Introduction to Satellite Network Technologies

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Geographical Coverage

Network Topologies

Determined by the communications requirements of all nodes

- Mesh
- Star
- Ring
- Hybrid

Transmission Media

Technical and economics factors as well as the management criterion determine the medium to employ:

- Satellite
- Terrestrial
- Mix

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Access

a) By the domain:
   - FDMA (Frequency Division Multiple Access)
   - TDMA (Time Division Multiple Access)
   - CDMA (Code Division Multiple Access/SS)

b) By the assignment:
   - PAMA (Permanent Assignment Multiple Access)
   - DAMA (Demand Assignment Multiple Access)

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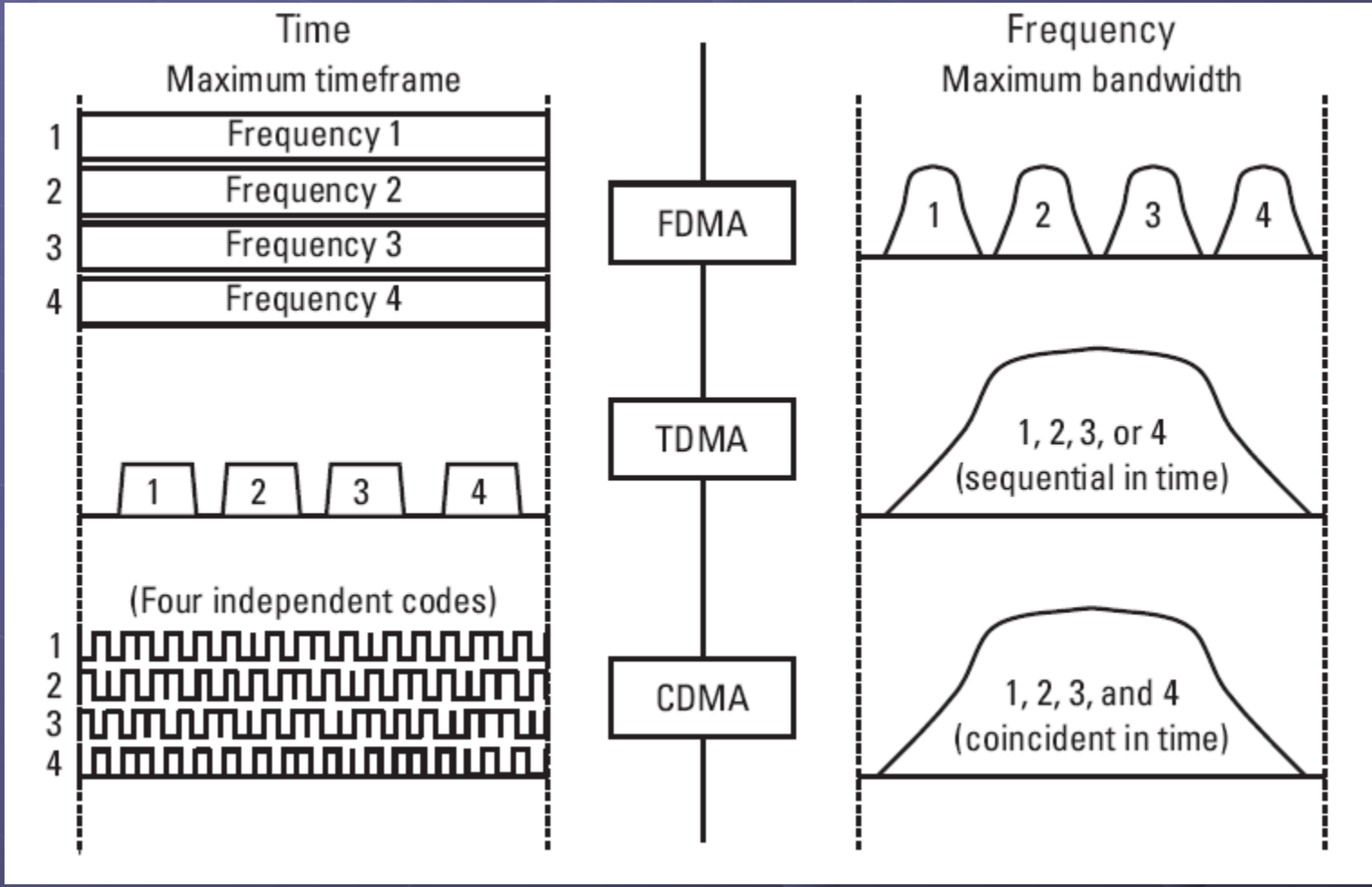
Access



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Access

Based on the mentioned access types, a combined scheme can be obtained such as FDMA-TDMA/DAMA which is used in the REDDIG network.

FDMA or MF, because several carriers are employed and each of them at a different frequency

TDMA, because each carrier has ‘slots’ which are accessed in the time domain

DAMA or BoD, because each ‘slot’ is assigned on demand. PAMA also can be used.

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Access

According to the outbound and inbound of data, access scheme to satellite also can be defined as:

TDM / TDMA	Outbound: time division multiplexing towards all nodes Inbound: random or fixed multiple access of some nodes
TDMA / TDMA	In both directions, outbound and inbound, the access is multiple to/from any node

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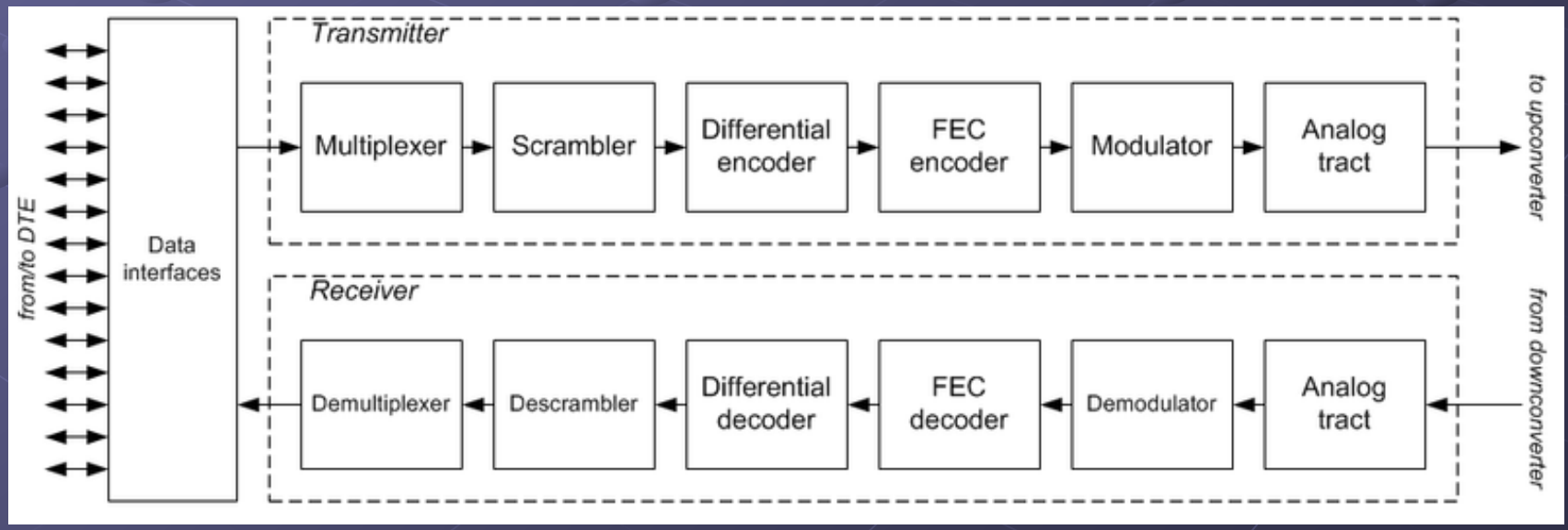
Modulation Techniques

The main function of modulation is transforming the ‘information’ (IR) into a radio signal for transmission and, together with the codification, determine the bandwidth (BW) to be occupied in the satellite.



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Modulation Schemes

- BPSK Bi-Phase Shift Keying

  1 bit per symbol

- QPSK Quadra-Phase Shift Keying

  2 bits per symbol

- 8PSK Octal-Phase Shift Keying

  3 bits per symbol

- 16QAM 16 Quadra Amplitude Modulation

  4 bits per symbol

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Codification & Error Correction

Codification is directly associated to error correction techniques which are fundamental in satellite communications due to limited power of satellite transponders and to the low level of C/N ratio arriving to the receiving station.

FEC (Forward Error Correction) is a method of obtaining error control in data communications in which the source sends redundant data in order to correct the errors arriving at the destination once they are detected. This reduces drastically the need for retransmissions.

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Codification & Error Correction

Types of FEC

- *Algebraic or Block Coding*
- *Convolutional Coding* (*Sequential* and *Viterbi decoding*)
- *Concatenated Coding*, combines codification schemes, *Block* plus *Convolutional.*
- *Turbo Coding,* one of the most efficient codes besides the *LDPC coding.*

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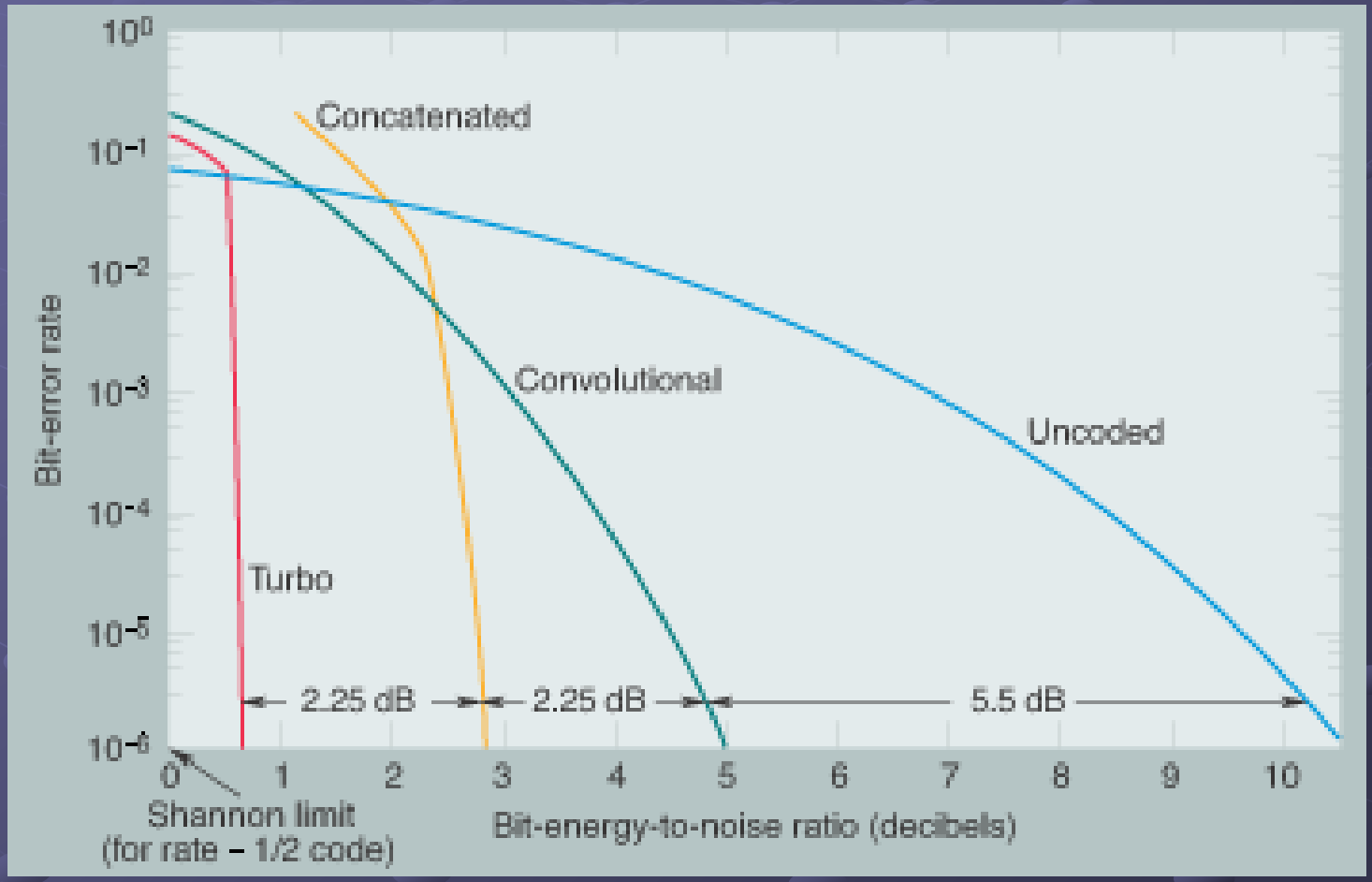
Codification & Error Correction



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Codification & Error Correction

Types of FEC

- *LDPC (Low Density Parity Check)*, linear code of high performance, employed in the DVB-S2 standard.
- *Adaptive Coding*, flexible configuration of parameters according to the receiving conditions (fading). Employed in the DVB-S2 standard.

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Codification & Error Correction

FEC Rates

Among the most used:

- *Convolutional (Viterbi):* 1/2, 2/3, 3/4, 5/6, 7/8
- *Reed Solomon (RS):* 188/204, 216/236
- *Turbo:* 1/3, 2/5, 1/2, 2/3, 3/4, 5/6, 6/7, 7/8
- *LDPC:* 1/4, 1/3, 2/5, 1/2, 3/5, 3/4, 5/6, 8/9, 9/10

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Information Rate

General Equation

IR = SR x m x FEC x (1- OH)

IR = *Information Rate*

SR= *Symbol Rate = Baud Rate*

m = *Modulation Factor* BPSK=1, QPSK=2, 8PSK=3, 16QAM=4

FEC= (*Turbo Code Rate*) or (*Viterbi Rate x RS Rate*)

OH = *TDMA Overhead* including *guard bands*

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IR , m&FEC, Eb/No, Power, Bandwidth

Modulation and FEC rate and FEC coding method	Minimum threshold Eb/No (BER=10E-8)	Information rate bit/s	Symbol rate. per information bit rate (*)	Occupied bandwidth Hz at -10 dB points. 1.19 times the symbol rate	Allocated bandwidth Hz (suggested carrier to carrier spacing) 1.35 times the symbol rate
QPSK 1/2 rate FEC Viterbi	7.2 dB	1	1	1.19	1.35
QPSK 1/2 rate FEC Vit&RS	4.9 dB	1	1.092	1.30	1.475
QPSK 21/44 FEC Turbo	3.1 dB	1	1.048	1.246	1.414
QPSK 3/4 rate FEC Turbo	4.3 dB	1	0.667	0.793	0.9
QPSK 7/8 FEC Turbo	4.4 dB	1	0.571	0.68	0.77
8-PSK 3/4 rate FEC Turbo	6.7 dB	1	0.444	0.53	0.6
16-QAM 3/4 rate FEC Turbo	8.1 dB	1	0.333	0.397	0.536
16-QAM 7/8 rate FEC Turbo	8.2 dB	1	0.286	0.340	0.386

(*) Not included OH

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IR , m&FEC, Eb/No, Power, Bandwidth

General considerations when selecting the modulation scheme, FEC and SR:

- D/L EIRP and G/T (sat) for each node
- Eb/No required in operating conditions (including rain fading)
- E/S EIRP required by each node
- Compliance with BW(sat) < = D/L(sat)