MPEG-4 Video Coder
A Robustness Point of View

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Introduction

- Real-time video transmission is difficult because of constraints on bandwidth, delay, complexity and channel reliability.

- Delay-sensitive by definition and cannot easily make use of retransmission.

- Variable-rate nature and extensive use of entropy coding renders compressed stream vulnerable to errors.

Current Video Coding Standards

- ISO (MPEG-1/2/4) and ITU (H.324, specifically H.263 and related video codecs)

- Common approach: combine block-based motion compensation with DCT coding of the prediction error.

- Both motion-compensation information and transformed prediction error are coded using VLC, which leads to error-vulnerability.

Research into Robustness

- Layered source coding, classified bit streams, combined source-channel coding, FEC, ARQ, error concealment, etc.

- Wireline standards compatibility is important, solutions for wireless video should involve little transcoding.

- MPEG-4 is designed with low bit-rate video coding and error resilience in mind.

How to Evaluate?

- Random error channel, packet-lossy channels and bursty channels are simulated.
- Evaluation criteria include: PSNR, fraction of bits in error, fraction of frames in error, overhead.
- Only simple error concealment techniques are used.

MPEG-4 Introduction

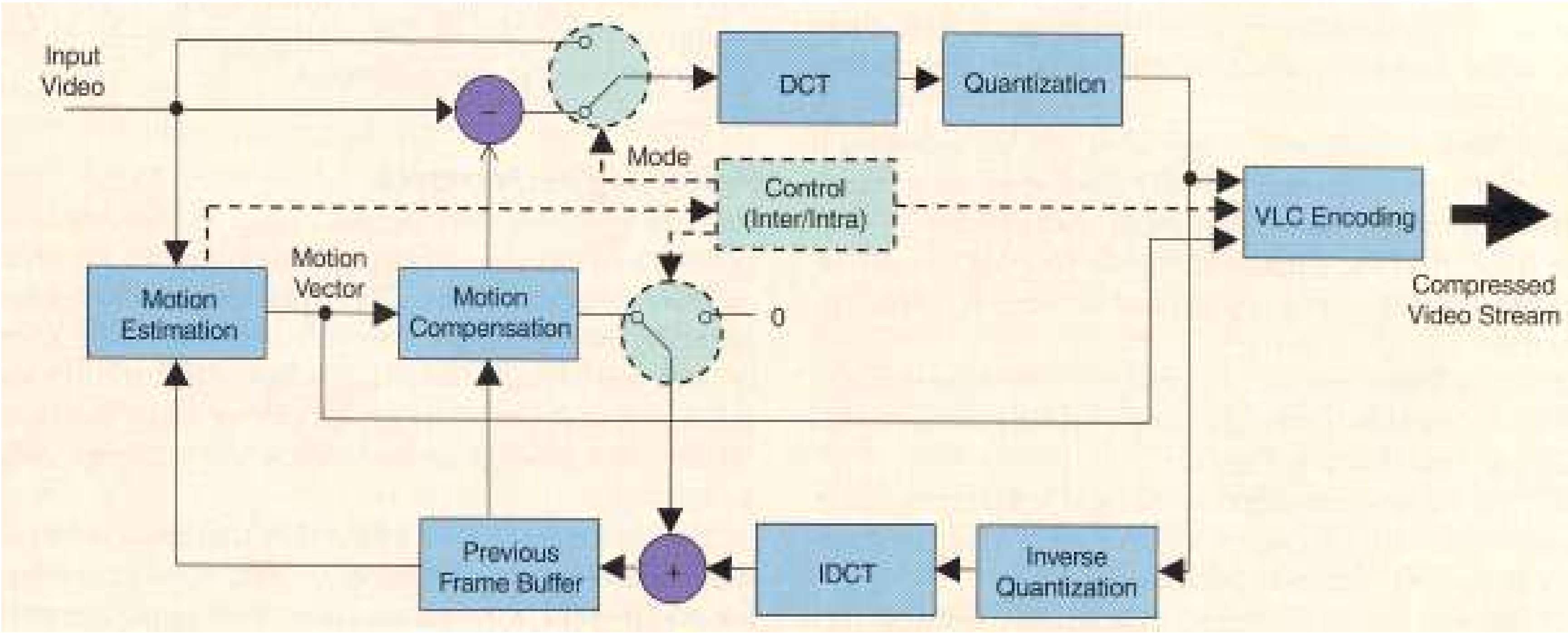
- Video Objects (VO) is used.

- Two main parts: shape coder and the traditional motion/DCT coder applied to VOP, VOL instead of GOB.

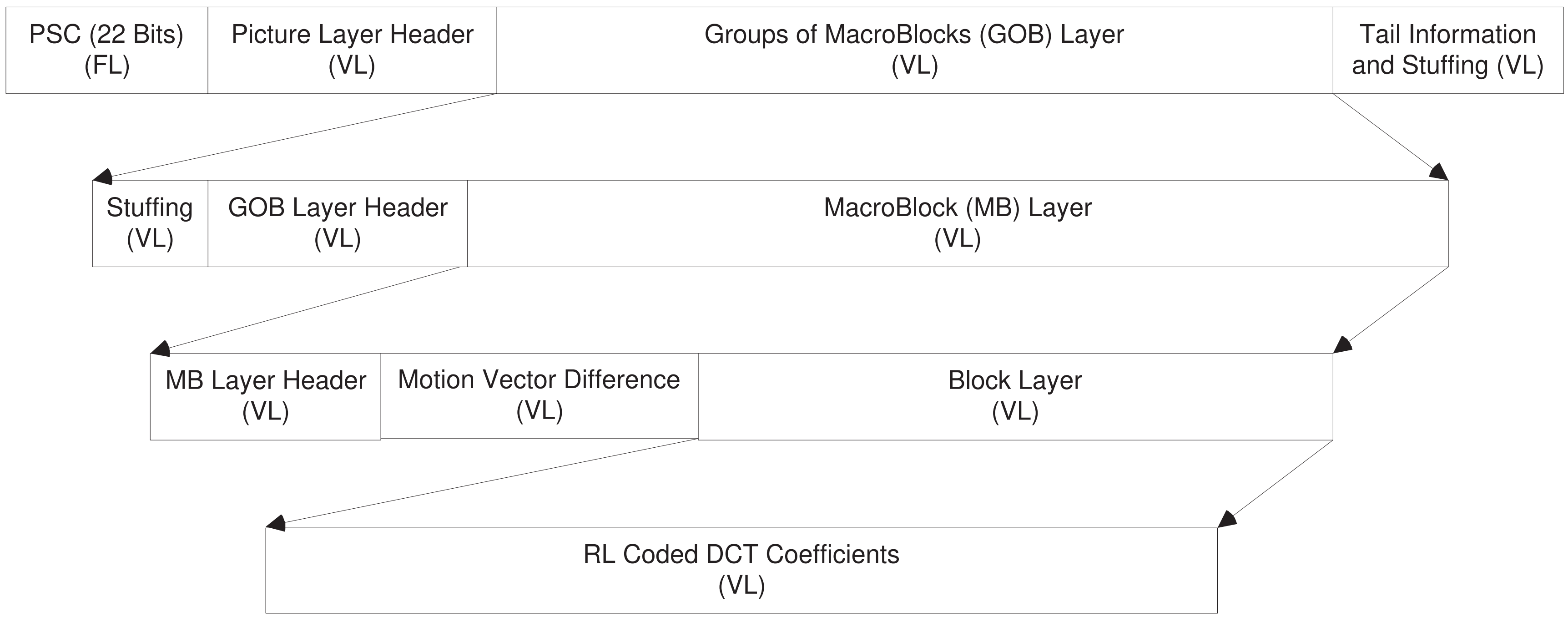
- Layered coding: temporal (frame-rate), spatial (resolution), SNR (quantization) scalability.

- First standard which explicitly includes an error resilient mode containing a set of new tools.

MPEG-4 Coder Diagram



MPEG-4 Bit Stream Syntax



Resynchronization

- Proposed by Motorola, it prevents error propagation by placing resync markers in the compressed bit stream.

- Packet approach: length of packets are not based on number of MBs but on number of bits contained in the packet.

- Fixed interval synchronization: VOP start codes. and resync markers appear only at allowable, fixed interval locations in the bit-stream.

Error Isolation: Data Partitioning

- A packet is divided into finer logic units, each contains one type of information.
- Secondary markers are placed between logic units.
- Each correctly decoded logic unit contains one type of information for all MBs in the packet.
- Proposed by Texas Instruments.

Header Extension Code (HEC)

- 1 bit field, proposed by Matsushita.
- Important header information describing the frame is repeated following the HEC.
- It has been proven to significantly reduces the number of discarded video frames.

Adaptive Intra Refresh (AIR)

- Standard-compatible technique of using non predictive INTRA coding.
- Forcefully encodes some macroblocks in intra-mode to flush out possible errors.
- Adaptively perform intra refresh based on the motion in the scene.
- Very effective in stopping error propagation at the cost of a large overhead.

Data Recovery: RVLC

- RVLC (reversible variable length codes) are used with almost no loss of coding efficiency.
- RVLC can also help detecting errors which are not detectable by normal VLC.
- Data partitioning provides the necessary syntax change for the application of RVLC.
- Proposed by Toshiba.

Error Concealment

- Spatial and temporal interpolations, simple techniques like block replacement.

- Maximally smooth recovery, projection on convex sets, motion compensated temporal prediction, etc.

- Highly dependent on the performance of the resynchronization scheme.

Robust Multiplexing

- Apply errors directly to the compressed stream is unreasonably pessimistic for certain networks.
- Multiplexing and packetization steps can be important source for error.
- Included in H.324 but NOT in MPEG-4, fortunately they are converging.

Misc Features

- No fixed I-P frame pattern, intra refresh of macroblocks can be done asynchronously.

- Half-pixel precision of motion vectors, allows for four motion vectors per macroblock.

- Motion-vectors are also predicted and prediction errors encoded.

Conclusion

- It is only a matter of time before wireless video exchange becomes commonplace.
- Standard-compatible, robust implementations of video codec needs to be explored.
- MPEG-4 appears to be a promising candidate (we need to put our hands on a MPEG-4 coder!)