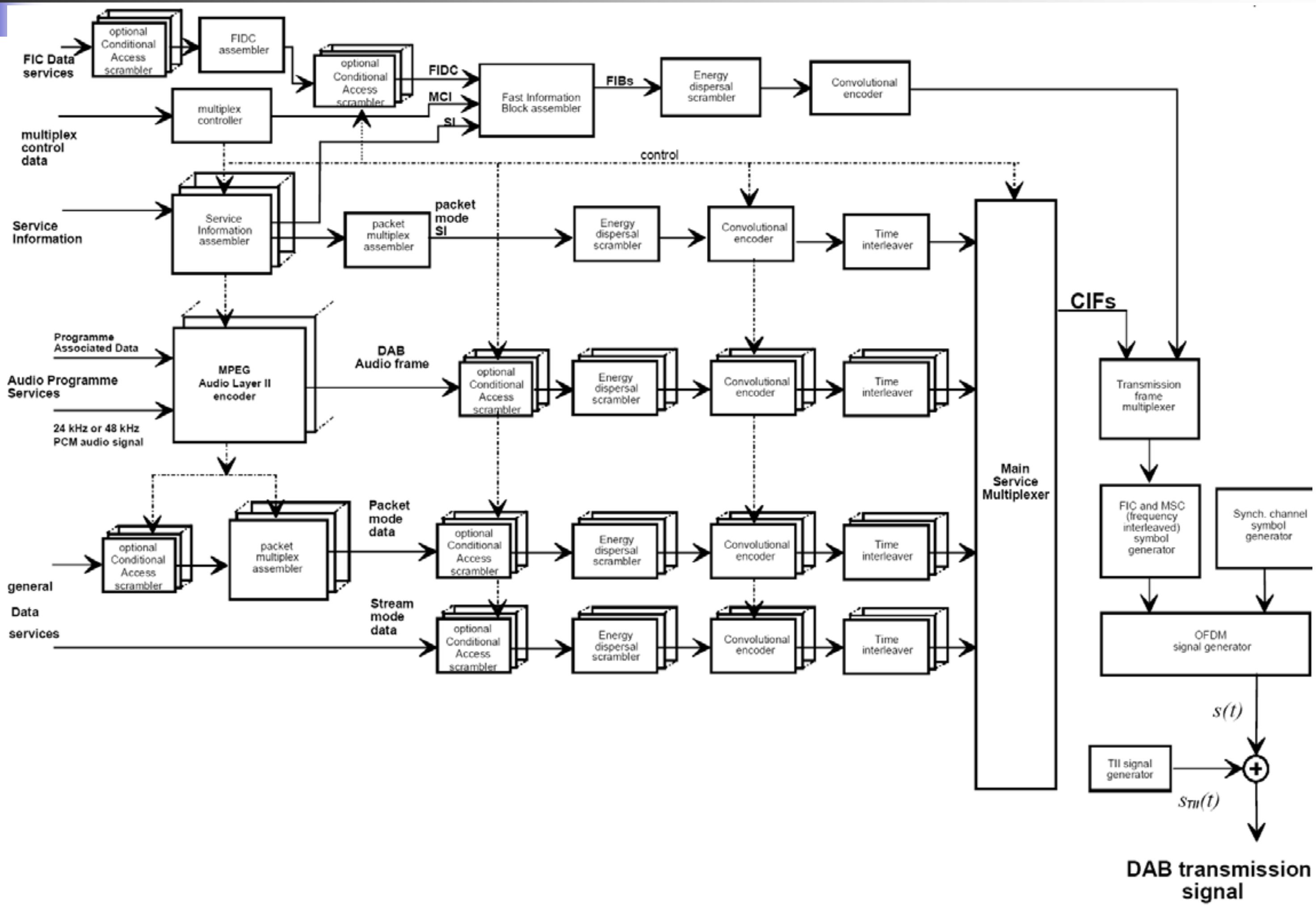
History of DAB

- In 1980s the first digital sound broadcasting systems providing CD like audio quality for satellite delivery.
  - Frequency band 10 to 12GHz
  - Little sound data compression
  - Not aimed at mobile reception
- In 1987 the Eureka-147 project was born
- First DAB standard was achieved in 1993
- In 1995 the ETSI adopted DAB as the only European standard for digital radio

DAB specification

- 1.5 MHz bandwidth
- Frequency band between 30MHz to 3GHz
- 1.5 Mbit/s signal rate
- 8-384 kbit/s audio rate
- Up to 63 mono audio channel or 12 stereo audio channel

Block diagram



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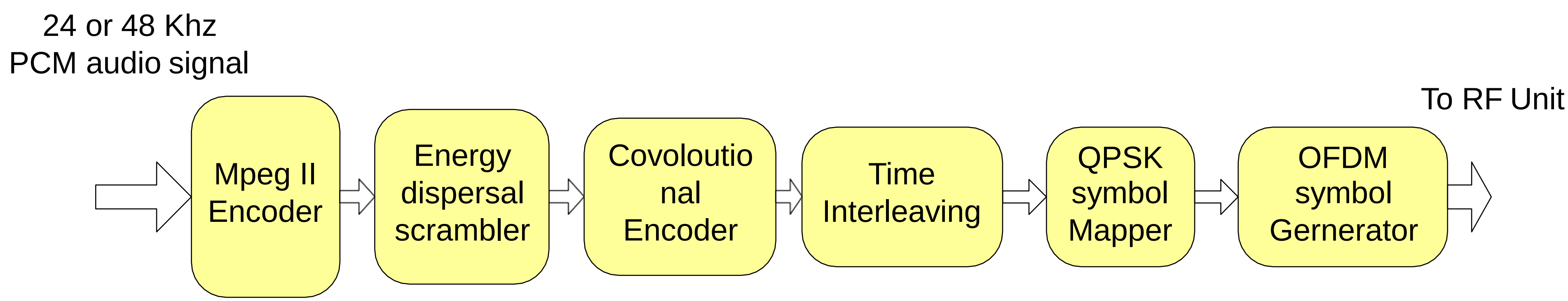
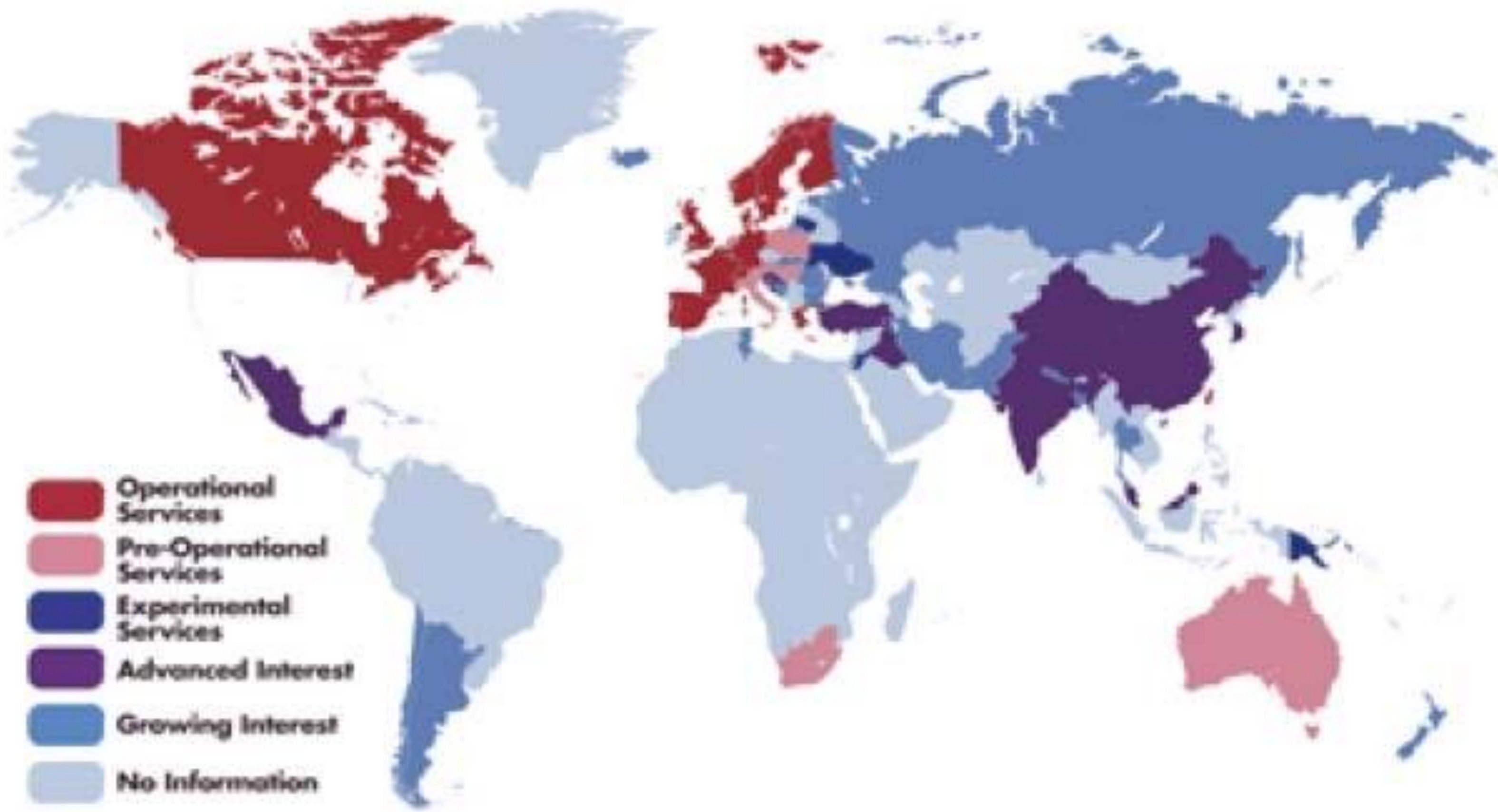
Important block



DAB World Coverage Map



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IBOC DAB

- Permit a smooth evolution from current analog radio broadcasting to fully digital radio broadcasting.
- Allow broadcaster to keep current analog transmission
- No new spectrum required for AM or FM transmission
- Near CD Quality for FM
- FM stereo quality sound for AM station
- No new tower or transmitter site
- New data capabilities for AM and FM stations

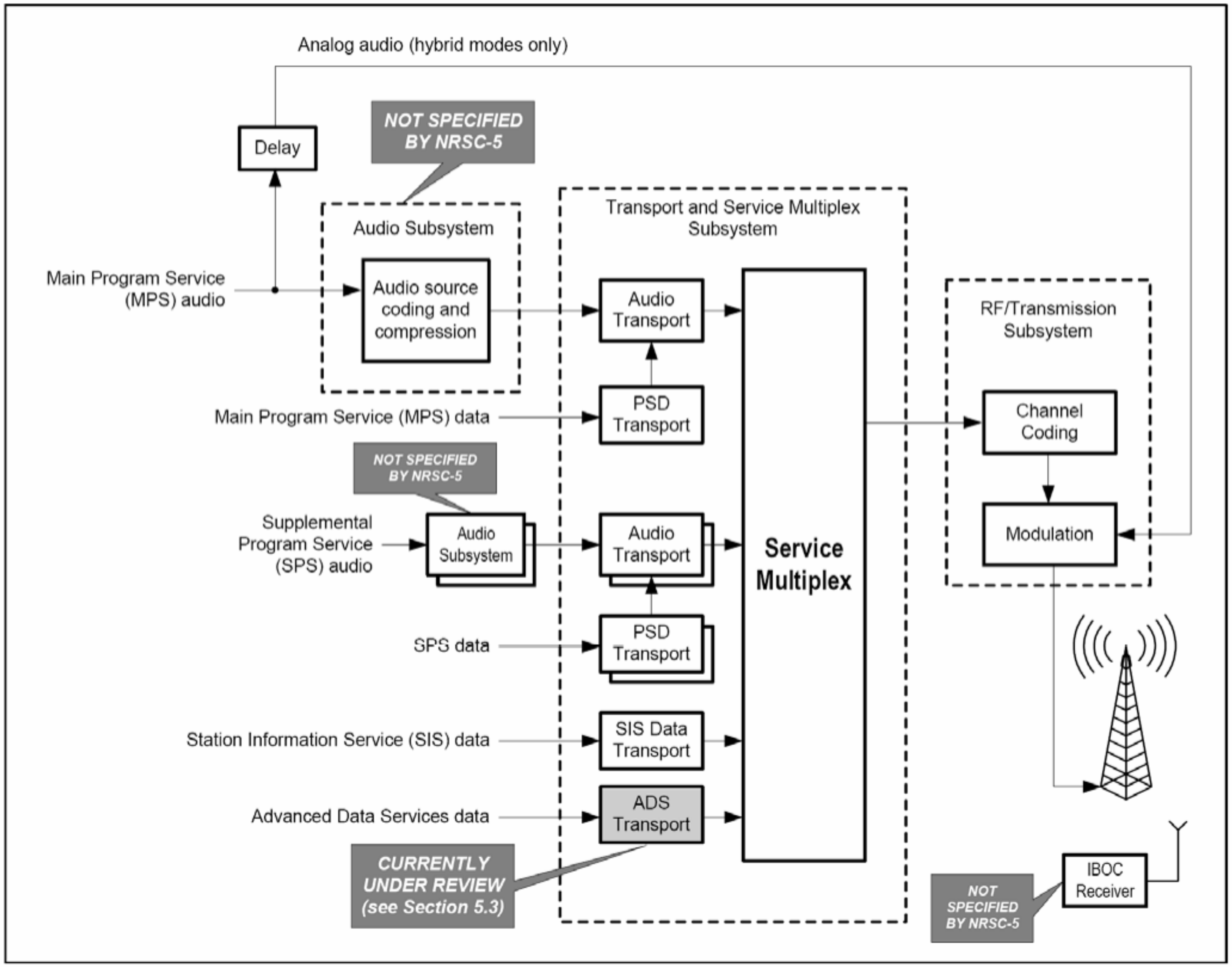
IBOC DAB History

- 2001
  - iBiquity was born
- 2002
  - IBOC technology approved by the FCC
- 2003
  - First AM and FM stations begin broadcasting with HD Radio
- April, 2005
  - IBOC DAB Standard (NRSC-5) approved

IBOC DAB

- RF/transmission subsystem
  - Coding and interleaving
  - Mapping
  - Orthogonal frequency division multiplexing (OFDM) modulation
  - Up-conversion to the AM or FM band
- Transport and service multiplex
  - Takes the audio and data information
  - Generate stream of packets
- Audio and data input subsystems
  - Audio source coding

Block diagram



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Transmission subsystem

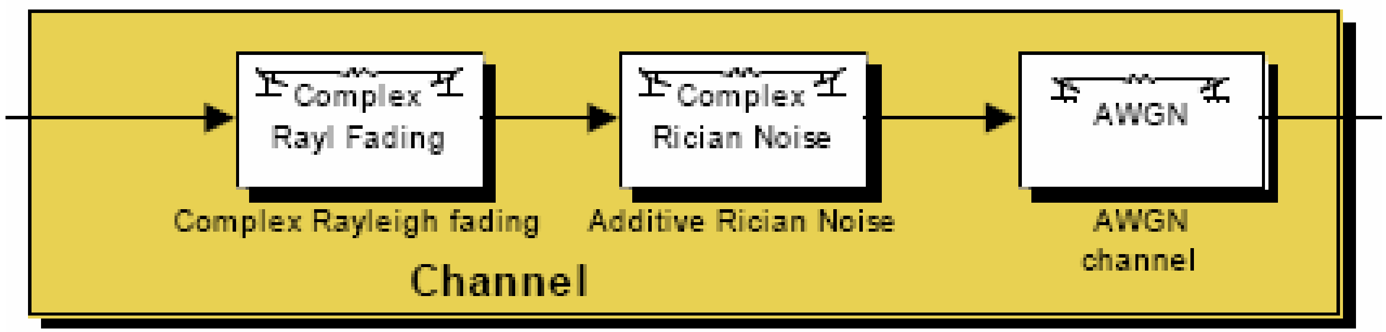
- Interface Layer
  - Transfer PDU frames
- Logical Channels
  - specify grade of service
- Channel Coding
  - Scrambling (Energy dispersal)
  - Channel Encoding
  - Interleaving

Transmission subsystem

- Subcarrier Mapping and Modulation
  - QPSK, 16QAM,64QAM
  - 2048 OFDM modulation
- Pulse shaping
- Up conversion

Mobile radio channels

- Attenuation
- Multipath Effects
- Doppler Shift



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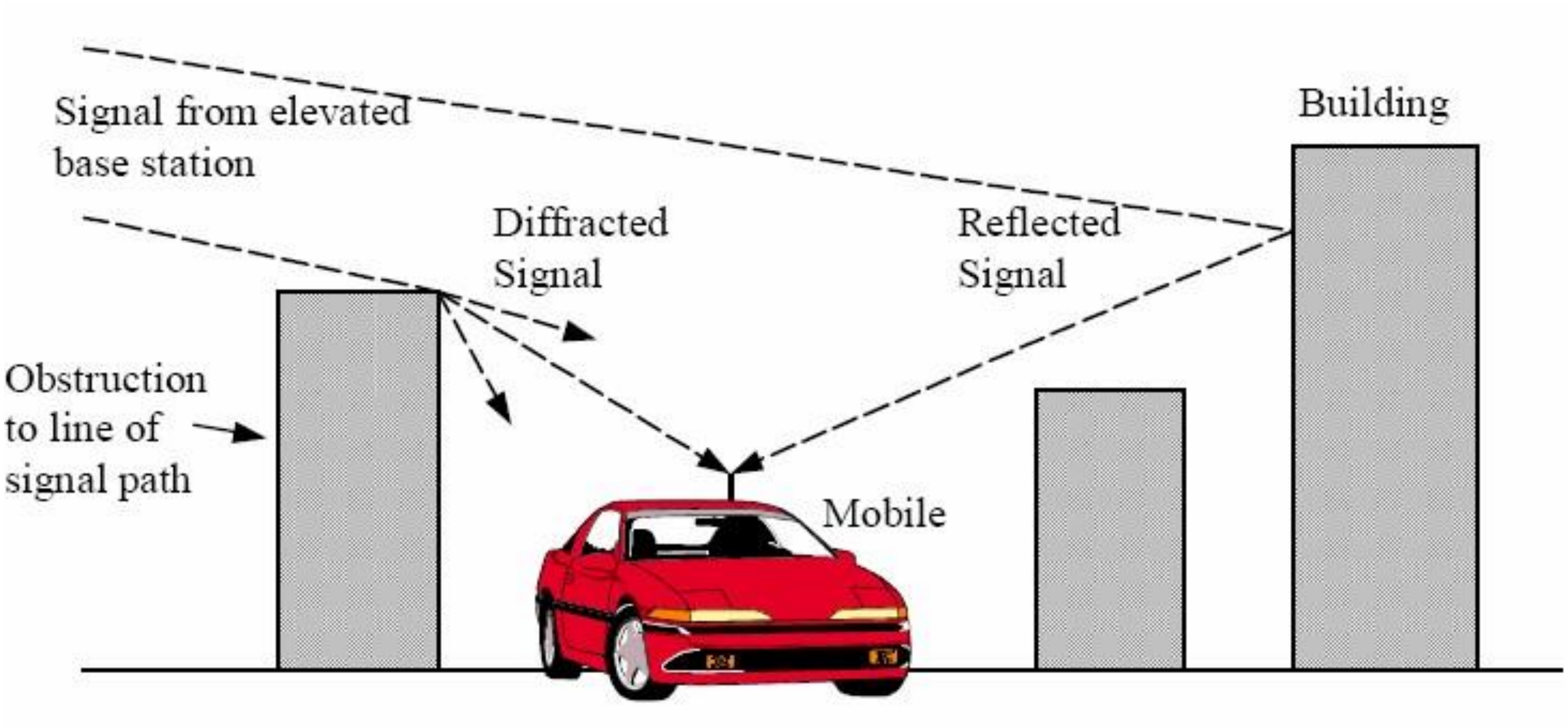
Radio Propagation Effects



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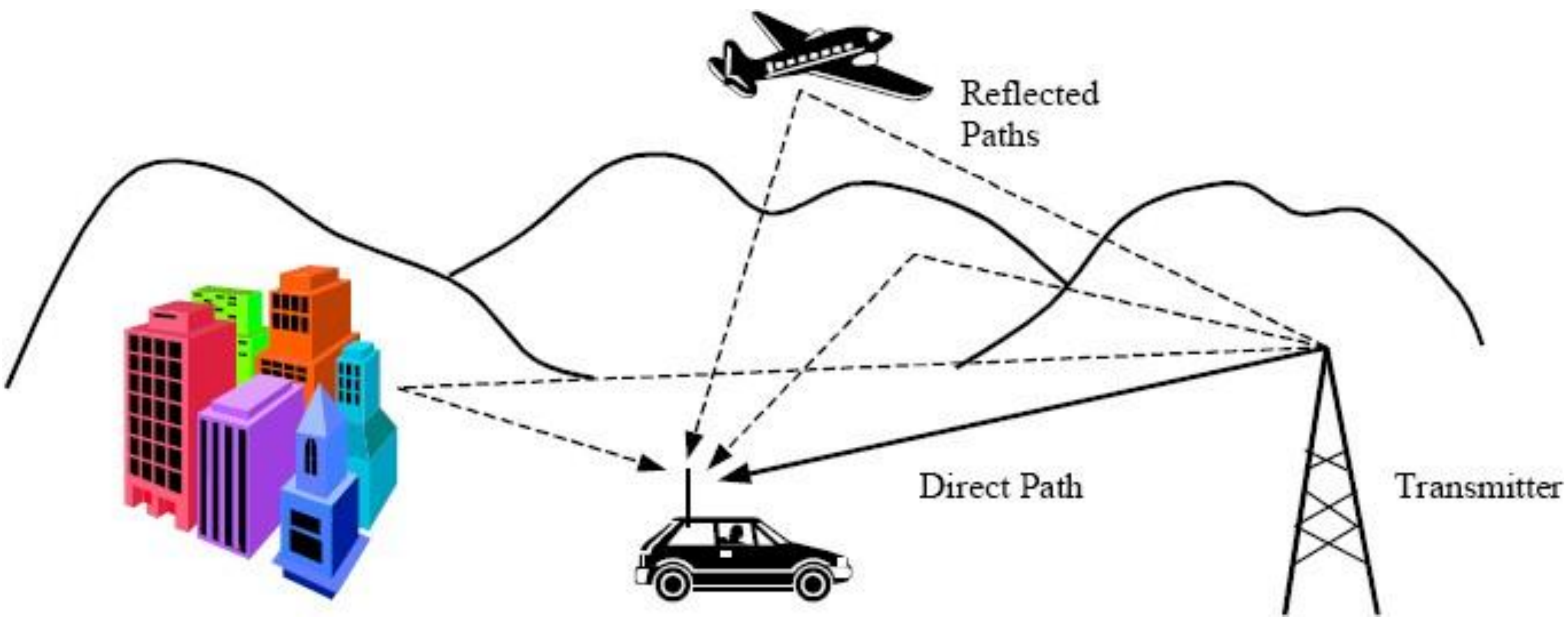
Attenuation source

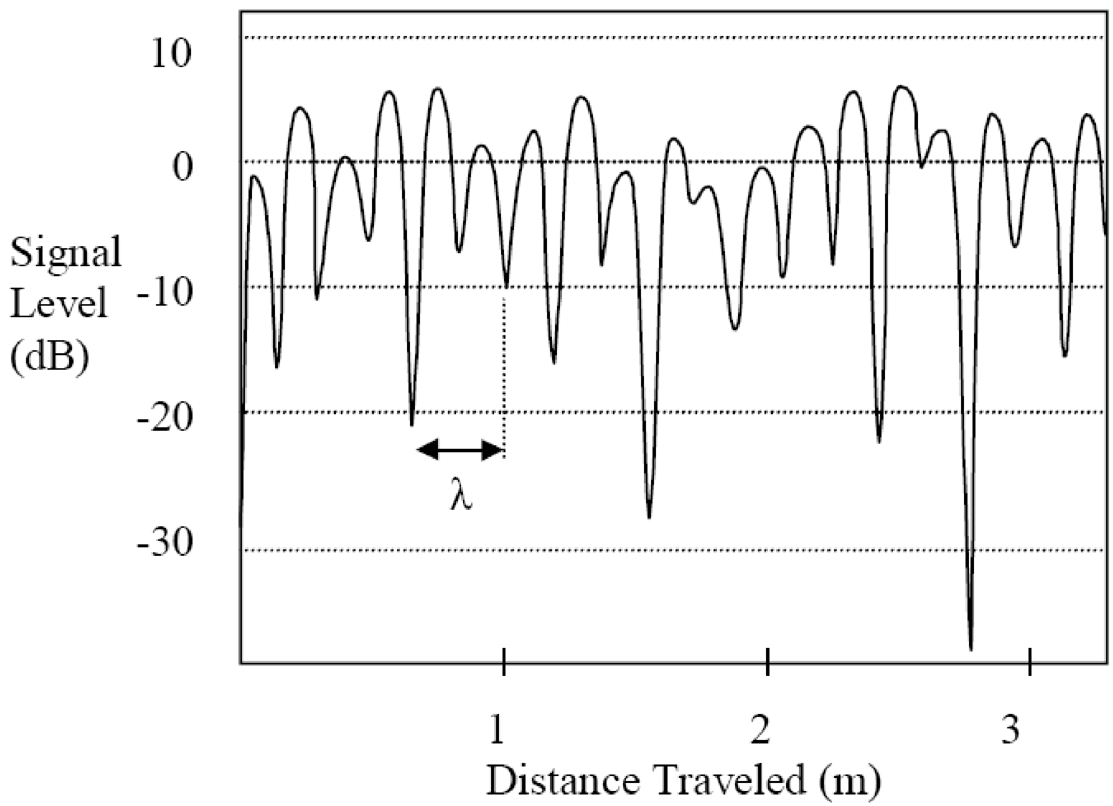
- Any objects which obstruct the line of sight signal
- Diffract off the boundaries of obstructions
  - Low frequencies diffracting more than high frequency signals
- High frequency signals, require line of sight for adequate signal strength

Multipath effects



Fast fading

- Relative phase of multiple reflected signals can cause constructive or destructive interference at the receiver



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Rayleigh Fading

- Rayleigh distribution describes the probability of the signal level being received due to fading.

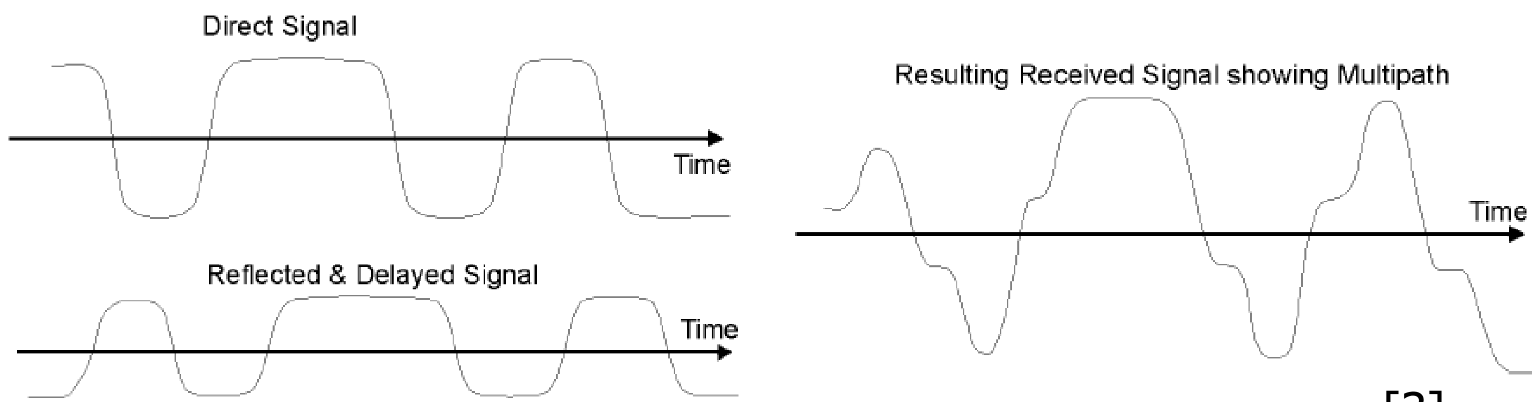
Signal Level (dB about median)	% Probability of Signal Level being less then the value given
10	99
0	50
-10	5
-20	0.5
-30	0.05

Frequency Selective Fading

- Channel spectral response is not flat
- Deep nulls in the received signal power
- For narrow bandwidth entire signal can be lost
- This can overcome in two ways:
  - Transmitting a spread spectrum as CDMA
  - Split the transmission into many small bandwidth carriers (OFDM)

Delay Spread

- Time spread between the arrival of the first and last multipath signal
- Lead to inter-symbol interference
- ISI can be minimized by CDMA or OFDM



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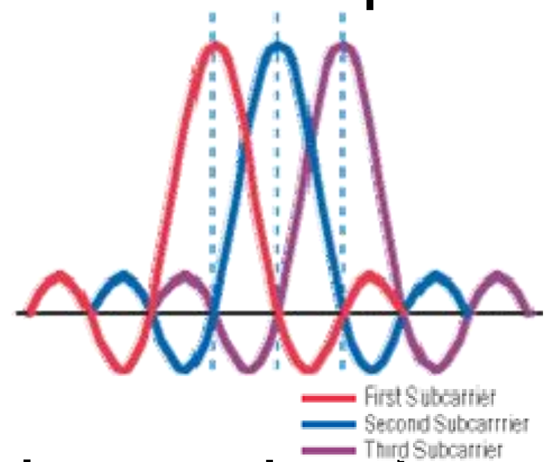
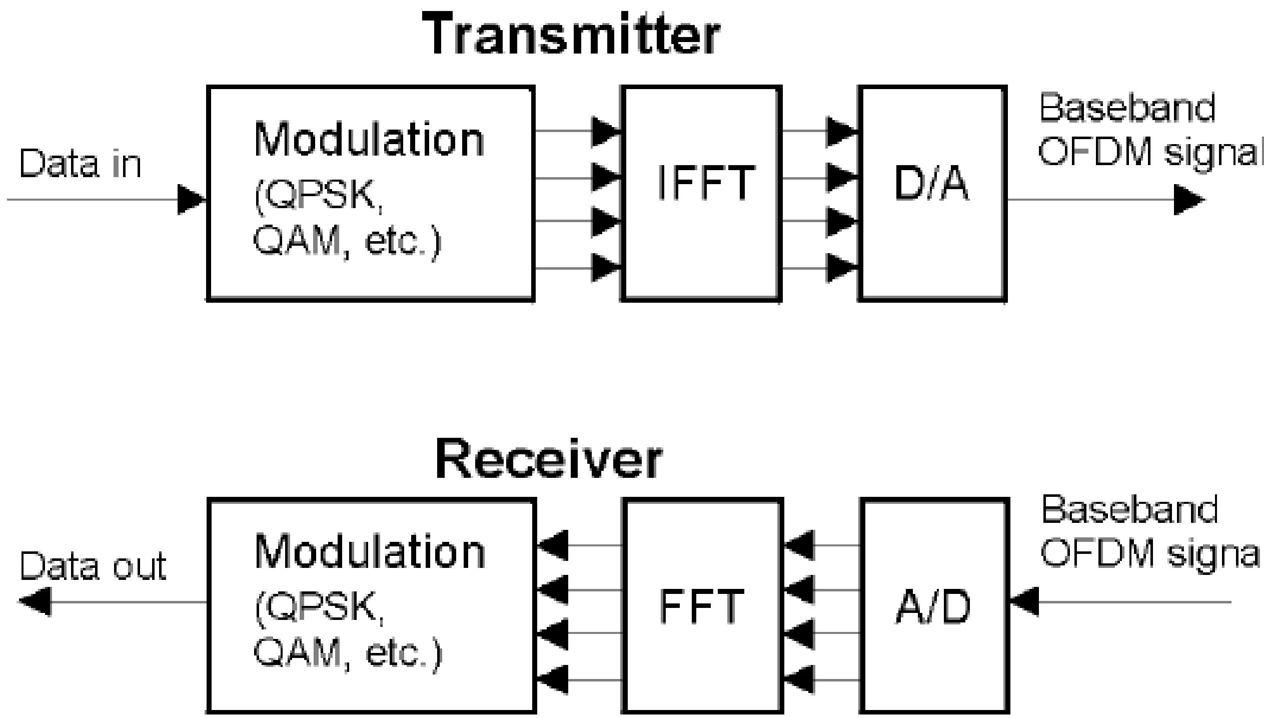
OFDM

- Similar to FDM but OFDM uses the spectrum much more efficiently
- Multicarrier technique
- Divides the spectrum into many carriers



- Sub carrier are orthogonal to each other
- bandwidth of each channel is typically 10kHz-30kHz (for voice communications)
- Multipath tolerance (by guard interval)

OFDM generation



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OFDM

- Noise performance was depend on the modulation technique used for modulating each carrier
- Minimum SNR required for BPSK was ~7dB, ~12dB for QPSK and ~25dB for 16PSK
- Total immunity to multipath delay spread when reflection time is less then the guard period
- Delay Spreads of up to 100µsec could be tolerated, corresponding to multipath reflections of 30km

OFDM

- It is very sensitive to frequency, and phase errors between the transmitter and receiver
  - phase noise of the transmitter
  - Frequency offset errors between the transmitter and receiver
- This problem can be overcome by synchronizing the clocks or by reducing the number of carriers used.

OFDM

- Clipping of the OFDM signal have little effect on the performance
- Allowing the peak power of the signal to be clipped up to 6 - 9dB
- Tolerance to clipping reduces the dynamic range overhead

Adding Guard interval to OFDM

- Robustness against multipath delay spread
- The level of robustness, can be increased more by the addition of a guard period
- Cyclic extension effectively extends the length of the symbol without loss of orthogonality

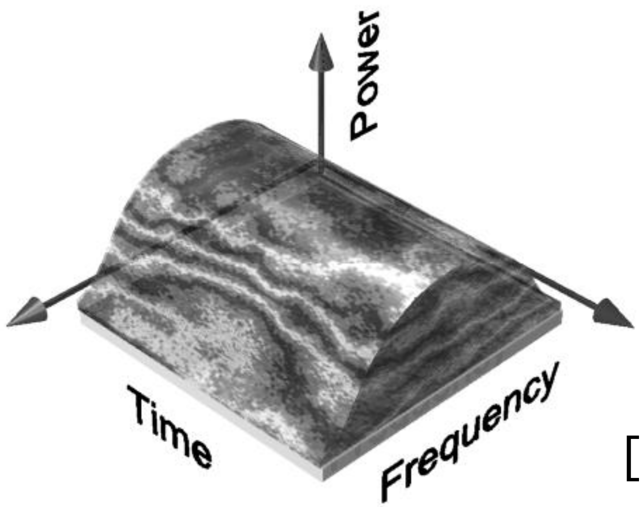
OFDM system implementation

- **Using general purpose DSPs**
- most of the processing is required in performing the fast fourier transform (FFT)
- The complexity of performing an FFT is dependent on the size of the FFT.

CDMA

- What is CDMA (Code Division Multiple Access)
- Spread spectrum technique
- Narrow band message is multiplied by a pseudo random noise code (PN code)
- All channels use the same frequency band and transmit simultaneously
- Signal is recovered by correlating the received signal with the PN code used

CDMA DAB



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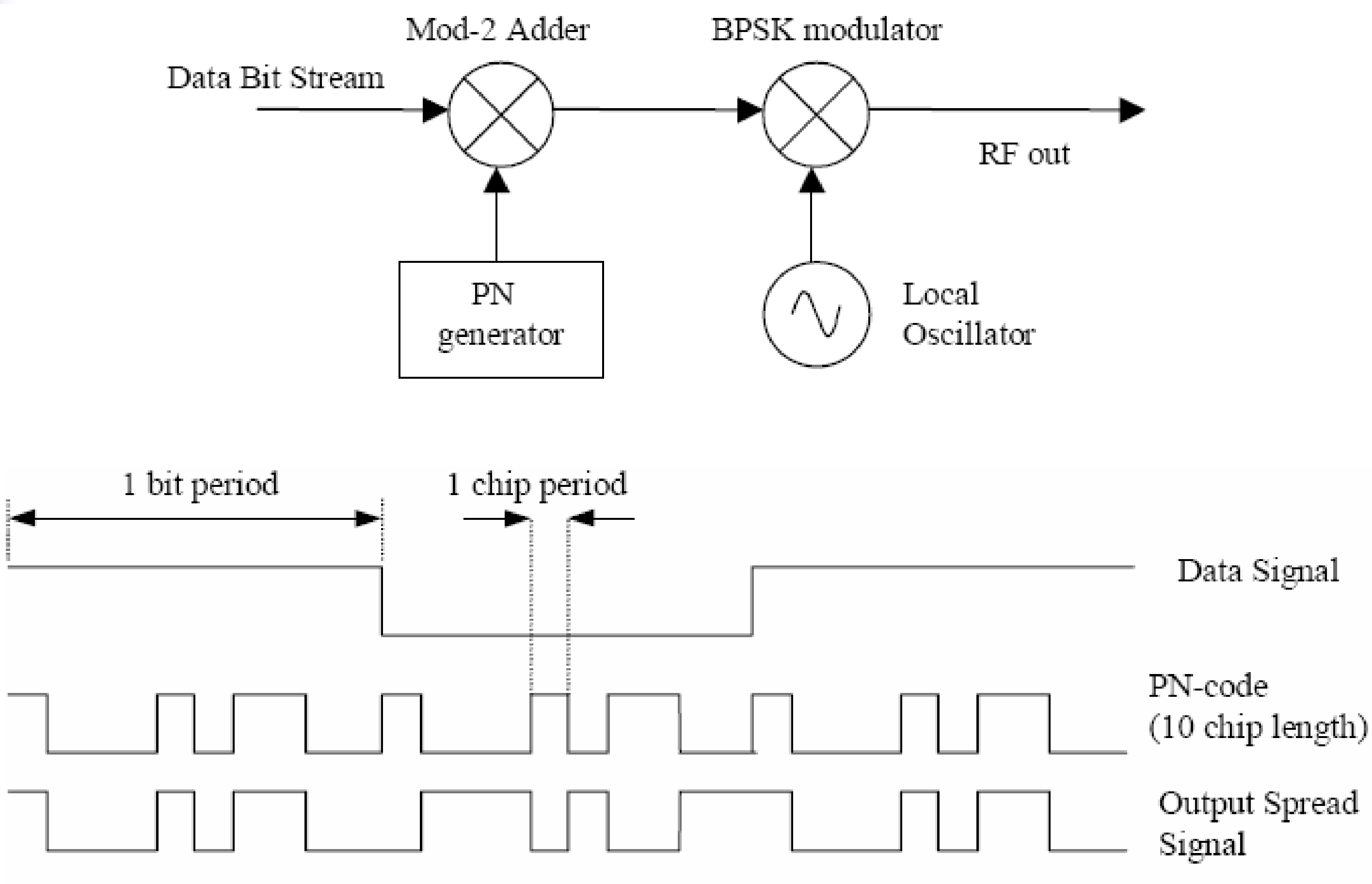
- Signal hiding and non-interference with existing systems.
- Accurate Ranging
- Multiple User Access
- Multipath tolerance

CDMA generation



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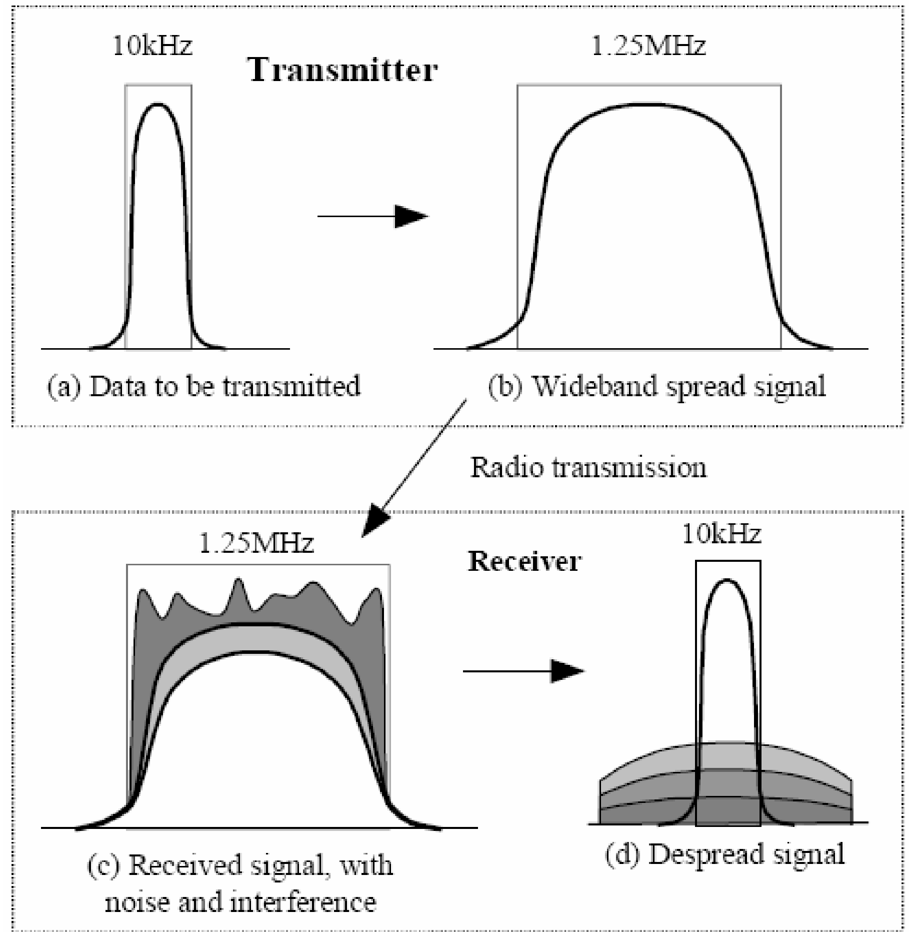
CDMA

- Data to be transmitted is spread by modulating the data using a PN code.
- Received signal is recovered by multiplying the signal by the original spreading code



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Comparison

- OFDM was found to perform very well compared with CDMA
- OFDM allow up to 2-10 times more channel than CDMA

Reference

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2. H. U. Bilbao, "DAB Transmission System Simulation,"*M.Sc Thesis, August 2004.*
3. E. Lawrey, "The suitability of OFDM as a modulation technique for wireless telecommunications, with a CDMA comparison" *M.SC Thesis*
4. S.Y. Yeo, M.S. Beak, M.J. Kim, Y.H. You, "High capacity and reliability techniques for digital audio broadcasting system," *IEEE Transactions on Consumer Electronics,* vol. 50, no. 2, MAY 2004.
5. H. C. Papadopoulos, C. W. Sundberg, "Postcanceling techniques for simultaneous broadcasting of analog FM and digital data," *IEEE Transactions on Communications,* vol. 51, no. 1, January 2003[3]

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6. ETSI EN 300 401 “Radio Broadcasting Systems Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers”

Questions?