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Advanced Digital Television

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Outline

- Introduction
- ADTV System Overview
  - Compression Encoder/Decoder (CE/CD)
  - Prioritization Encoder/Decoder (PE/PD)
  - Transport Encoder/Decoder (TE/TD)
  - Modem-FEC Encoder/Decoder(MFE/MFD)
- Compression Encoder/Decoder
  - Pre/Post Processing
  - Video Compression Processor
  - Receiver Error Recovery
- Prioritization Encoder/Decoder
  - Priority Processor
  - Rate Controller
- Transport Encoder/Decoder
  - ransport Processor
  - Rate Buffering
- Modem-FEC Encoder/Decoder
  - Forward Error Correction (FEC)
  - R.F. Modem
- Coverage Area
- Summary

Introduction

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 can achieve higher picture quality than analog systems of the same bandwidth**
  - digital encoding uses the flexibility of computing
  - compression will follow the computing technology curve

- **Digital transmission offers freedom from transmission impairments**
  - low noise is just as important as resolution

Other Benefits of Digital HDTV

- **Overall technology infrastructure will be digital**
  - communications (B-ISDN and teleconferencing)
  - recording (DVCRs and discs)
  - ICs (DSPs, TV receivers etc.)

- **Non-entertainment uses of "High-Resolution Video" will hasten technology development and lower costs**
  - Computing ("Convergence of Video and Computing")
  - Defense
  - Space
  - Medical

- **Digital flexibility and ease of encryption (i.e., pay-per-view) will create new service opportunities**

- **Broadcasting and Consumer Electronics will be best served by leveraging the digital infrastructure**

Data Compression Issues

- **HDTV in a 6 MHz co-channel is *very* challenging**
  - requires high data compression rates
  - difficult transmission environment

- **Must robustly survive uncorrectable bit errors**

- **Must consider channel change (and resync) time**

ATRC Data Compression Effort

- **Within the ATRC, there was an intensive effort to select a data compression approach**

- **Many approaches were considered**
  - Motion-compensated DCT
  - Motion-compensated QMF
  - Hybrid SBC/VQ
  - MPEG derivatives

- **Approaches were simulated and compared under impaired transmission conditions**

- **an MPEG derivative was chosen because it offered**
  - outstanding picture quality
  - opportunities to add robustness
  - acceptance of a widely accepted emerging standard

Allocation Issues

- **In order to provide simulcast service, co-channel spacings will have to be reduced**
- **Digital simulcast signals must not degrade reception of NTSC stations, therefore they must be lower power**
- **This means that the existing NTSC is a high-power interference to the digital simulcast channel**
- **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

Technical Challenges

- Design a digital transmission system for terrestrial broadcast that can co-exist with existing NTSC
- Design a digital transmission system with adequate capacity, robustness, and coverage area for HDTV
- Design a data compression system that achieves outstanding quality at the available data rate
- Design a data compression system that survives uncorrectable bit errors
- Meet the FCC timetable with a testable system
- Provide a level of interoperability and extensability that will foster future growth and new opportunities

ADTV System Overview

ADTV Services

- **High-quality HDTV pictures**
  - data prioritization provides robustness
  - flexible support of video formats

- **Four digital audio channels of CD-quality sound**
  - commensurate with an HDTV video sevice
  - four channels nominally make up two stereo pairs
  - audio compression will closely follow industry standards for digital audio, e.g., MUSICAM™

- **ADTV supports an auxiliary data channel for program-related information (e.g., encryption) or any other community service information.**

Video Specifications

- **Video Characteristics**
  - 1050/2:1 interlace raster format
  - 29.97 Hz frame rate
  - 16:9 aspect ratio

- **Active Video**
  - luminance 1440 (H) x 960 (V)
  - chrominance 720 (H) x 480 (V)

- **Horizontal Resolution (static and dynamic)**
  - 810 TVL per Picture Height

- **ADTV will support industry production standards**

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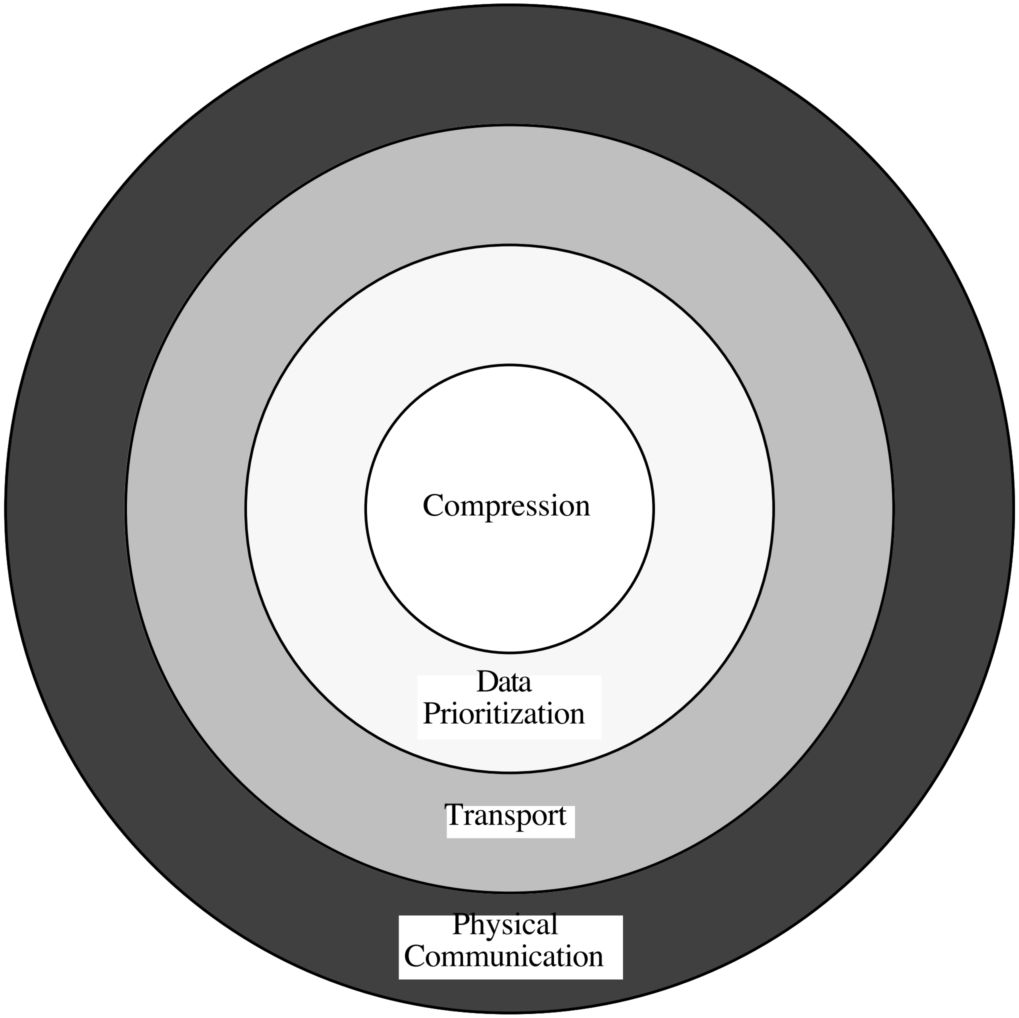
System Architecture



Compression Algorithmic Layer

- Input/Output Pre-/post-processing.
- Data Compression/Decompression

Prioritization Layer

- Separate data into different priority queues.
- Combine data from different priority queues into coherent data streams for decompression.
- Receiver error control.

Transport Layer

- Data multiplexing/demultiplexing.
- Cell-relay formatting.
- Error detection.
- Delay-compensating buffering.

Physical Communication Layer

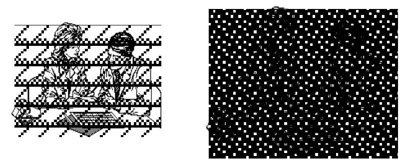
- Channel coding (FEC).
- Physical modem modulation.
- Channel adaptive data equalization.
- Frequency translation to/from r.f.

Figure 1.1: ADTV Layered Architecture.

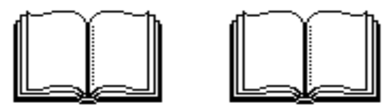
The "OSI Layers" of ADTV

Picture

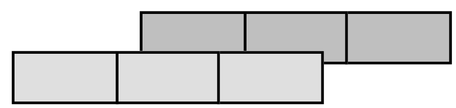
Picture Components



Codes



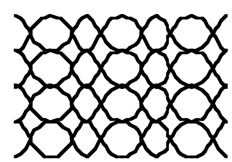
Packets



Bits

1101001110110101010001011

Symbols



Key Elements of ADTV

- **MPEG++**
  - upgrades MPEG to HDTV performance levels
  - provides video data prioritization for robustness
  - complexity in the encoder, not the receiver
  - future quality improvements by encoder upgrades

- **Prioritized Data Transport**
  - cell relay-based data transport layer
  - supports prioritized delivery of video data
  - provides graceful service degradation
  - provides service flexibility (video, audio, data)
  - layered data format provides an interface for other delivery media by providing several logical “entry points” into the data stream

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

System Rationale

- **MPEG++**
  - well-proven compression techniques
  - based on a widely-accepted emerging standard
  - important modifications are necessary for HDTV

- **Prioritized Data Transport**
  - reliable delivery of variable length coded compressed video
  - layering provides media and service transparency
  - provides flexible support of multiple video, audio, and data services, without specific constraints on the bit-rate
  - cell relay structure complements ATM mode of B-ISDN
  - provides compatibility with emerging telecommunications standards

- **Spectrally Shaped QAM**
  - QAM is well-proven and widely-accepted
  - important modifications necessary for simulcast

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System Parameters

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%**

Table 1.2: ADTV System Parameters.

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ADTV System Block Diagram

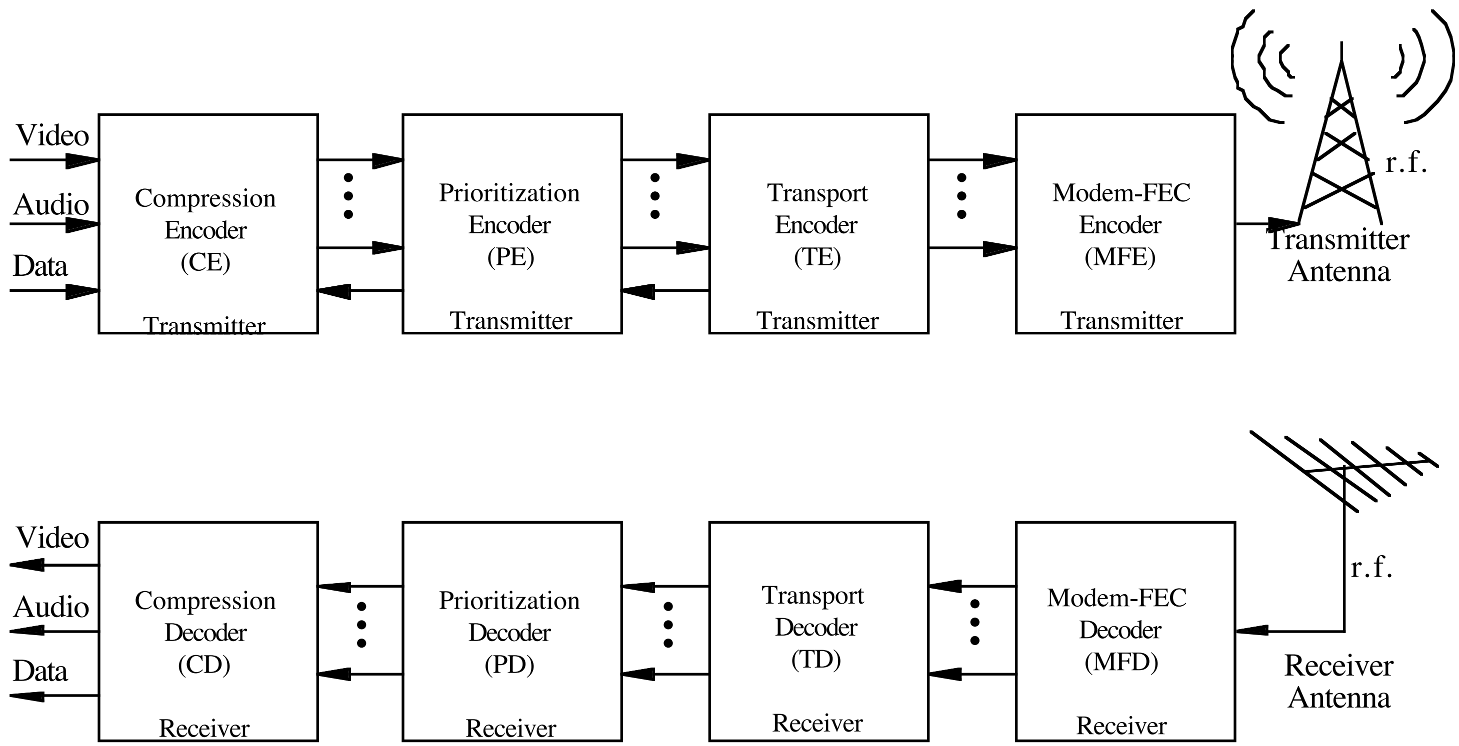

Figure 1.2: Overall System (Transmitter to Receiver).

ADTV System

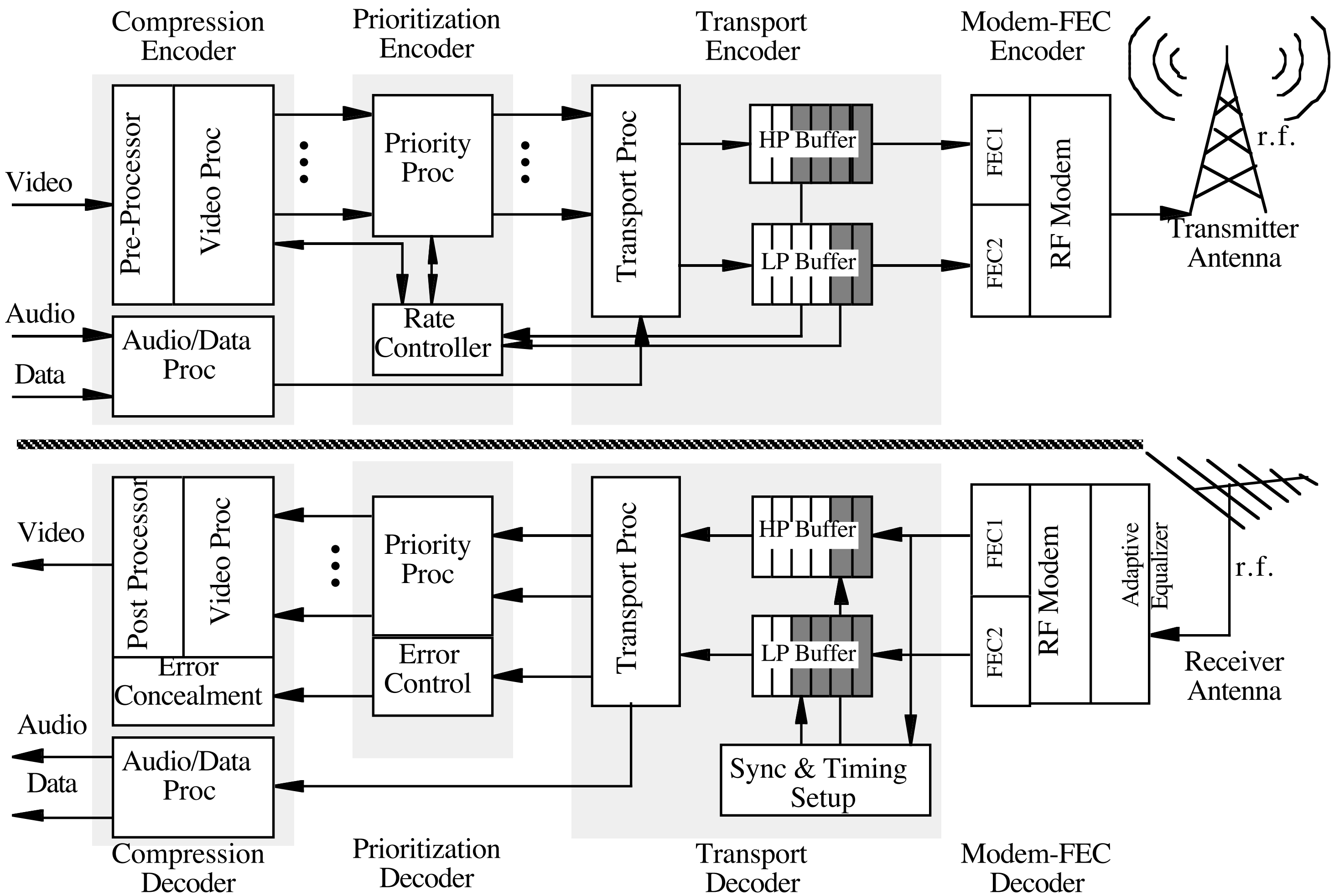

Figure 1.3: Typical Blocks/Modules of Each Layer.

Compression Encoder/Decoder

- Pre- and post-processing for video format operations
- Motion estimation
- Motion-compensated predictive coding
- DCT
- Adaptive quantization
- Variable length coding/decoding
- Error recovery

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Prioritization Encoder/Decoder

- Knows the type of each data element
- Identify channel error protection requirements for each piece of information
- Dynamically assigns priority to data elements
- Rate control

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Transport Encoder/Decoder

- Multiplexes prioritized data into cells
- Adds CRC codes for error detection capability
- Segmentation allows chaining while avoiding error propagation
- Rate buffering

Modem Encoder/Decoder

- Priority-dependent Reed-Solomon FEC codes
- Data interleaving to protect against burst errors
- Spectrally Shaped QAM

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Compression Encoder/Decoder

Pre- and Post-Processing

- **Matrix**

- **A/D and D/A conversion**
  - 1440 (H) x 960 (V)

- **Chrominance down- and up-conversion**
  - 720 (H) x 480 (V)

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Predictive Video Compression

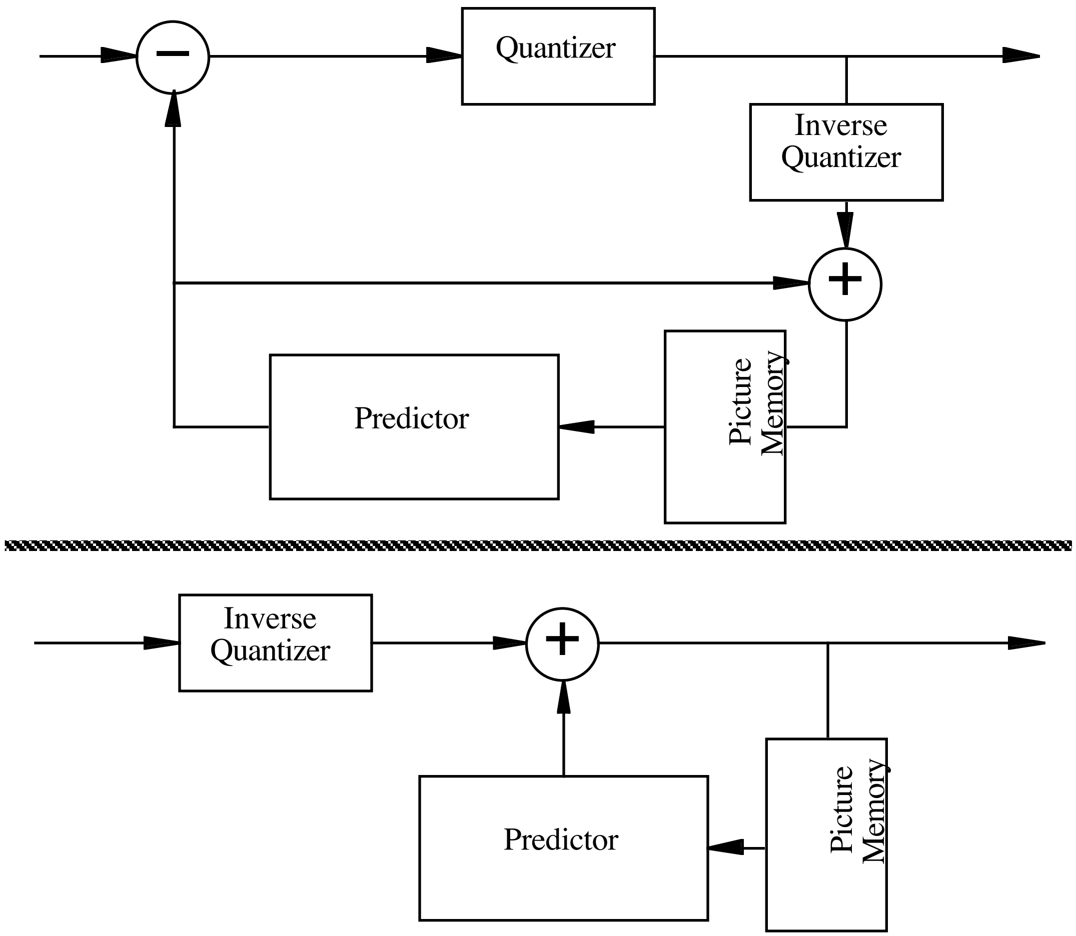

Figure A.1: A Generic Predictive Video Compression Codec.

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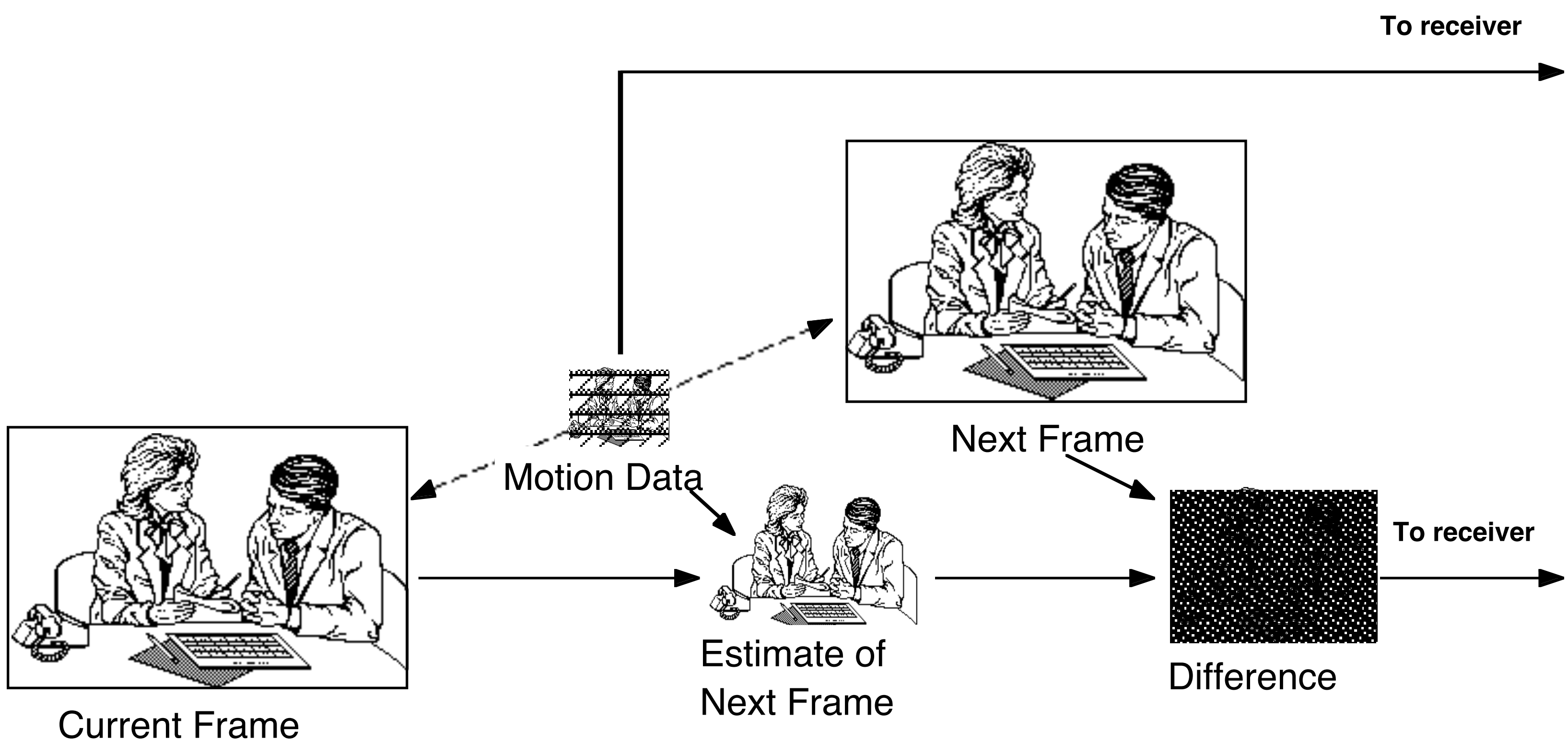
Motion-Compensated Video Compression



Motion-Compensated Video Compression

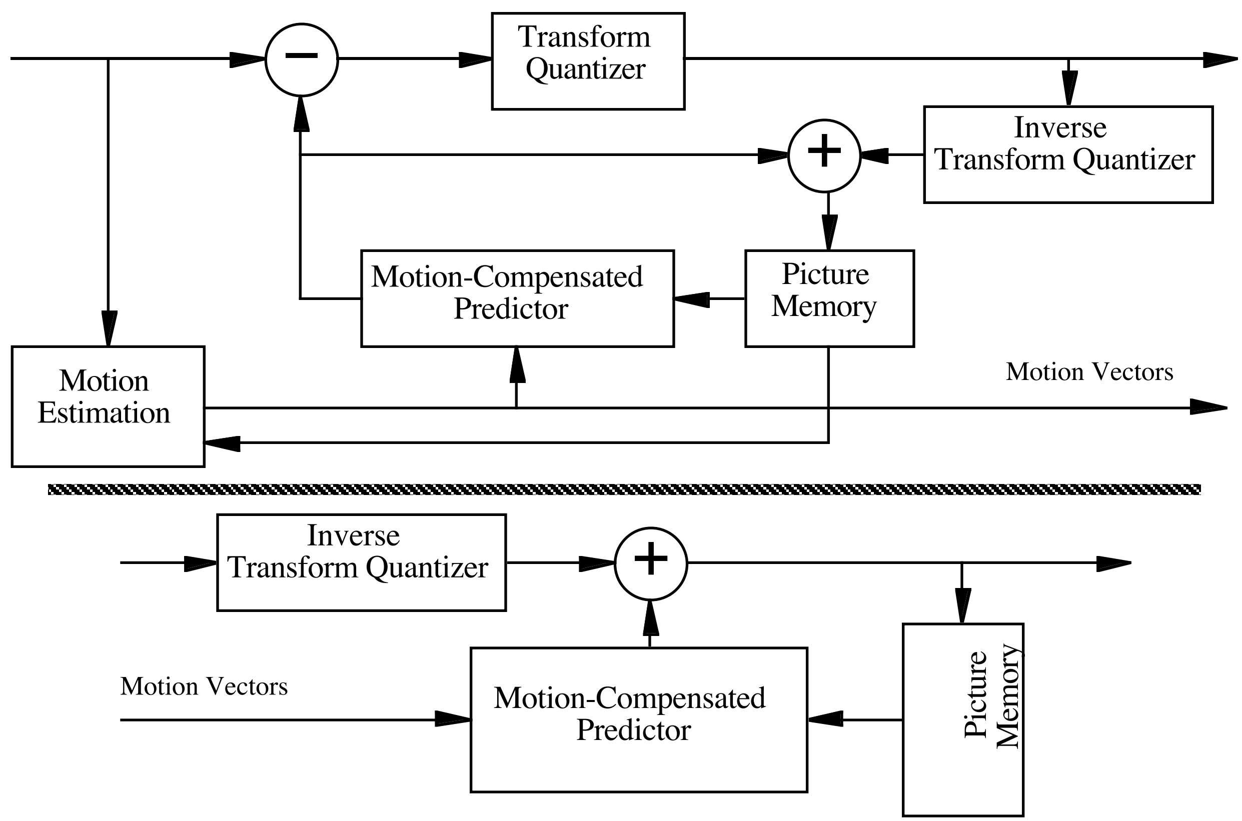


Figure A.2: A Generic Motion-Compensated Predictive Video Codec.

Definition of Terms

Video Sequence	A video sequence is a collection of picture representations and the associated chronological relationship among the pictures.
Picture	A picture is a two dimensional representation of the scene to be displayed. Hereafter in this document, unless specified otherwise, a picture refers to the set of two-dimensional pixel arrays of Y, U, and V representing a particular video raster frame.
Group of Pictures	A Group of Pictures (GOP) is a series of pictures with a particular structure. A GOP comprises up to three types of pictures: the I-frames, the P-frames, and the B-frames. Each type of picture is subjected to (at the encoder side) and reconstructed from (at the decoder side) different coding and decoding processes. An example of a GOP is shown in Figure 2.3.

Group of Pictures

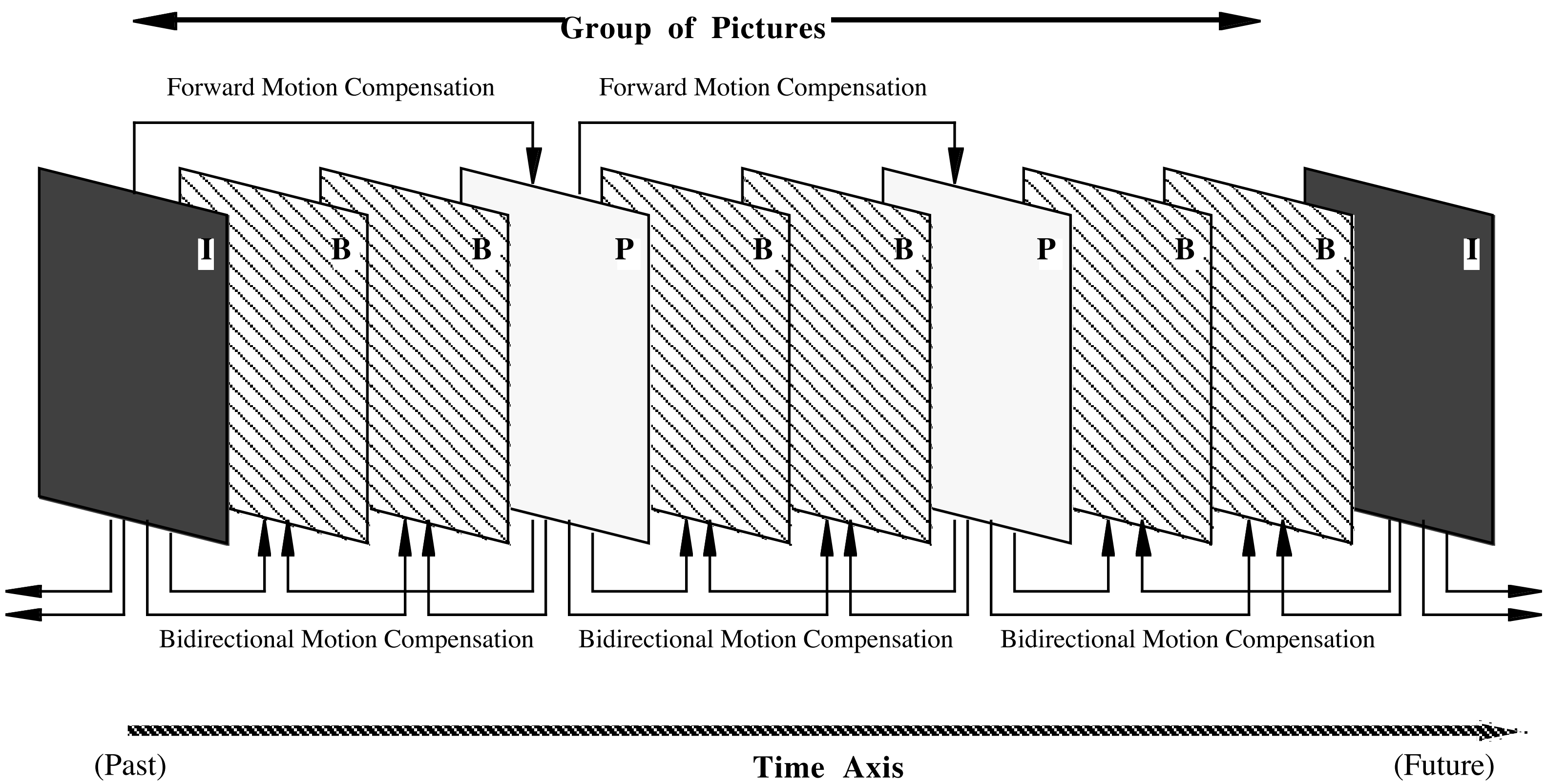


Figure 2.3: An Example of a Group of Pictures.

Definition of Terms, cont'd

I-Frames (Intra-frames)	I-frames are processed by intra-frame operations. They serve as anchors to the temporal prediction and/or interpolation processes.
P-Frames (Predicted-frames)	The compression of P-frames rely on temporal prediction from previous anchor pictures (either I- or P-frames.) The motion compensation is incorporated in the temporal prediction, and because the motion estimation is always from the past into the future, the motion compensation is called *forward* motion compensation.
B-Frames (Bidirectionally-predicted frames)	B-frames are always temporally predicted from two adjacent anchor pictures. The anchor pictures can be either I- or P-frames. The B-frame temporal prediction uses motion compensation in both *forward* and *backward* directions, and hence the name Bidirectional prediction. B-frames are not used in prediction. Figure 2.3 shows the temporal relationship of the three types of pictures.

Definition of Terms, cont'd

Basic Block	For the purpose of performing the Discrete Cosine Transform (DCT), a picture is divided into basic blocks. Each basic block is an 8x8 array of values (pixels or DCT coefficients.) In a picture, the pixels for a particular block are spatially adjacent to each other just as they are in the block, i.e., there is no rearrangement of pixels from the picture to the basic block structure. Figure 2.1 shows a basic block and its relationship to a picture.
Macro Block	A macro block comprises four basic Y blocks and one basic U block and one basic V block. The Y, U, and V blocks corresponds the same spatial area in a picture. Figure 2.2 shows a macro block and its relationship to a picture.
Slice	A slice is a set of integer number of adjacent macro blocks from a picture.

Blocks and Macroblocks

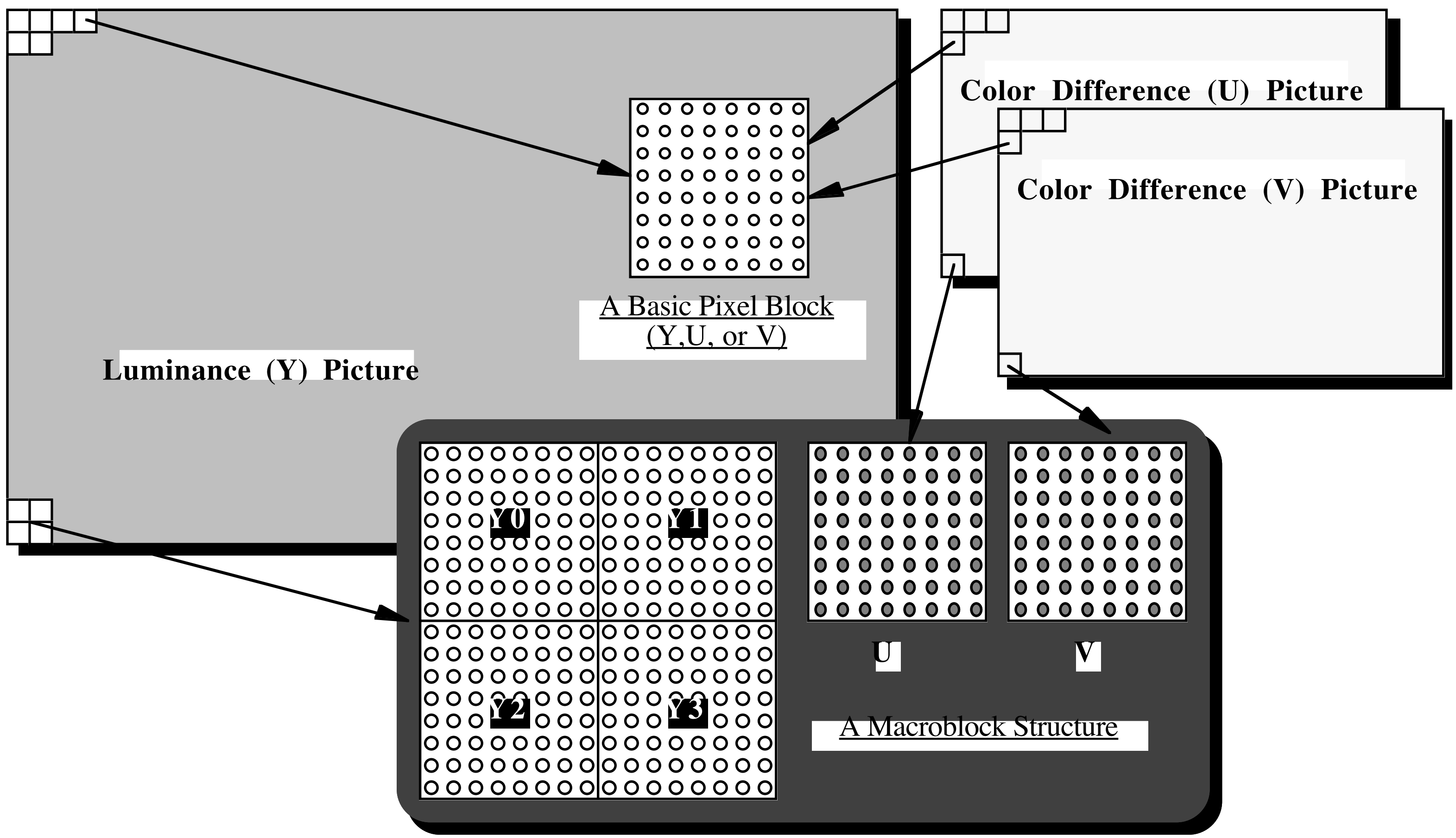
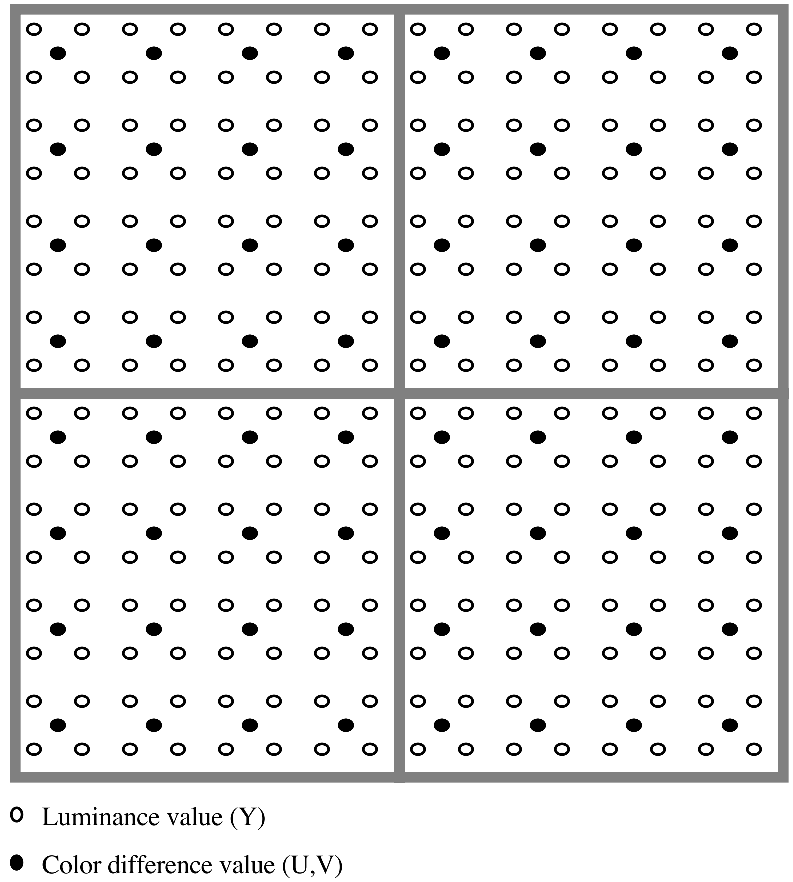


Figure 2.1: Picture Basic Block and Macroblock.

Macroblock Structure

Figure 2.2: Spatial Relationship of Y, U, V Values in a Macroblock.



DCT Zigzag Scan

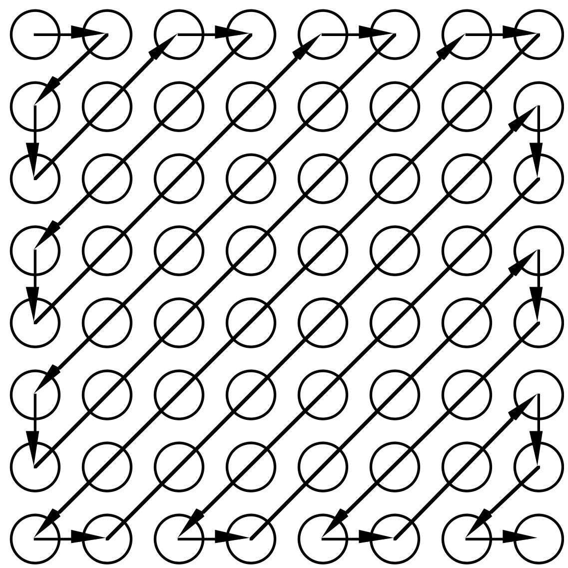


Figure A.3: Zigzag Scanning for an 8 by 8 Block of DCT Coefficients.

Compression Encoder

- **Input Sequencer**

- **Raster line to Macroblock converter**

- **Compression processing**
  - I-frame
  - P-frame
  - B-frame

- **Differential, Run-length and Variable-length Coding**

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Compression Encoder

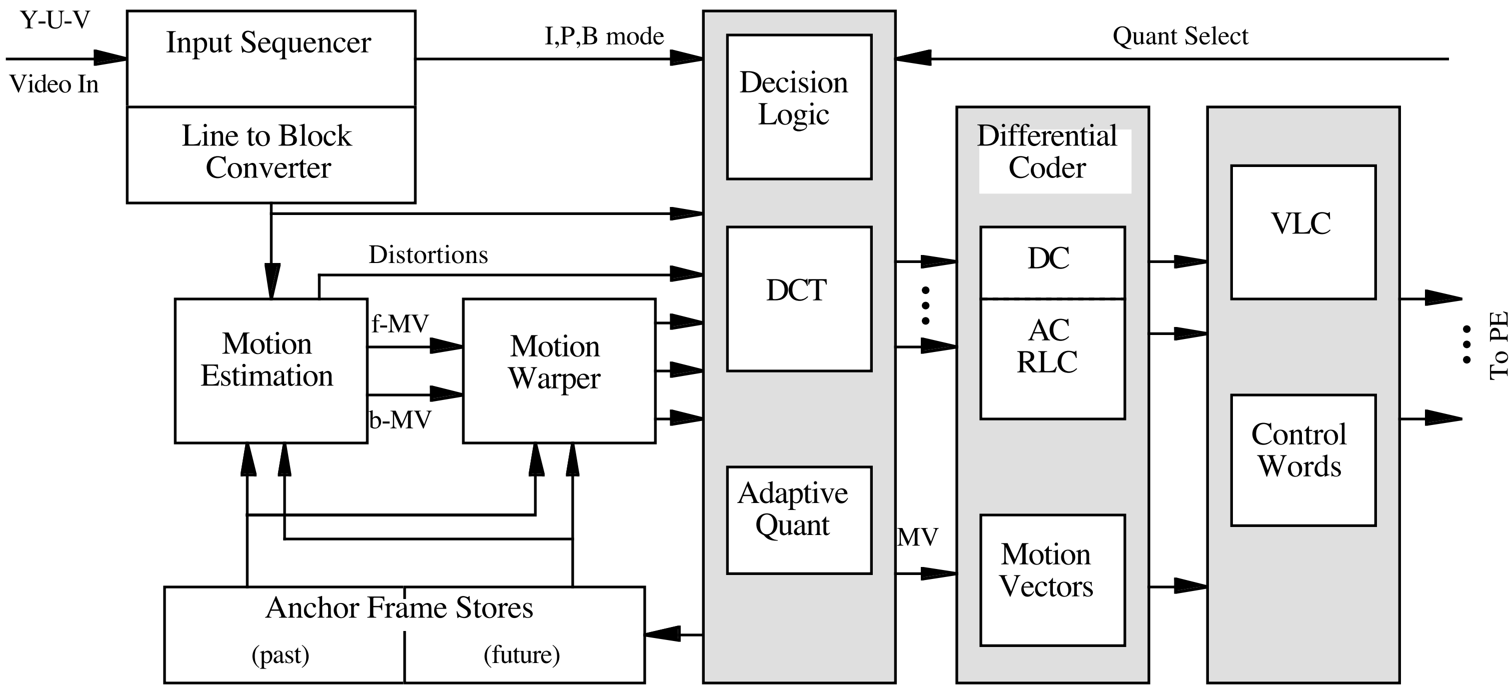

Figure 2.5: Video Compression Encoder.

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Input Sequencer

$$\cdots\ P_{-3}\ B_{-2}\ B_{-1}\ I_0\ B_1\ B_2\ P_3\ B_4\ B_5\ P_6\ B_7\ B_8\ I_9\ \cdots$$

(a) Frame Display Order

$$\cdots\ P_{-3}\ B_{-5}\ B_{-4}\ I_0\ B_{-2}\ B_{-1}\ P_3\ B_1\ B_2\ P_6\ B_4\ B_5\ I_9\ \cdots$$

(b) Frame Process and Transmission Order

Figure 2.4: Display and Process/Transmit Frame Order

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Encoder DCT

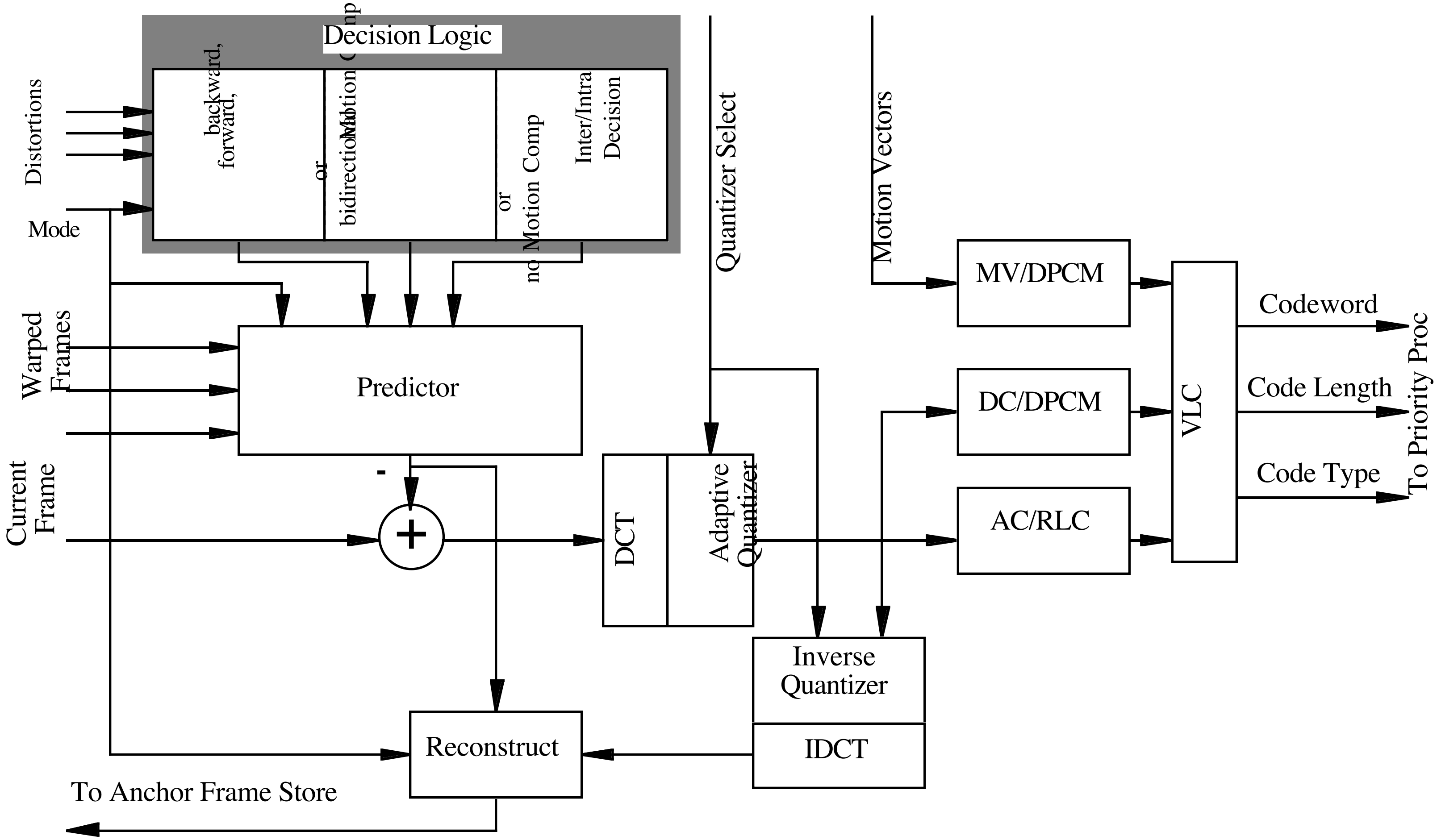

Figure 2.6: Encoder DCT Block.

Video Compression Decoder

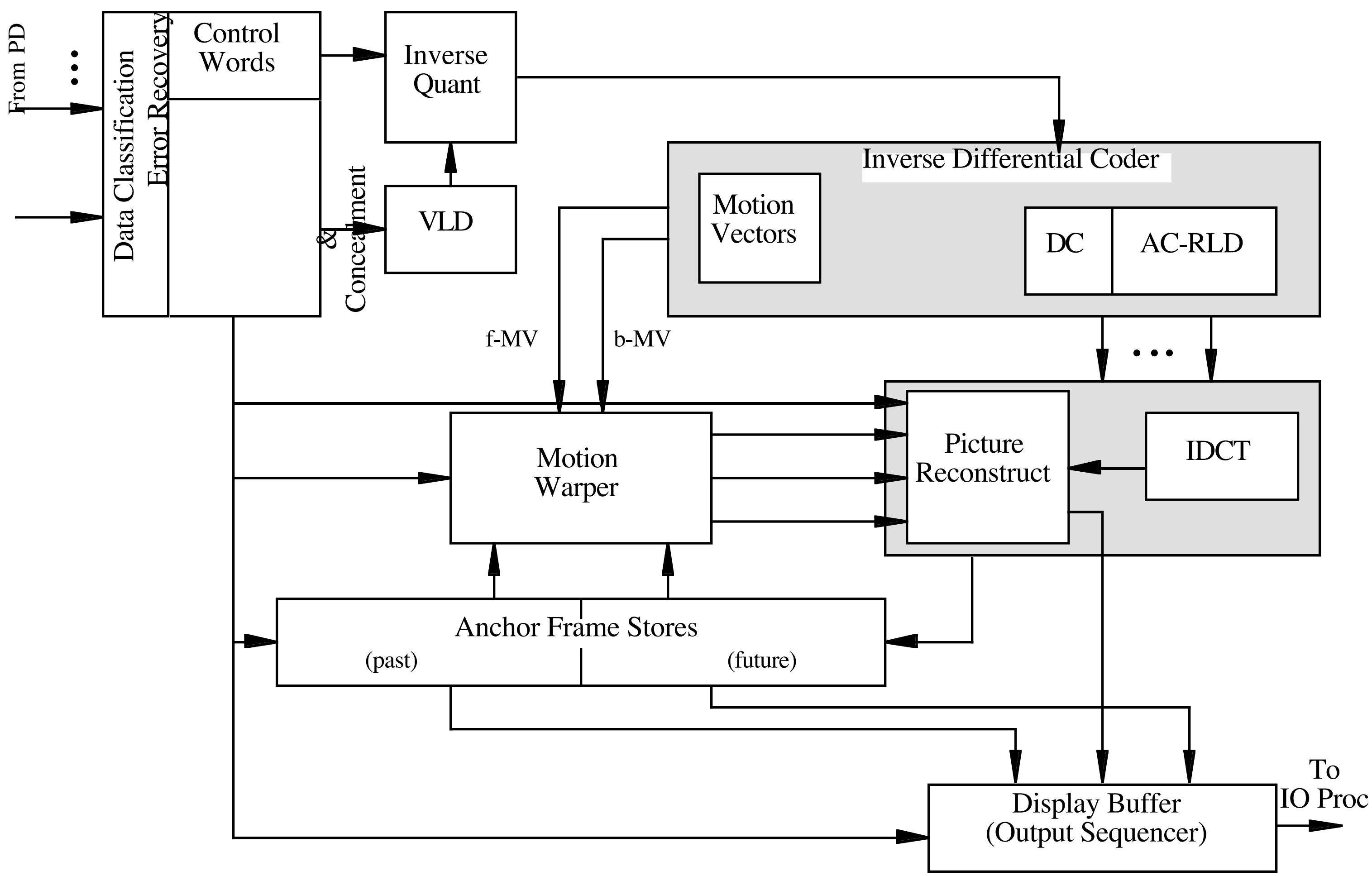

Figure 2.7: Video Compression Decoder.

Receiver Error Recovery

- Unlike computer networks, broadcasting prevents any re-transmission of erroneously-received data
- Error recovery measures must be carried out by each individual reciever
- The specifics of error handling should be at the discretion of reciever manufacturers

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Prioritization Encoder/Decoder

Prioritization Encoder/Decoder

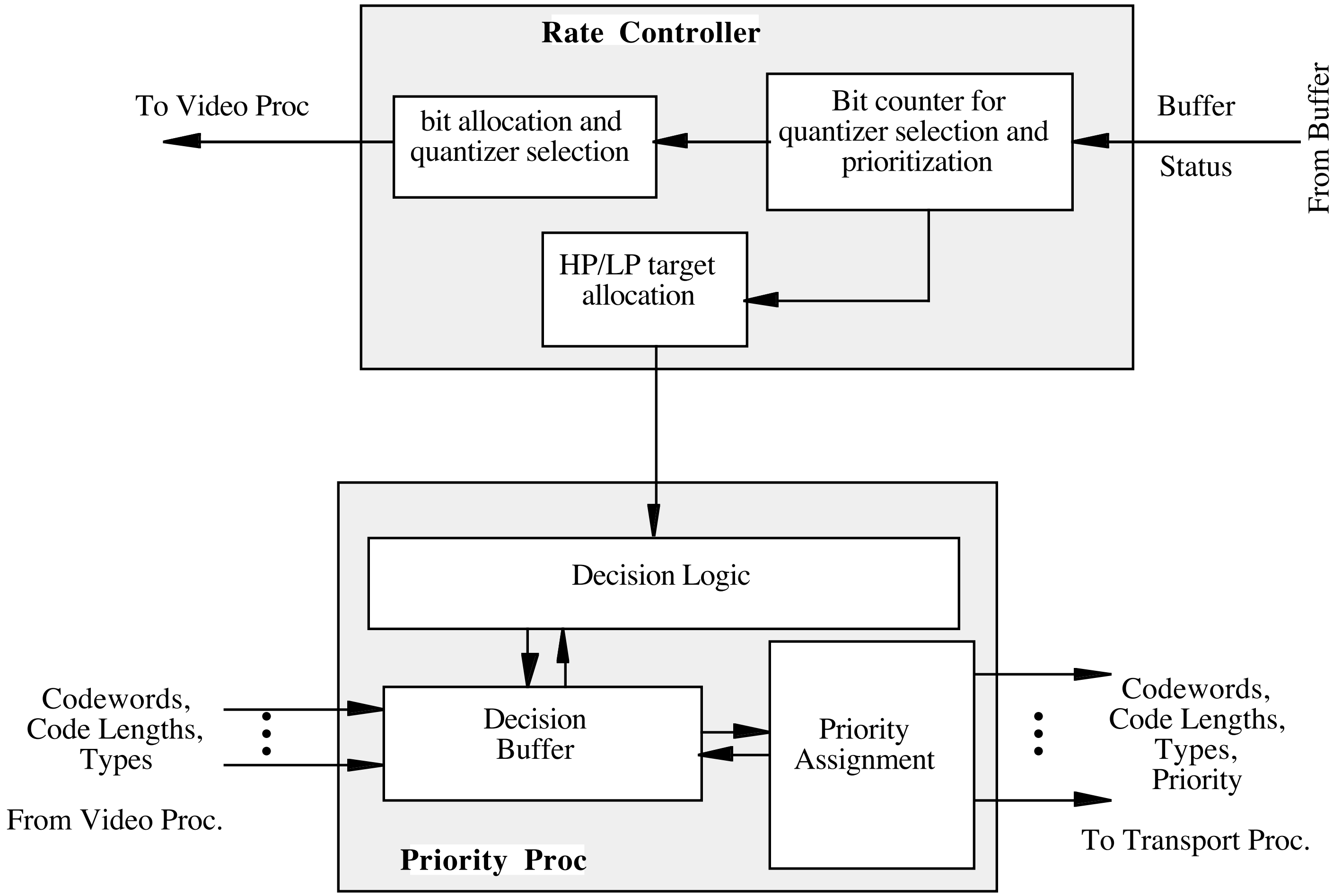

Figure 3.1: Data Prioritization Encoder.

Priority Processor

- **Target-allocation of HP/LP traffic per GOP**
  - based on bits allowed by rate controller
  - pre-allocation of HP and LP bits is performed

- **HP/LP priority assignment**
  - allocation of bits is performed causally

- **Update of the HP/LP allocation within a GOP**
  - based on information from all previously coded GOP frames
  - allocation of HP and LP bits is adjusted for each frame

- **HP/LP allocation updates within each frame**
  - priority analysis interval
  - fine tuning to compensate for transport overhead not included in HP/LP priority assignment

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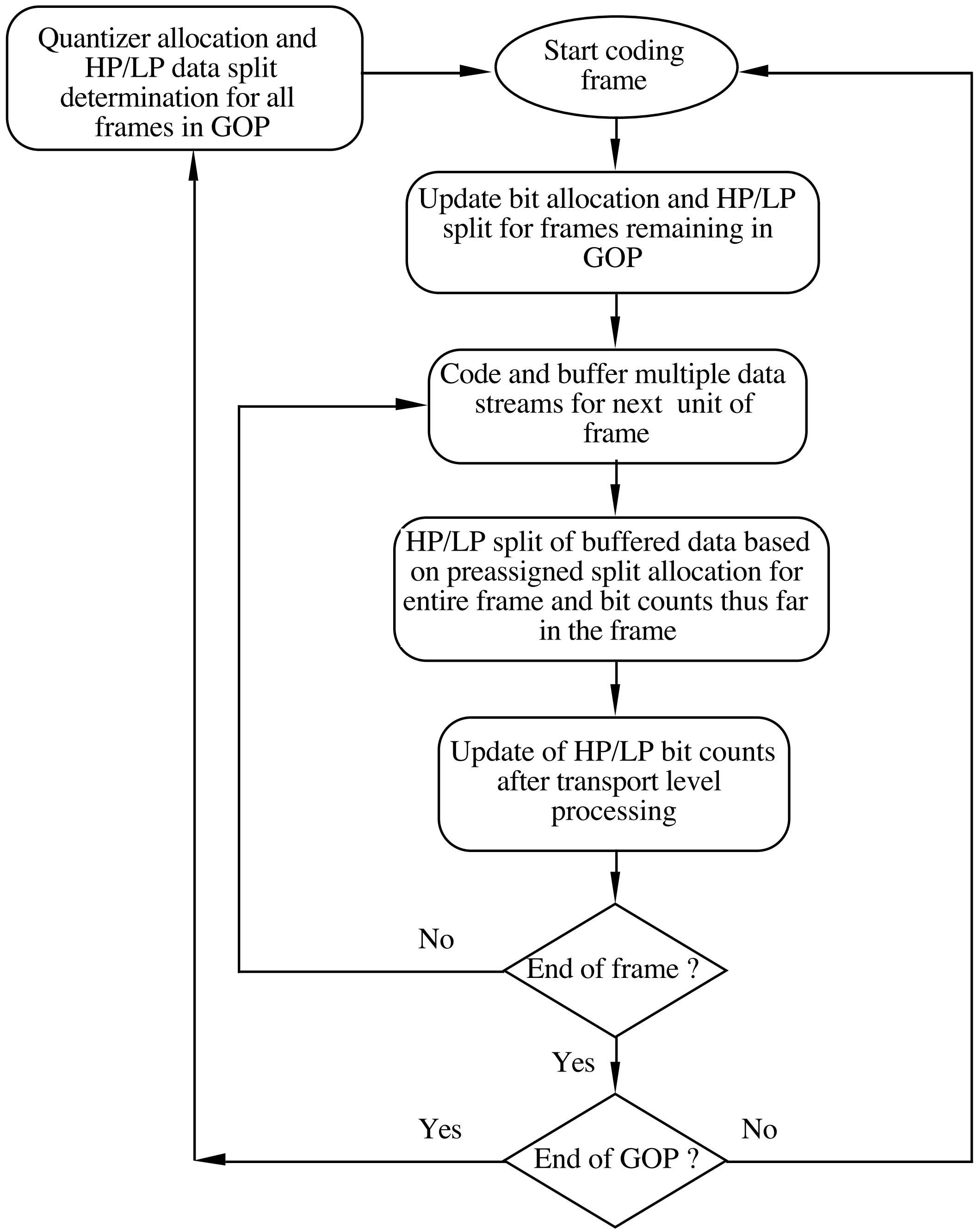

Quantizer allocation and HP/LP data split determination for all frames in GOP
Start coding frame
Update bit allocation and HP/LP split for frames remaining in GOP
Code and buffer multiple data streams for next unit of frame
HP/LP split of buffered data based on preassigned split allocation for entire frame and bit counts thus far in the frame
Update of HP/LP bit counts after transport level processing
No
End of frame ?
Yes
Yes
End of GOP ?
No

Codeword Ranking

- **I-frame codeword ranking**
  1. Headers
  2. DC values
  3. Low frequency coefficients
  4. High frequency coefficients

- **P- and B-frames codeword ranking**
  1. Headers
  2. Motion vectors
  3. DC values
  4. Low frequency coefficients
  5. High frequency coefficients

- **Audio and Auxiliary Data are always HP**

Receiver Priority Processor

- Reconstructs the priority rank list from the received data elements

- Receives error indicators from Transport processor, and notifies Compression Decoder to take appropriate action

Rate Controller

- **Measure buffer occupancy and compute quantization parameters for the Compression Encoder**

- **HP/LP rate allocation**
  - measure HP and LP buffers
  - compute HP:LP target ratio

- **Quantization Control**
  - compute compression parameters for next slice/macroblock
  - goal is to achieve equal picture quality within a GOP while keeping the rate allocation within a defined range

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Transport Encoder/Decoder

Transport Encoder

- **Package data elements into *cells***
  - fixed size data packet
  - header field is dependent on payload data
  - trailer field contains FEC bits
- **Receives data element, type, and priority information**
- **Generates appropriate header fields for data groups**
- **Receives additional slice and macroblock level information for segmentation and chaining**
  - segmentation provides efficiency in using fixed-size cells
  - limits propagation of errors from one cell to the next

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Transport Cell Format

- **Cell size** **256 Bytes**
- **Link-level Overhead** **3 Bytes (1.1%)**
- **Payload Size** **253 Bytes (98.8%)**

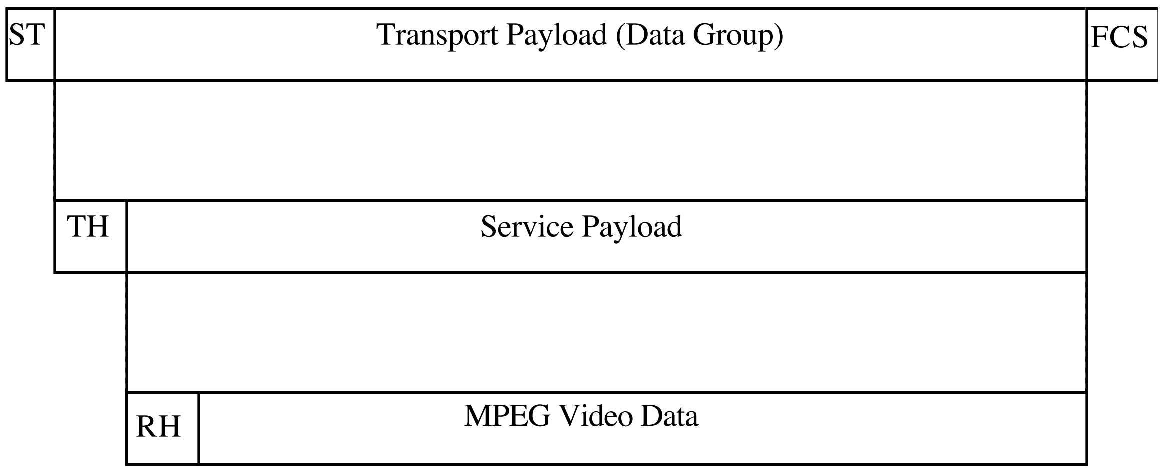

Figure 4.1: Transport Cell Structure.

Transport Cell Format

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

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

- **Transport header**
  - provides chaining and segmentation capability
  - provides opportunity for error indication

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

Transport Decoder

- Attain cell synchronization
- Perform CRC check
- Always maintains cell sequencing
- Header information allows data group resynchronization immaediately following an erroneous cell
- Pass data group error information to the Priority Decoder

Rate Buffering

- Elastic rate buffers in the transmitter smooth out rate variations and provide a constant bit rate for the modem
- Elastic rate buffers in the reciever are complementary, and provide an overall fixed delay
- Transmitter buffer states are sent at GOP intervals to allow complete complementary synchronization

Modem-FEC Encoder/Decoder

RF Transmission Problems

- Terrestrial channel is *very* challenging one
- There can be as much as 20-30 db signal strength variation at a given location
- Noise is not stationary (impulse, etc.)
- Co-channel interference is a “jamming” signal
- Need to minimize interference with NTSC channels

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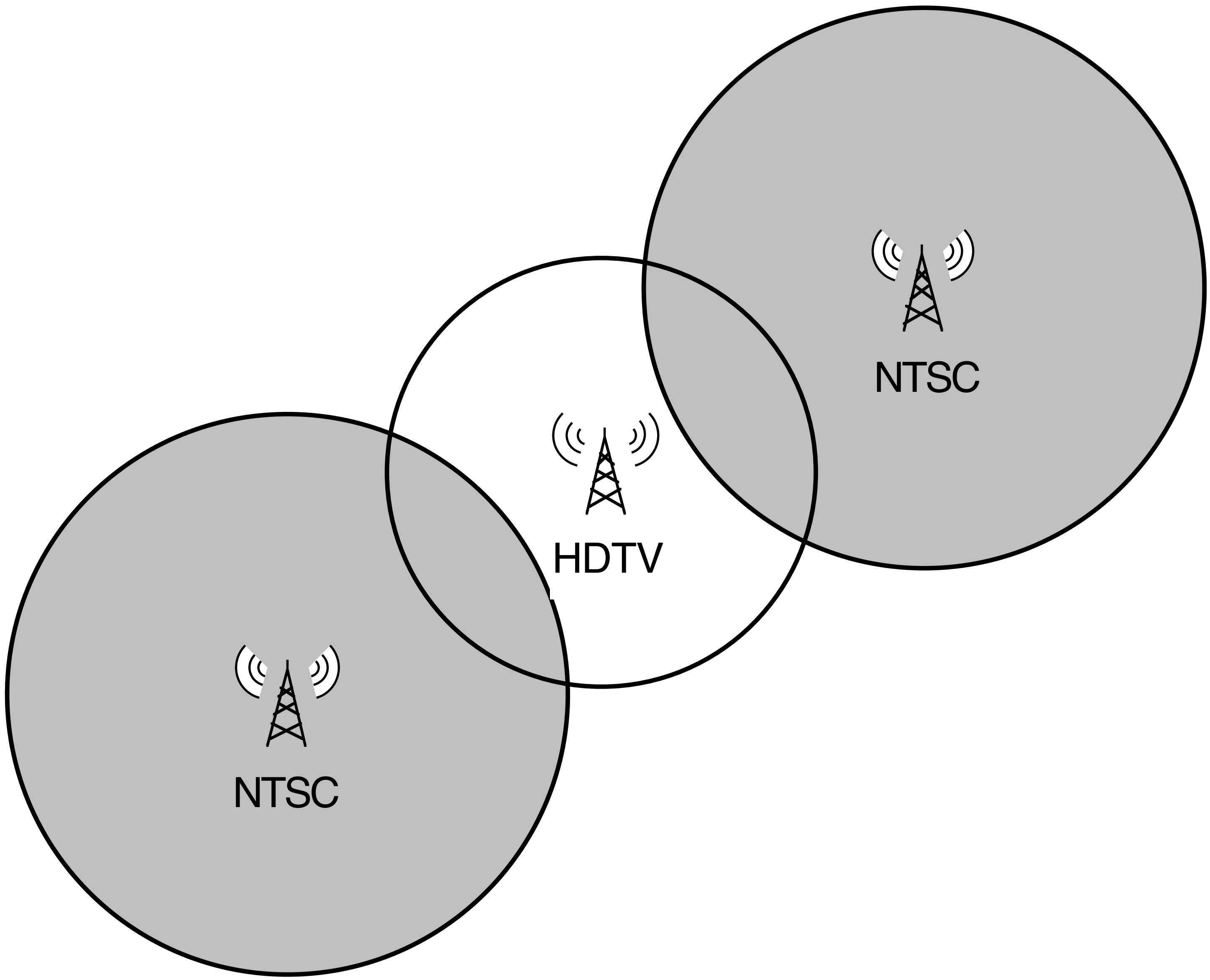
Simulcast Co-Channel Allocation



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RF Interference Issues

- **NTSC characteristics**
  - Picture, color and sound carriers
  - RF peak power at sync tips
  - Harmonic/spectral structure related at line and field frequency multiples
  - Artifacts created by external interference are strongly dependent on their spectral and time structures
- **Digital ATV characteristics**
  - noise-like spectrum, without strong specular components
  - robustness (tolerance to high levels of noise and interference) is a strong requirement
  - should create low interference to co-channel NTSC
  - robustness and low NTSC interference are contradictory
  - trade-off between the two factors depends upon channel spectrum allocation scenarios
  - performance of ADTV and any digital ATV will depend upon the spectrum allocation rules (to be decided by industry and/or the FCC)
- **Working with SS/WP-3 to address interference issues**

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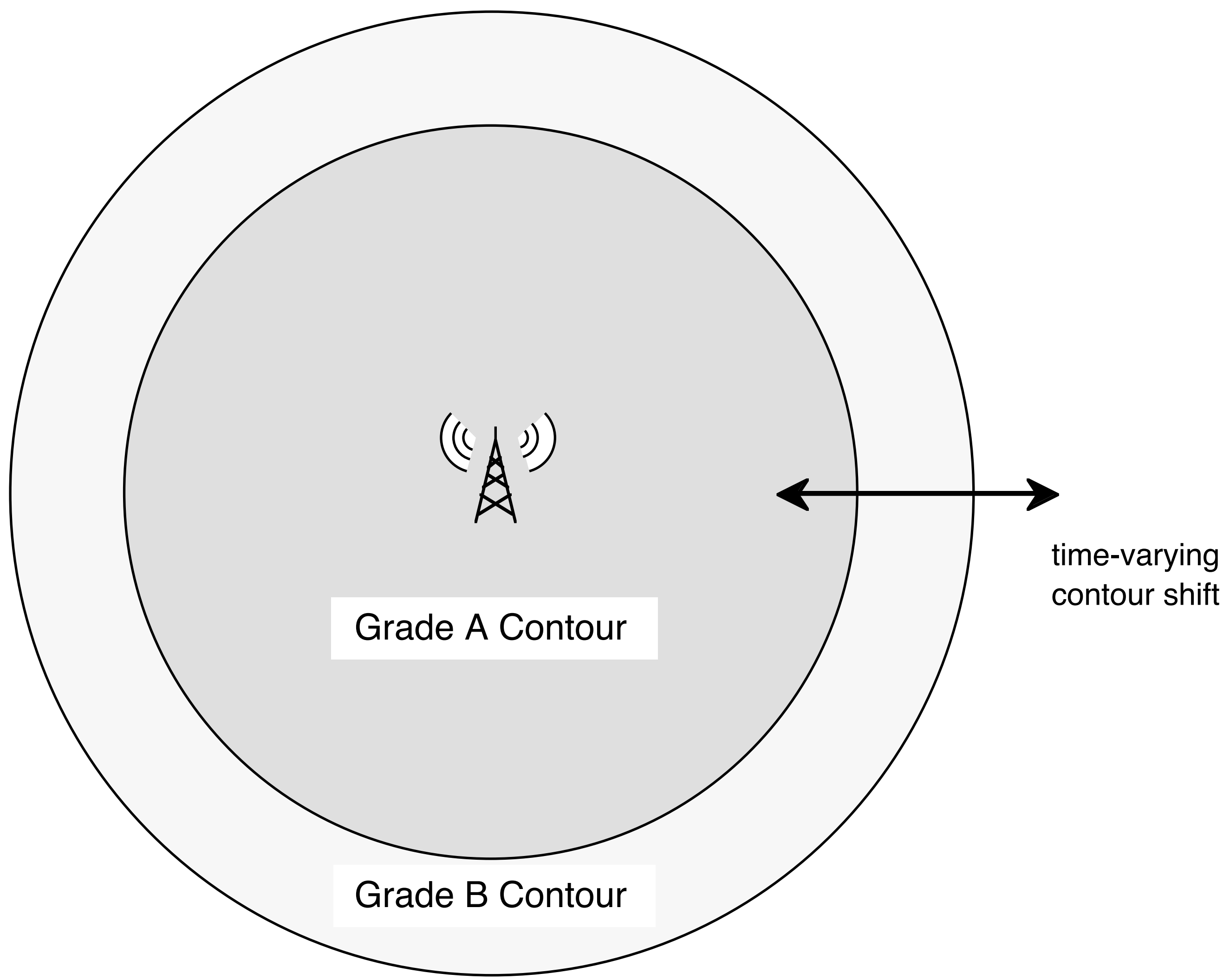
ADTV Coverage Area



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Exciter and Transmitter Components

Forward Error Correction

- **Reduce transmission errors to an acceptable level**
  - 10^{-6} BER means 20 errors every second
  - 10^{-8} BER means 1 error every five seconds
  - 10^{-10} BER means 1 error every 8.33 minutes

- **Insert sync and framing information to identify block and interleaving boundaries**

- **Insert Reed-Solomon codes**
  - Reed-Solomon coding on 8-bit bytes
  - error correction per FEC block: 8 to 10 bytes

- **Interleave bytes over multiple blocks to mitigate the effects of burst errors**

Data Modulator

- **Spectrally shaped QAM modulation**

- **Shaping parameters are being optimized**

- **NTSC friendly attributes due to rejection of ADTV components by NTSC receiver, and low sensitivity of ADTV to NTSC interference**

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QAM Modulator

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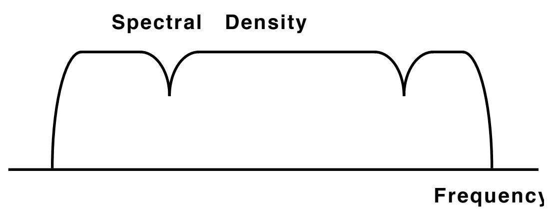
ADTV Channel Spectrum



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High Power Amplifier (HPA)

- Klystrons, Klystrodes, or Tetrodes, with "good linearity" are required

- Linearity (as a function of power) requirement depends on out-of-band emission, which is more in digital ATV systems than in NTSC

- Linearity requirement depends, to a lesser degree, on in-band intermodulation component levels

- Pulsed Klystrons are to be avoided, because of strong nonlinear behavior during pulsing

- Peak-to-average power ratio is being optimized in conjunction with spectral shaping. It is likely to be in the range of 5 to 7 dB

- HPA power required depends upon coverage requirements, and gain of the antenna system

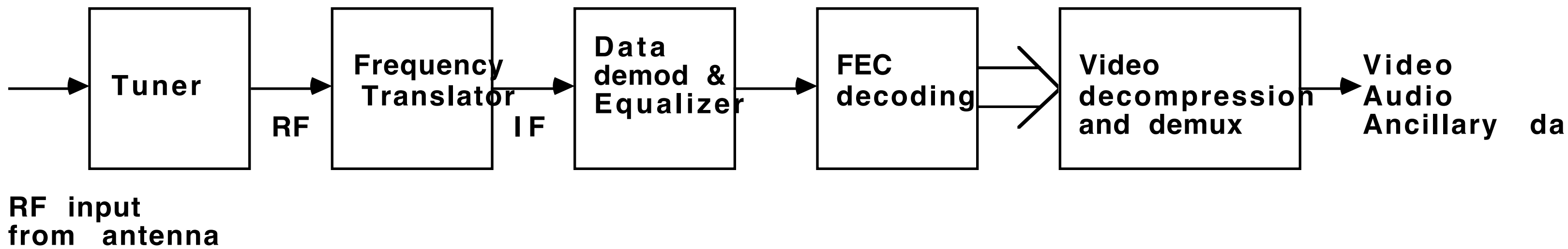
Other Components

- **RF Filtering (Filterplex)**
  - not mandatory
  - depends upon HPA out-of-band emission levels

- **Antenna and Feed Systems**
  - Frequency response requirement (including HPA)
    Amplitude: -0.5 to +0.5 dB in 6 MHz
    Group Delay variation: No more than 50 ns
  - Experiments to be done in the near future may show that these can be relaxed to -0.75 to +0.75 dB and 75 ns)

- **ATRC is developing transmitter hardware specifications along with SS/WP-2 Field Testing Task Force**

ADTV Receiver



- **Tuner: Good quality standard TV receiver tuner**

- **Equalizer**
  - Cancels single and multiple ghosts, up to 16 microseconds
  - Range may be extended to 40 microseconds
  - Integral part of the digital modem

ADTV On Cable TV Channels

- To transmit ADTV no major upgrades of headend or transmission equipment are necessary
- Demodulation of off-air channel to bits and remodulation is not mandatory, although such a regeneration is a good practice, in general
- ADTV will coexist with NTSC adjacent channels
- ADTV can be transmitted as 6 MHz baseband in FM Super Trunks, or as 6 MHz "standard" channel in Fiber Optic AM Trunks
- ADTV is expected to be transparent to reasonable quality set-top-converters
- Additional research to address Cable TV issues is in progress

ADTV On Satellite Channels

- **Three ADTV channels can be transmitted through a conventional single C- or Ku-band transponder of 36 MHz bandwidth**
  - Satellite modulation assumed is Quaternary Phase Shift Keying (QPSK) at 60 Mbps data rate
  - Bits received from satellite link can be inexpensively remodulated to 6 MHz ADTV format
  - Remodulation does not involve major frame restructuring, insertion of headers, or new FEC for cable transmission

- **Two ADTV channels can be transmitted through a DBS transponder (24 MHz bandwidth), using a 40 Mbps QPSK modulated data stream**

PREDICTION OF COVERAGE

I. SYSTEM INDEPENDENT PARAMETERS, SCENARIOS, ASSUMPTIONS AND METHODS

A. FCC STATISTICAL FIELD STRENGTH PREDICTION PROCEDURES

- FCC(50/50): PREDICTS FIELD 30' ABOVE GROUND EXCEEDED AT 50% OF LOCATIONS 50% OF THE TIME. USED TO PREDICT DESIRED SIGNAL IN D/U CALCULATIONS.

- FCC(50,10): EXCEEDED 10% OF THE TIME. USED TO PREDICT UNDESIRED SIGNAL IN D/U CALCULATIONS.

- FCC(50,90): EXCEEDED 90% OF THE TIME. USED IN CALCULATIONS OF CNR (RECEPTION PLANNING FACTORS)

B. RECEPTION PLANNING FACTORS

- ANTENNA GAIN, CABLE LOSSES, NOISE FIGURE, FCC(50,50) - FCC(50,90).

- DESIRED TO UNDESIRED DISCRIMINATION OF RECEIVING ANTENNA.

PREDICTION OF COVERAGE

I. SYSTEM INDEPENDENT PARAMETERS (continued)

C. GRADE B CONTOUR (NTSC)

- FCC(50/50)= 64 DBmV/m for UHF (56 @ HVHF, 47 @ LVHF)
- CNR(TASO) = 28.5 dB WITH STANDARD FCC PLANNING FACTORS
- CNR(TASO) = $\frac{\text{AVAILABLE POWER AT PEAK OF SYNC}}{\text{EQV. AVAIL NOISE POWER IN 6 MHz CHANNEL}}$
- GRADE B CONTOUR IS USUALLY CONSIDERED AS LIMIT OF CIRCULATION BUT VARIATIONS IN RECEPTION CONDITIONS INSIDE AND OUTSIDE GRADE-B CONTOUR ARE VERY LARGE.

D. SUMMARY AND WARNING

- WHILE THERE IS GENERAL AGREEMENT OF USING THE METHODS OUTLINED ABOVE TO PREDICT COVERAGE ALL PARAMETERS AND ASSUMPTIONS MUST BE COMPLETELY SPECIFIED. NO GENERAL CONCLUSIONS ABOUT COVERAGE EVERYWHERE SHOULD BE BASED ON A FEW ILLUSTRATIVE SCENARIOS.

PREDICTION OF COVERAGE

II. SYSTEM DEPENDENT PARAMETERS, SCENARIOS, ASSUMPTIONS AND METHODS

A. DEFINITIONS:

- AVERAGE AND PEAK POWER (PEAK-TO-RMS RATIO)
- D/U RATIOS

B. D/U RATIOS (NEEDS MEASUREMENT AND SUBJECTIVE TESTS)

- NTSC Æ NTSC: WITH PRECISE CARRIER FREQUENCY OFFSET (10010 +/- 1 AND 20020 +/- 1 Hz) CCIR CONSIDERS A D/U RATIO = 28 dB AS TOLERABLE
- ATV Æ NTSC: SUBJECTIVE AND SYSTEM DEPENDENT
- NTSC Æ ATV: DEFINITION AND SYSTEM DEPENDENT
- ATV Æ ATV: DEFINITION AND SYSTEM DEPENDENT

PREDICTION OF COVERAGE 4

III. ATV COVERAGE LIMITED BY NOISE AND TRANSMITTER POWER

- **DEFINITIONS**

$$CNRA = \frac{\text{AVERAGE SIGNAL POWER}}{\text{NOISE POWER IN 6 MHz CHANNEL}}$$

$$CNRP = \frac{\text{PEAK SIGNAL POWER}}{\text{NOISE POWER IN 6 MHz CHANNEL}}$$

- **CNR AT GRADE B FIELD WITH FCC PLANNING FACTORS**

	NTSC	ADTV (Approx)
CNRA	- - -	20 dB
CNRP	28.5 dB	25.5 dB

- **WITH ANTICIPATED ADTV RECEPTION PLANNING FACTORS TO BE AT LEAST 7 dB BETTER THAN FCC PLANNING FACTORS, ADTV HAS THE SAME COVERAGE AS NTSC WITH PEAK POWER 10 dB BELOW AND AVERAGE POWER 15 dB BELOW NTSC PEAK POWER.**

PREDICTIONS OF COVERAGE

IV. ATV COVERAGE LIMITED BY NTSC COCHANNEL INTERFERENCE

- **ATV INTERFERENCE INTO NTSC**

  PRELIMINARY TESTS INDICATE THAT ALL DIGITAL SIGNALS INTERFERING INTO NTSC-TV TEND TO LOOK LIKE RANDOM NOISE. HOW MUCH INTERFERENCE IS TOLERABLE, FOR EXAMPLE, IN COMPARISON WITH -28 dB PRECISE OFFSET NTSC INTO NTSC COCHANNEL INTERFERENCE MUST BE DETERMINED BY SUBJECTIVE TESTS ON TYPICAL RECEIVERS RECEIVING NTSC SIGNALS OF QUALITY TYPICAL FOR QUALITY IN AREAS WHICH MAY BE EXPOSED TO ATV COCHANNEL INTERFERENCE.

- **ADTV SIGNAL IS DESIGNED TO MINIMIZE INTERFERENCE INTO NTSC RECEIVERS.**

PREDICTION OF COVERAGE

- **NTSC INTERFERENCE INTO ADTV**

  THE ADTV SIGNAL IS DESIGNED TO BE SO TOLERANT TO NTSC COCHANNEL INTERFERENCE THAT NTSC-INTERFERENCE INTO ADTV IS RARELY GOING TO BE THE FACTOR WHICH LIMITS ADTV COVERAGE.

- **INTERFERENCE INTO NTSC OF ADTV IN TABOO CHANNELS**

  DUE TO LOWER RADIATED POWER FROM ADTV STATIONS THAN FROM NTSC STATIONS NO SIGNIFICANT TABOO-CHANNEL PROBLEMS ARE ANTICIPATED AT THIS TIME. HOWEVER, WE SUPPORT A REVISION OF TABOO CHANNEL RULES, FOR EXAMPLE, FOR CO-LOCATION OF TABOO CHANNELS.

PREDICTIONS OF COVERAGE

V. COMMENTS ON SPECIFIC SCENARIOS (NOTE PREVIOUS WARNING)

A. SCENARIO IN ZENITH TECHNICAL DESCRIPTION (2/22/91)

- WE GENERALLY AGREE ON THE METHODS AND THE CALCULATION MADE USING FCC(50/50) AND FCC(50/10) FIELD STRENGTH PREDICTION PROCEDURES.

- WE REISSUE A WARNING THAT THIS IS ONLY ONE SCENARIO OF MANY POSSIBLE ONES.

- THE SCENARIO IS SOMEWHAT EXTREME AS A BASIS FOR ASSESSING TOLERABLE COCHANNEL INTERFERENCE. UHF-TV-COCHANNELS WITH PRECISE OFFSET RADIATING MAXIMUM POWER (5 MW) ARE SPACED AT MINIMUM DISTANCE (155 MILES) AND INTERFERE WITH EACH OTHER 15 MILES INTO GRADE-B CONTOURS WITH 28 dB D/U RATIOS ASSUMING A RECEIVING ANTENNA WITH A FRONT TO BACK RATIO OF ONLY 6 dB.

PREDICTIONS OF COVERAGE

- THE EXACT AMOUNT OF TOLERABLE ATV INTERFERENCE INTO NTSC WHICH LEADS TO A RANGE OF REDUCED ATV POWER (12 TO 23 dB) FROM AN ATV STATION 100 MILES AWAY IS NOT CLEAR. LATER THE 12 dB REDUCTION IS USED TO CALCULATE THE ATV COVERAGE LIMITED BY NOISE.

- HOWEVER, WE AGREE WITH THE ZENITH CONCLUSION ON PAGE 28 THAT THE ATV SYSTEM MUST BE VERY TOLERANT TO COCHANNEL INTERFERENCE FROM NTSC STATION. THE ADTV SYSTEM CERTAINLY MEETS THAT REQUIREMENT.

- WE HAVE CALCULATED MANY OTHER SCENARIOS INCLUDING MORE TYPICAL RADIATED TV-POWER, MORE TYPICAL STATION SPACINGS AND MORE TYPICAL RECEIVING ANTENNA PATTERNS.

- WE CONCLUDE THAT LOCAL SCENARIOS ARE VASTLY DIFFERENT AND REQUIRE DIFFERENT APPROACHES TO ATV STATION ALLOCATION FOR OPTIMUM COVERAGE.

PREDICTION OF COVERAGE

CONCLUSIONS

- FCC PROCEDURES USED FOR TV-COVERAGE PREDICTIONS CAN EFFECTIVELY BE APPLIED TO ATV-COVERAGE PROVIDED ALL PARAMETERS AND ASSUMPTIONS ARE SPECIFIED.
- OPTIMUM COVERAGE REQUIRES A VARIETY OF APPROACHES TO DIFFERENT LOCAL SCENARIOS.
- THE KEY SYSTEM DEPENDENT PARAMETERS ARE:

  CNRs (FOR AVERAGE AND PEAK SIGNAL POWER)

  D/U RATIOS: ATV INTO NTSC
NTSC INTO ATV
- THE ADTV SYSTEM IS SPECIFICALLY DESIGNED TO OPTIMIZE CNRs AND D/U RATIOS FOR BEST COVERAGE.

" ATRC

Summary

ADTV Summary

...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

- **Prioritized Data Transport**
  - 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**

" **ATRC**

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