Advanced Digital Television

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Advanced Television Research Consortium

Why Should HDTV Be Digital?

- **The HDTV standard should last for *50 years!***
  - necessary to preserve consumer investment
  - new adoption curves are costly to the industry

- **Digital compression provides better picture quality than an analog system of the same bandwidth**
  - digital encoding uses the flexibility of computing
  - improvements will follow computing technology advances

- **Digital transmission eliminates the picture impairments of analog transmission**
  - low noise is just as important as resolution

ADTV Services

- **High-quality HDTV pictures**
  - 16:9 aspect ratio
  - luminance 1440 (H) x 960 (V) (810 TVL/PH)
  - chrominance 720 (H) x 480 (V)
  - 1050/59.94 2:1 interlace raster format
  - adaptable to future video production standards

- **Four digital audio channels of CD-quality sound**
  - will closely follow industry standards (e.g., MUSICAM™)

- **Flexible support for auxiliary data**
  - program-related information (e.g., pay-per-view)
  - new community service information

- **Flexible mix of video, audio, and auxiliary data**
  - new service opportunities for the future

ADTV Features

- **Digital transmission that:**
  - survives the difficult RF transmission environment
  - has adequate capacity, robustness, and coverage area
  - can co-exist with NTSC

- **Data compression that:**
  - achieves outstanding quality at the available data rate
  - survives uncorrectable bit errors
  - has acceptable fringe area performance

- **An overall system that:**
  - enables real consumer products (e.g., fast channel change)
  - will foster future growth and new opportunities
  - allows broadcasters to stay competitive in the 21st century

Key Elements of ADTV

- **MPEG++ video data compression**
  - chosen as a result of thorough ATRC evaluation
  - ATRC adaptation of proven compression techniques embodied in an emerging ISO standard
  - upgrades MPEG to HDTV performance levels
  - provides video data prioritization for robustness

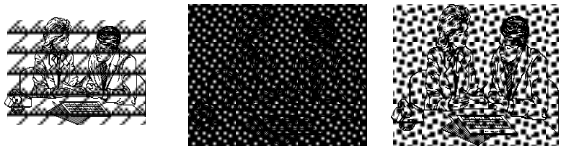
- **Prioritized Data Transport**
  - cell-relay data transport layer provides robustness
  - prioritized delivery of data allows "graceful degradation"
  - provides service flexibility (video, audio, data)

- **Spectrally Shaped QAM**
  - ATRC adaptation of proven and widely-accepted QAM
  - reduces interference *from* co-channel NTSC
  - reduces interference *into* co-channel NTSC

ADTV System Layers

Production Standard

Pictures



MPEG++ Compression

Video Components

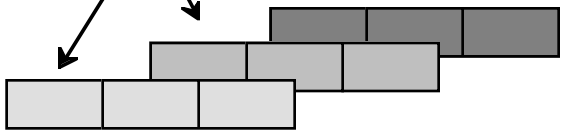
Coding

Data Prioritization

2 **1** **3**

Ranking

Transport

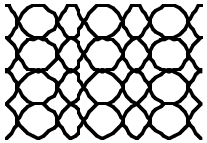


Cells

11010011101101010100101 1

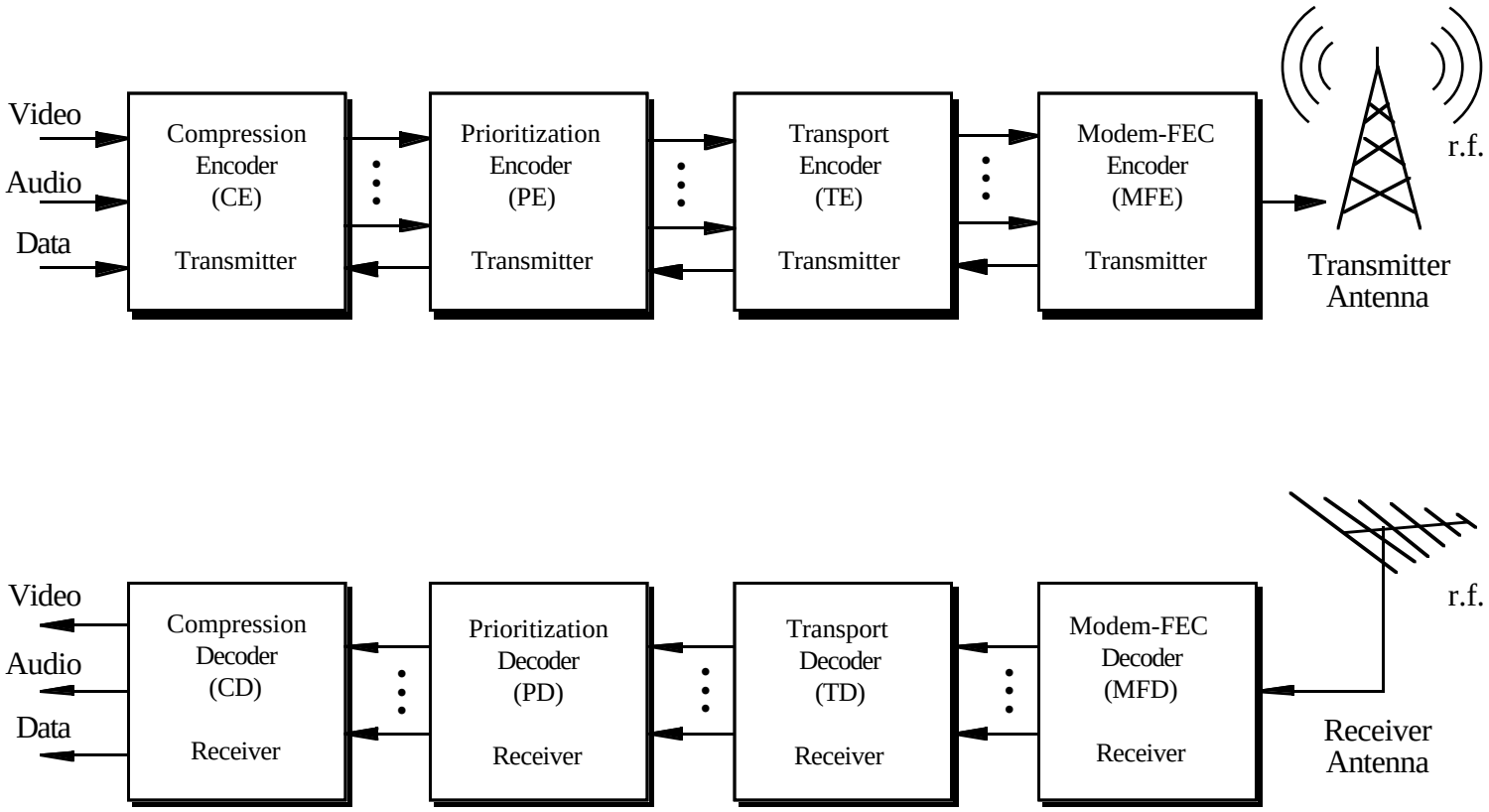
Bits

Physical Communication

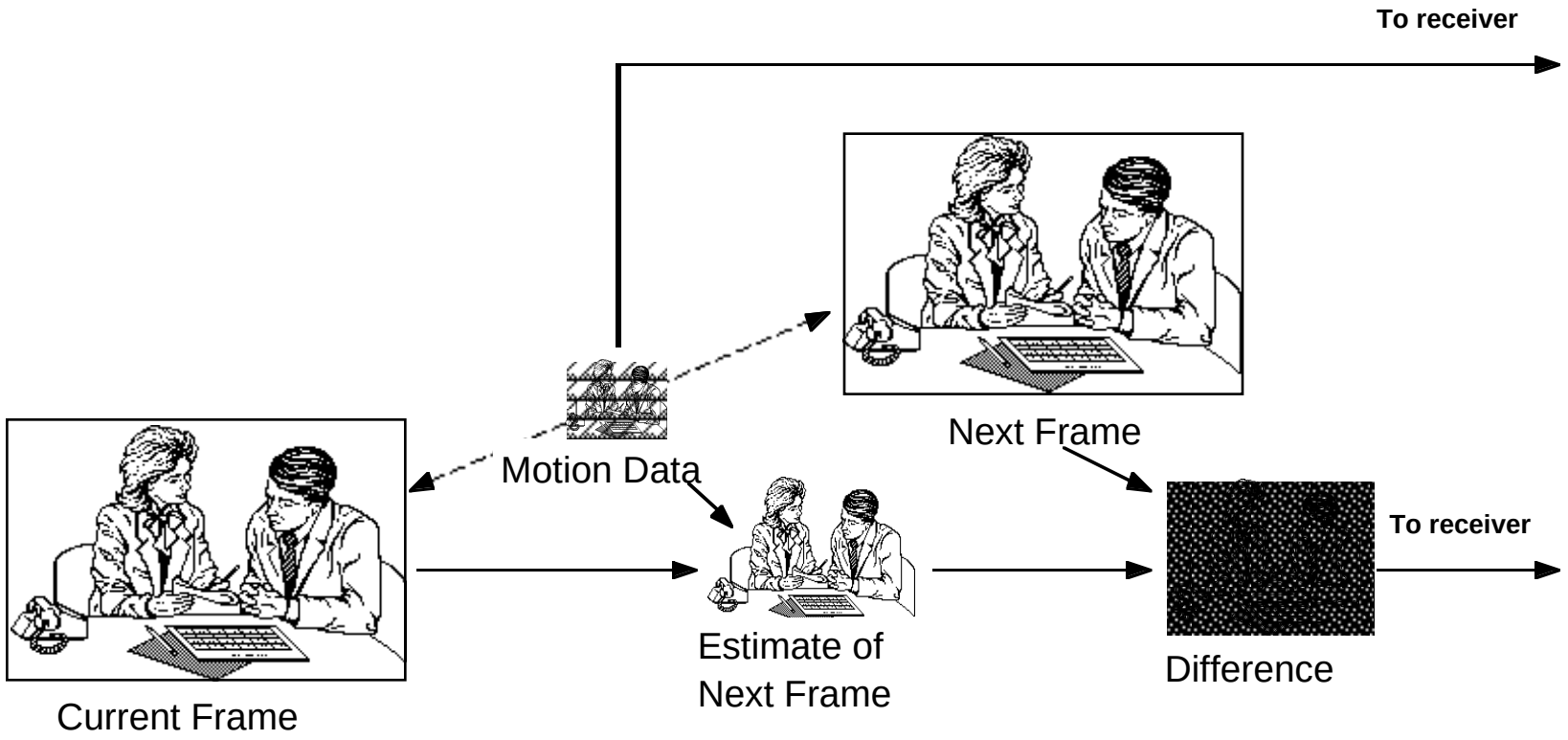


Symbols

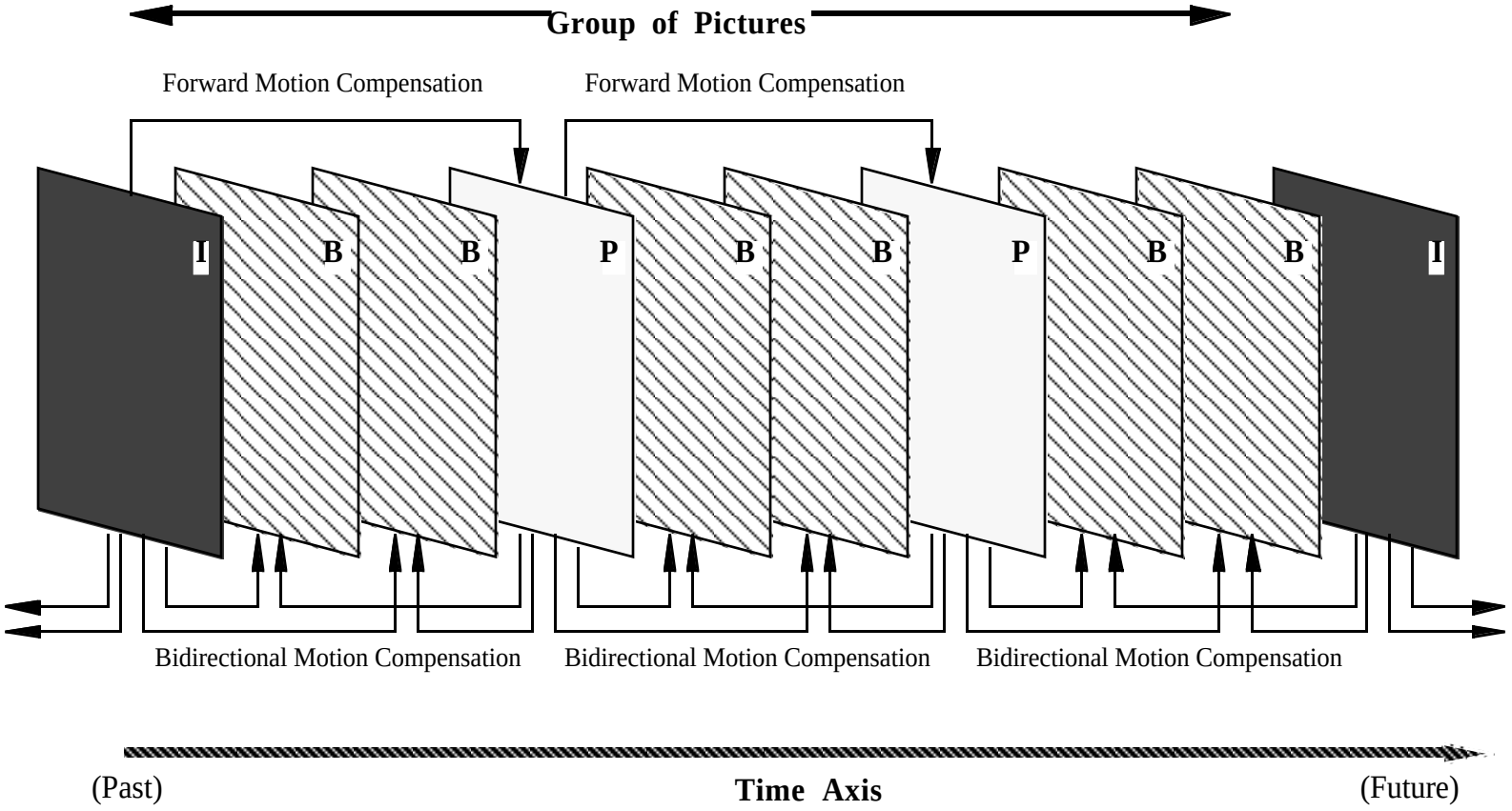
ADTV System Block Diagram



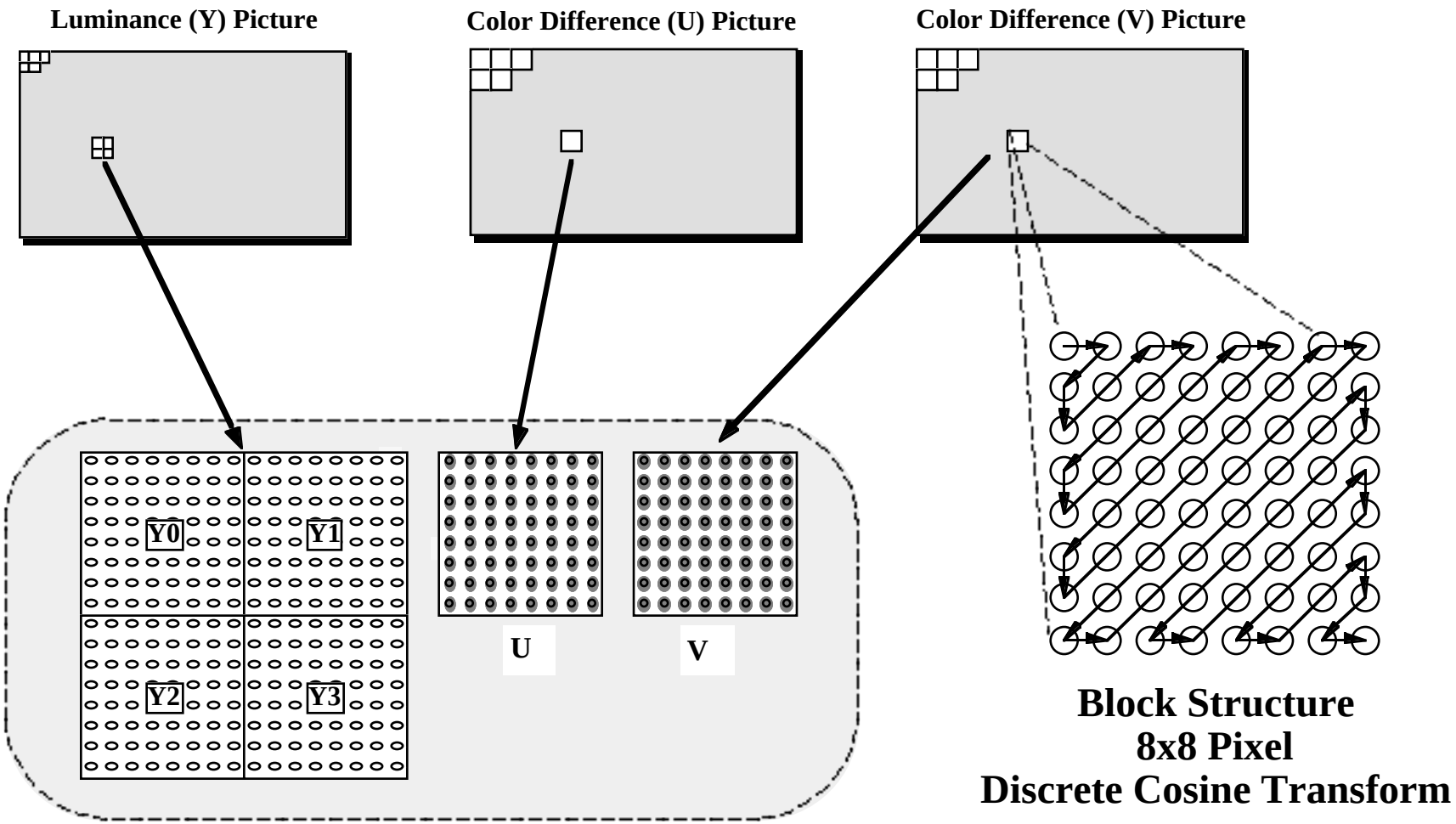
Motion-Compensated Video Compression



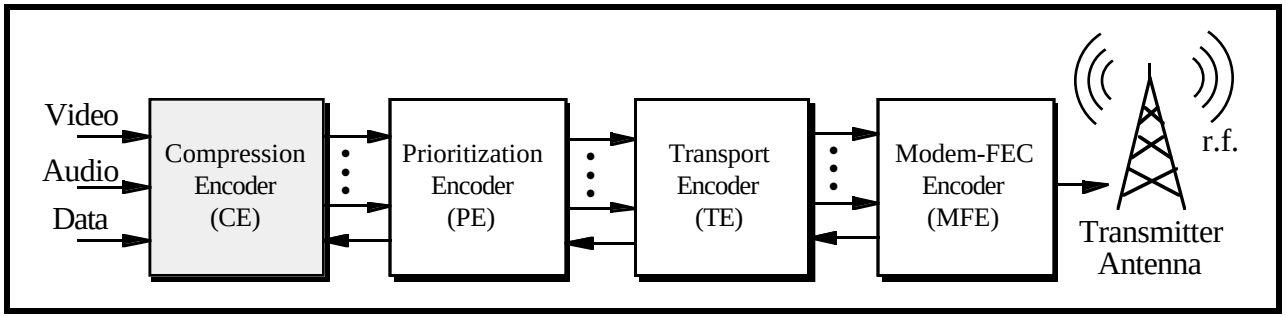
Group of Pictures



Blocks and Macroblocks

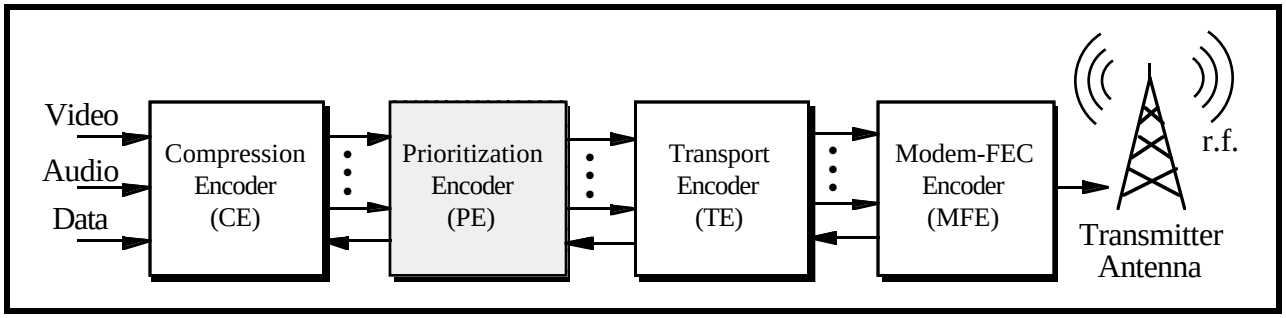


Compression Encoder



- **Video pre- and post-processing**
- **Frame Sequencing**
- **Motion estimation and compensation**
- **Raster line to Macroblock conversion**
- **Discrete Cosine Transform**
- **Adaptive quantization**
- **Variable length coding/decoding**

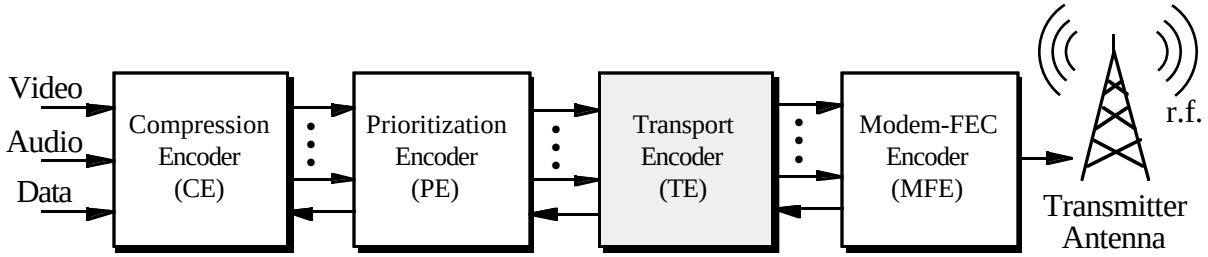
Prioritization Encoder



- **Dynamically assigns priority to data elements**
  1. Headers
  2. Audio
  3. Auxiliary Data
  4. Motion vectors
  5. DC values of DCT blocks
  6. Low frequency DCT coefficients
  7. High frequency DCT coefficients

- **Measures buffer occupancy and performs rate control**
  - compute compression parameters for next slice/macroblock
  - goal is to achieve equal picture quality within a GOP

Transport Encoder



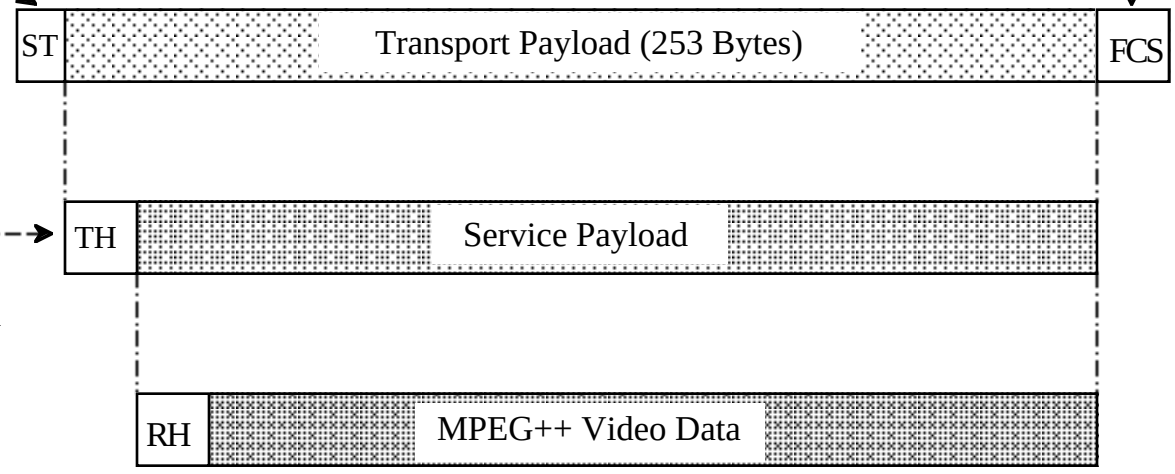
- **Receives data element, type, and priority information**
  - generates appropriate header fields
- **Packages prioritized data elements into *cells***
  - receives additional slice and macroblock level information
  - performs segmentation and chaining
- **Inserts CRC codes for error detection capability**
- **Rate buffering provides constant bit rate to Modem/FEC**
  - complementary buffers are used in the receiver
  - transmitter buffer states are sent at GOP intervals to allow complete complementary synchronization

Transport Cell Format

Each Cell is 256 Bytes

Service-type header
- priority
- service type (video, audio, data)

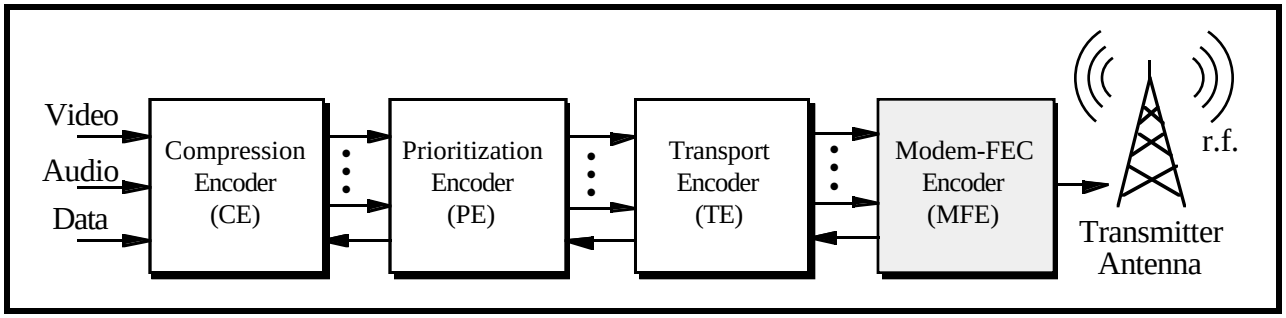
FCS trailer
- 16 bit CRC
- (as defined by CCITT)



Transport header
- chaining and segmentation
- opportunity for error indication

Service payload contains MPEG++ Record Header
- defines the start of a slice
- associate video data to the overall GOP

Modem-FEC Encoder

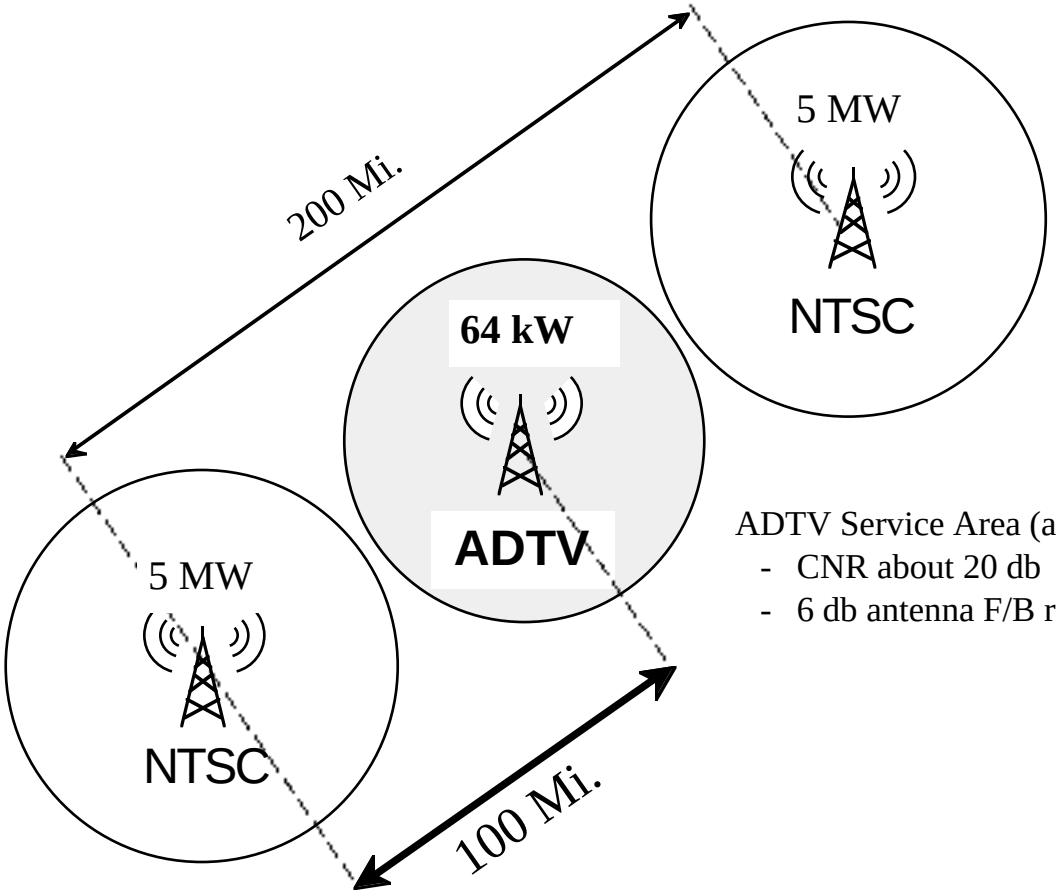


- **Priority-dependent Reed-Solomon FEC codes**
- **Data interleaving to protect against burst errors**
- **Insert sync and framing information**
- **Spectrally shaped QAM modulation**
  - noise-like spectrum

Allocation Issues

- **In order to enable simulcast service, co-channel spacings will have to be reduced**
- **In order to not degrade viewers' reception of NTSC stations, ADTV signals will use lower power**
- **ADTV will accomodate interference from existing NTSC stations, despite their higher power**
- **There are complex tradeoffs to be made among:**
  - Power
  - Coverage area
  - Modulation technique
  - Interference characteristics
  - Data rate
  - Bit error rate and characteristics
  - Receiver complexity and cost

ADTV Co-Channel Scenario



ADTV Service Area (about 50 miles)
- CNR about 20 db
- 6 db antenna F/B ratio

NTSC Grade B Contour (57 miles)
- CNR 28 db
- D/U ratio 28 db
  (ADTV into NTSC)
- 6 db antenna F/B ratio

Advanced Digital Television

...a television system designed for the next 50 years...

- **Advanced MPEG++ data compression**
  - upgrade MPEG to HDTV performance levels
  - provide video data prioritization for robustness
  - future quality can improve from encoder upgrades

- **Prioritized Data Transport**
  - a robust cell relay-based data transport layer
  - supports prioritized delivery of video data
  - provides graceful service degradation
  - provides service flexibility (video, audio, data)

- **Spectrally Shaped QAM**
  - reduces interference *from* co-channel NTSC
  - reduces interference *into* co-channel NTSC

- **ADTV -- a robust, gracefully-degrading system that provides a practical simulcast solution for broadcasters**

ADTV Overview

Video Characteristics	
Raster Format	1050/2:1 Interlace
Aspect Ratio	16:9
Frame Rate	29.97 frames/sec
Active Video	
Luminance	1440 (H) x 960 (V)
Chrominance	720(H) x 480 (V)
Horizontal Resolution (Static and Dynamic)	810 TVL per Picture Height
Transport Cells	
Cell Size	256 Bytes
Link-Level Overhead	3 Bytes (1.1%)
Payload Size	253 Bytes (98.8%)
Total Data Rate	**21.00 Mbps**
Video	14.98 Mbps
Audio	1.02 Mbps
Data (max.)	0.04 Mbps
Error Correction and Link-Level Cell Overhead (percentage of total rate)	**23.6%**

ACTV and ADTV

... a complementary approach to widescreen NTSC and HDTV...

- **ACTV provides NTSC-compatible 16x9 service**
  - **Broadens the delivery base for widescreen production**
  - **Establishes widescreen displays** in high-volume manufacturing (helps to lower the cost of **HDTV receivers)**
  - **Provides broadcasters with a profitable way to address two markets** -- both **NTSC and HDTV**

- **Advanced Digital Television is the wave of the future**
  - Advanced data compression enables HDTV in 6 MHz, and puts broadcasters on an equal footing with other media
  - Low-power digital signal minimizes NTSC interference, and thus allows more simulcast stations to be approved
  - Robust encoding provides a larger coverage area for simulcast, and improves the economics of new HDTV service
  - Digital flexibility assures a useful standard well into the 21st century