AVC/H.264 Advanced Video Coding Codec, Profiles & System

Ali Tabatabai

ali.tabatabai@am.sony.com

Media Processing Division

Sony Electronics Inc.

Content

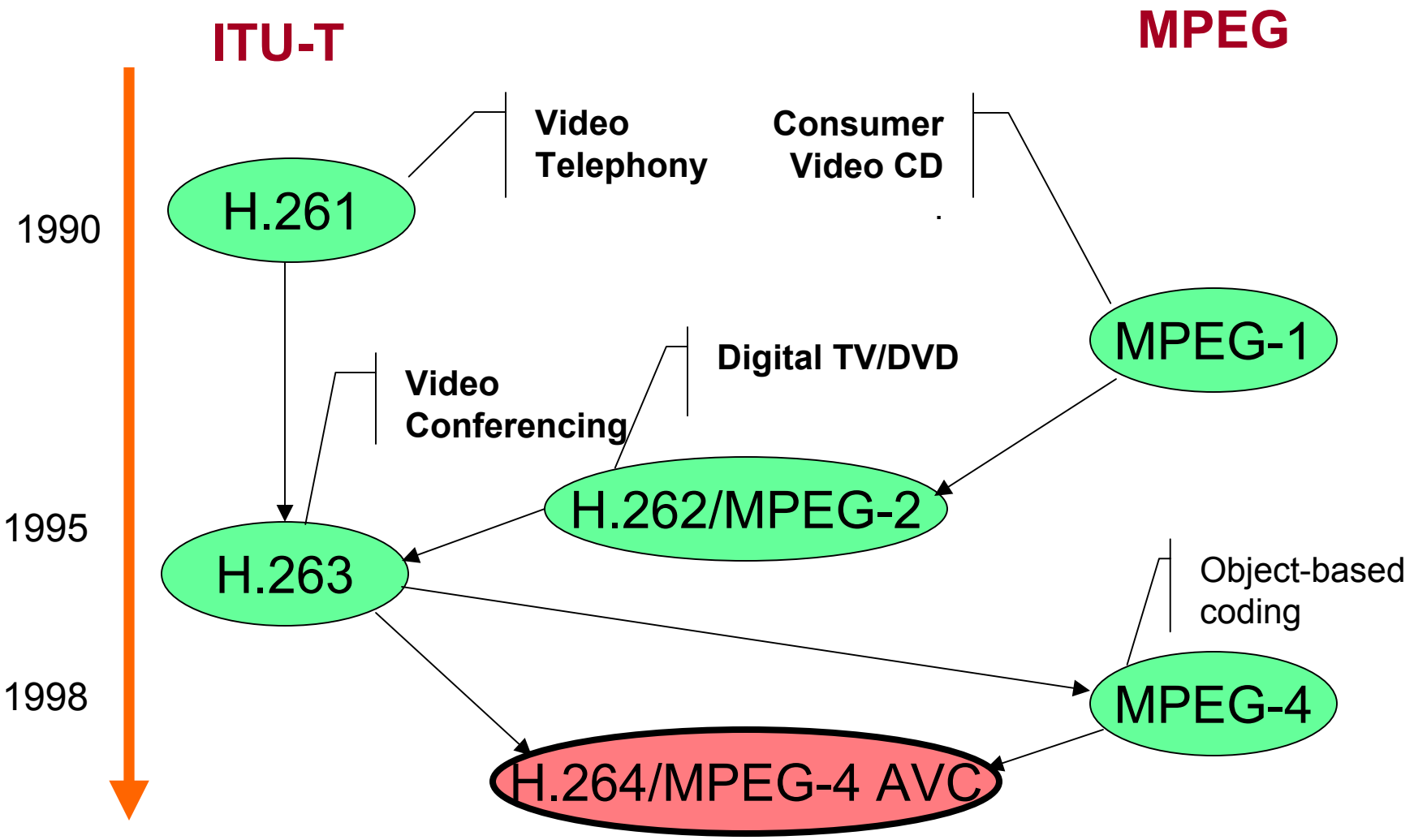
- Overview
- Rate Distortion Performance
- Codec Complexity
- Profiles & Applications
- Carriage over the Network
- Current MPEG & JVT Activities
- Conclusion

Video Coding Standards: A Brief History

Video Standards and JVT Organization

- Two organizations dominate the video compression standardization activities:
  - ISO/IEC Moving Picture Experts Group (MPEG)
    - International Standardization Organization and International Electrotechnical Commission, Joint Technical Committee Number 1, Subcommittee 29, Working Group 11
  - ITU-T Video Coding Experts Group (VCEG)
    - International Telecommunications Union – Telecommunications Standardization Sector (ITU-T, a United Nations Organization, formerly CCITT), Study Group 16, Question 6

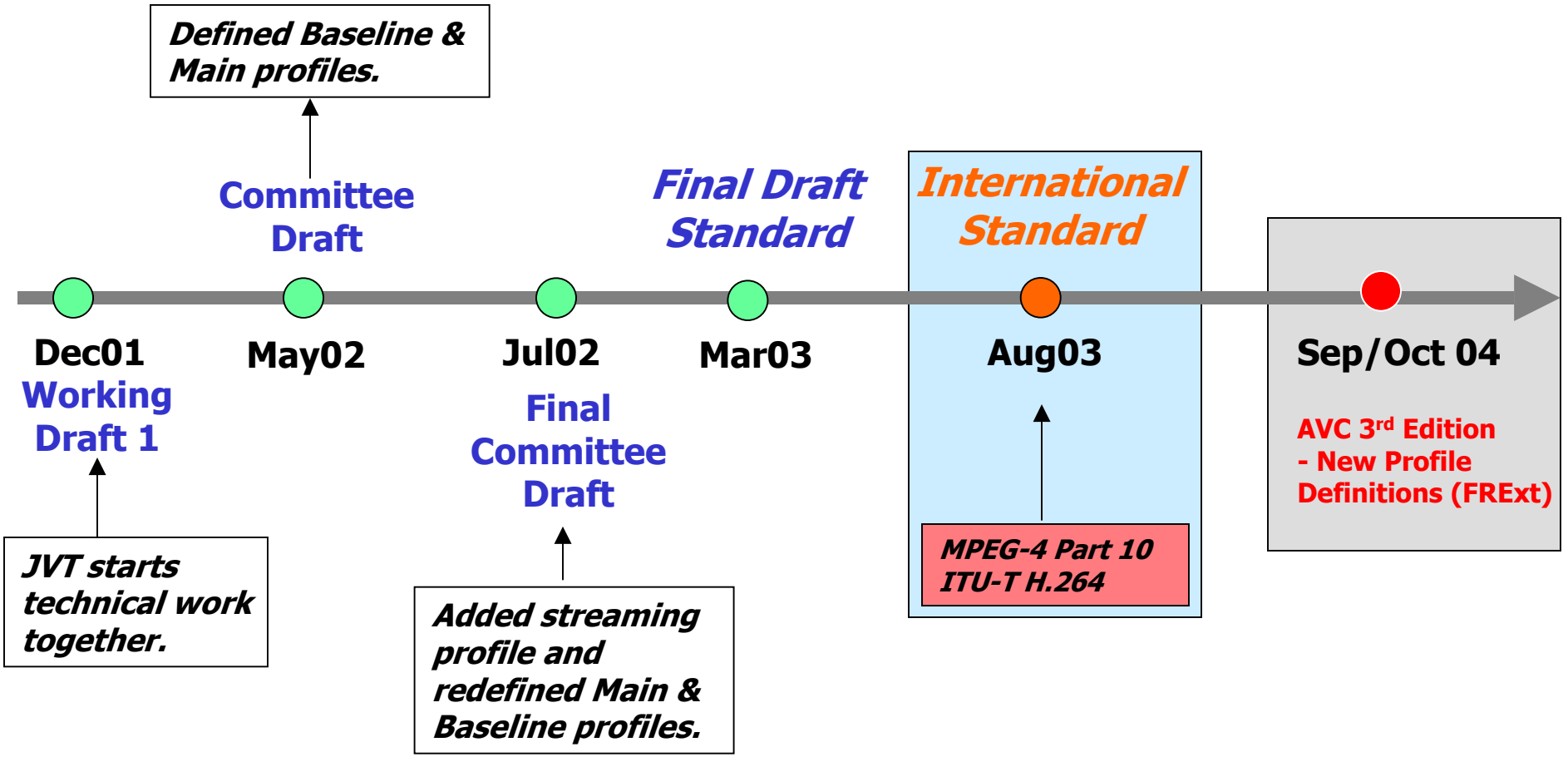
Evolution of Video Compression Standards



Joint Video Team
ITU-T VCEG and ISO/IEC MPEG

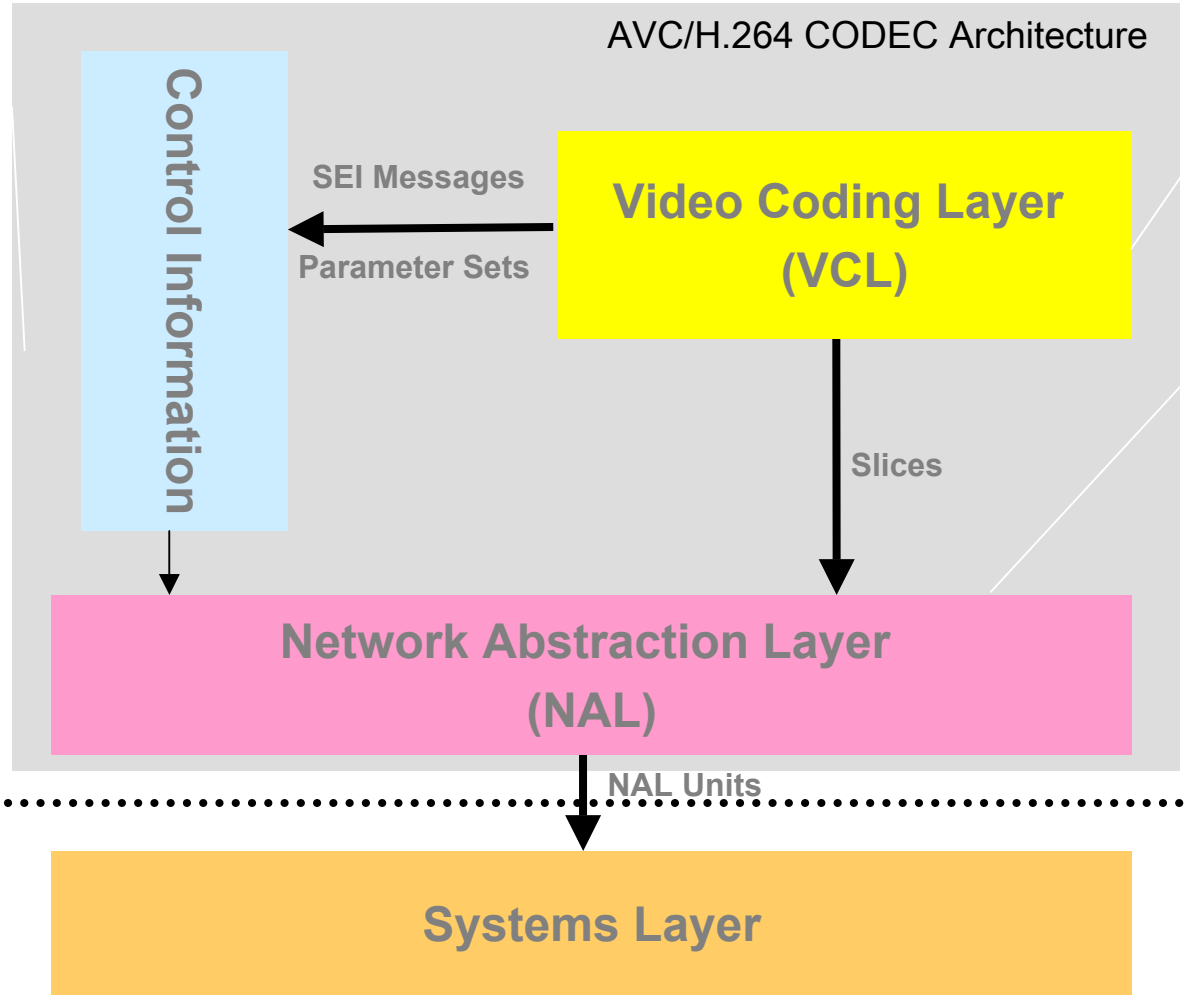
- Design Goals
  - Simplified and Clean Design
    - No backward compatibility requirements.
  - Compression Efficiency
    - Average bit rate reduction of 50% compared to existing video coding standards (MPEG-2, MPEG-4, H.263).
  - Improved Network Friendliness
    - Clean and flexible interface to network protocols
    - Improved error resilience for Internet and mobile (3GPP) applications.

AVC/H.264 Standards Development Schedule



AVC/H.264 Coding Technologies

Architecture



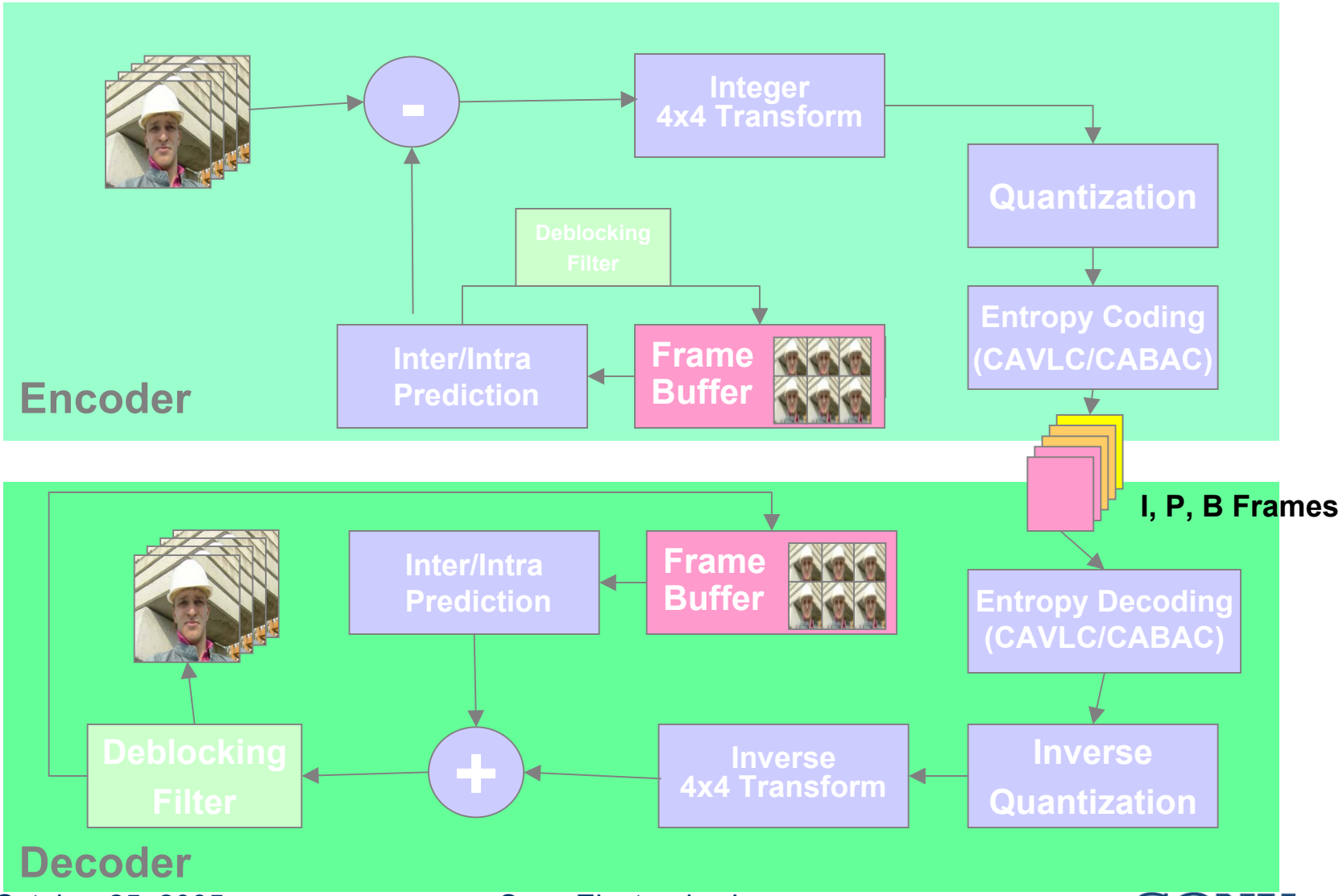
Contains information needed to control operation of decoding of video coding layer data.

Responsible for efficient coding of video data.

Defines an generic format for sending JVT video data over a network.

The layer that encapsulates the JVT CODEC data for transport, controls timing, etc.

AVC/H.264 Block Diagram



Some AVC/H.264 Key Features

- Variable Block Sizes for Motion Compensation
  - 4X4, 8x8, 8x16… to 16X16
- Quarter-Pel Motion
- Multiple Reference Pictures
- Intra Prediction
- Block Transform
  - Integer 4x4 Transform – No drift
  - 8x8 Transform for FRExt-Only
- Adaptive Entropy Coding
- De-Blocking Filter

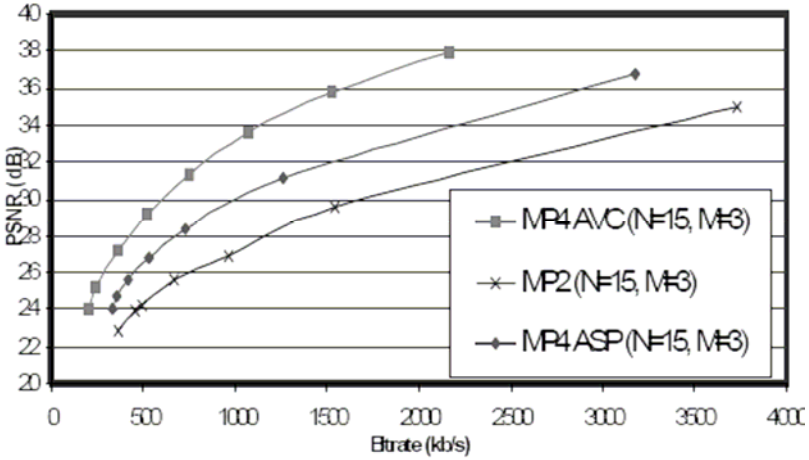
Deblocking Filter

- Deblocked filter reduces visible blocking artifacts block edges.
- Deblocking is an integral part of the coding loop, not a post-processing
- Typically reduces bit rate by 5-10% compared to no filtering.

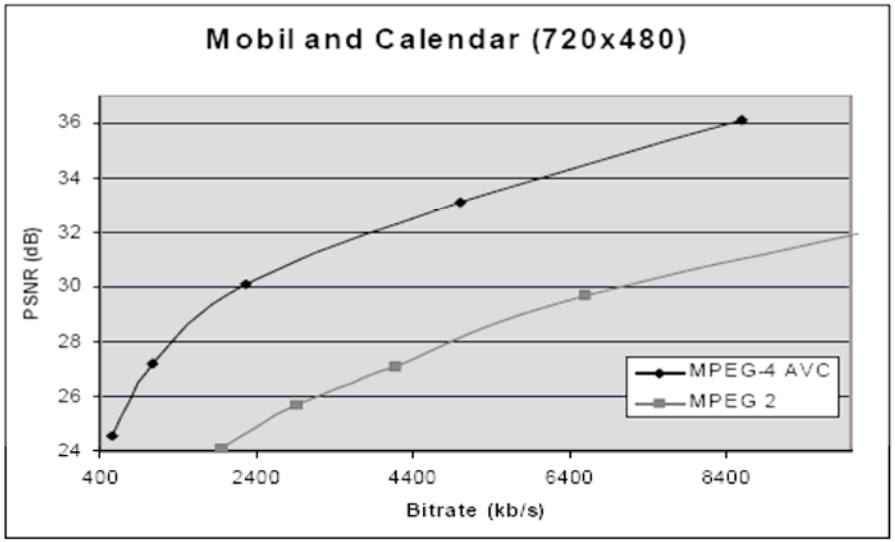
Before Deblocking

After Deblocking

AVC/H.264 Performance



Mobile & Calendar Sequence at CIF resolution



Original Version of AVC (without FREXt)
Mobile & Calendar Sequence at BT.601 (720x480) resolution

*G. Sullivan, P. Topiwala and A. Luthra, "The H.264/AVC Advanced Video Coding Standard: Overview and Introduction to the Fidelity Range Extensions," SPIE Conference on Applications of Digital Image Processing XXVII, vol. 5558, pp. 53-74, Aug. 2004.

Complexity of the Codec

- Smaller block sizes for motion compensation.
- Longer filters for motion compensation
- Multi-frame motion compensation
- More complicated mode selection
- Intra prediction
- Deblocking filter
- Arithmetic coding

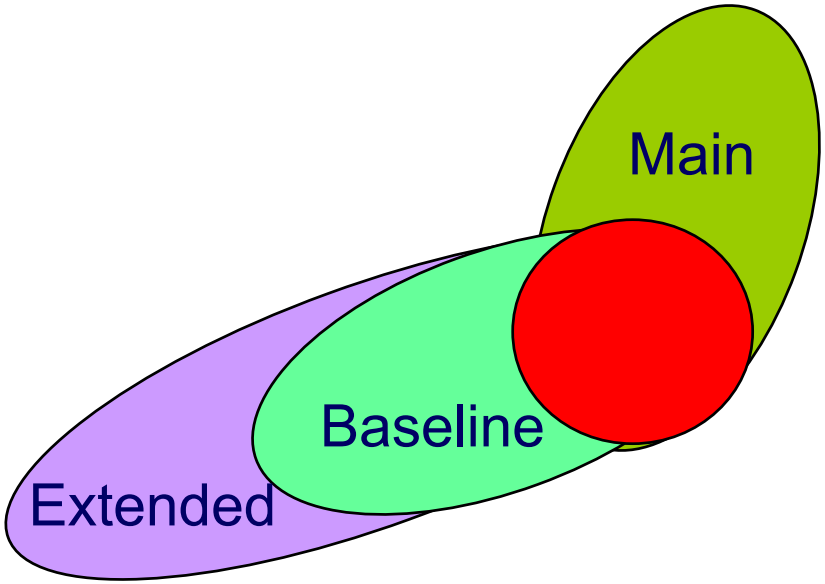
AVC/H.264 Profiles

Application Areas of AVC/H.264

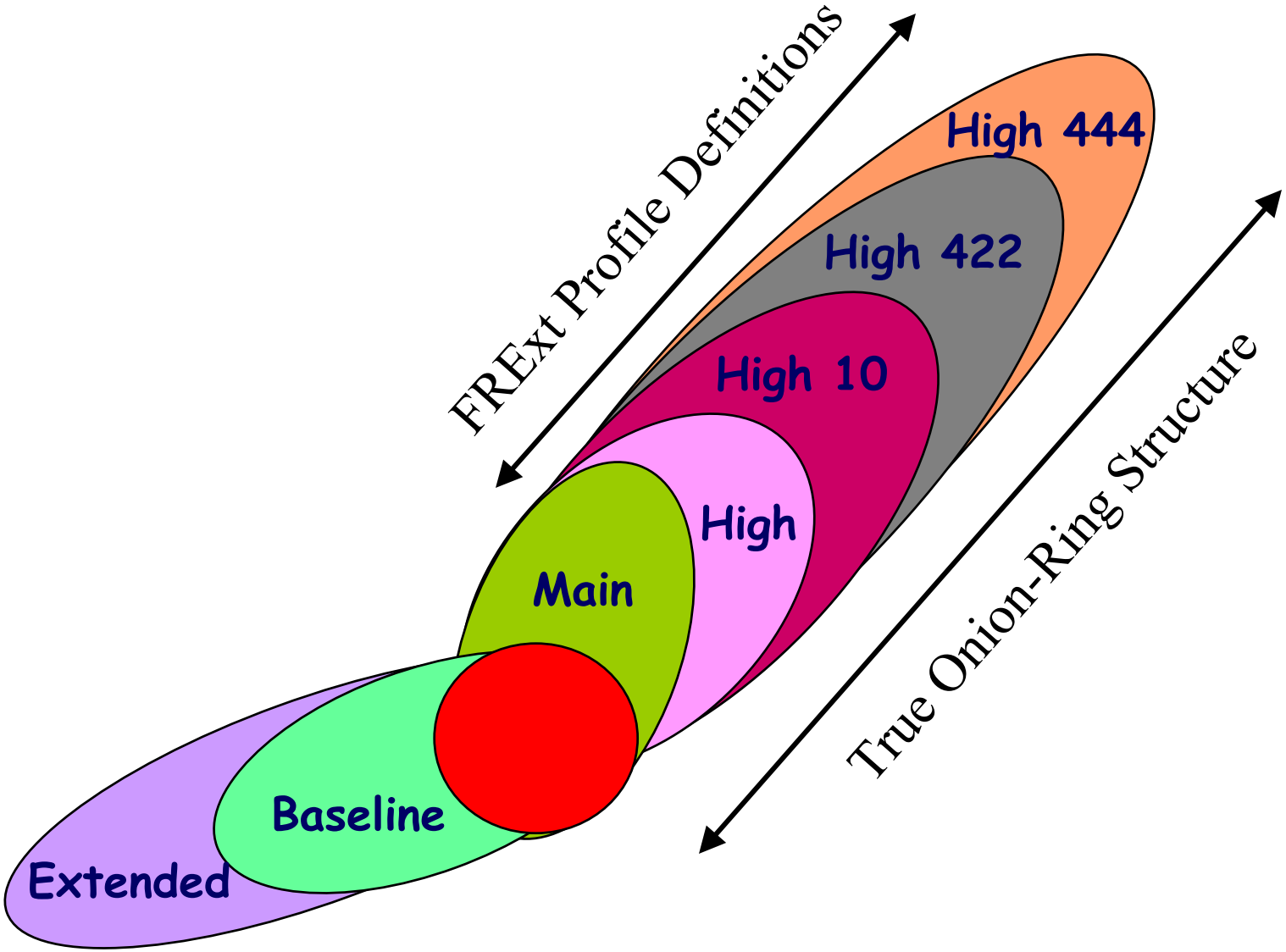
- Entertainment Video (1 - 8+ Mbps, higher latency)
- Conversational H.32X Services (usually < 1Mbps, low latency)
- Streaming Services (usually lower bit rate, higher latency)

AVC/H.264 Profiles

- Three Profiles: Baseline, Main and Extended
  - **Baseline:** Low-latency, real-time video coding applications such as video conferencing.
  - **Main:** Broadcasting, packaged media, and high-end (e.g. digital cinema) applications.
  - **Extended:** IP-based video streaming applications over both wired and wireless networks.



Current Profile Definition



New Profiles in the FRExt

- The FRExt Amendment defines four new profiles:
  - High (HP)
  - High 10 (Hi10P)
  - High 4:2:2 (Hi422P)
  - High 4:4:4 (Hi444P)
- All these profiles build upon the Main Profile (MP)

ISO/IEC: AVC Current Status

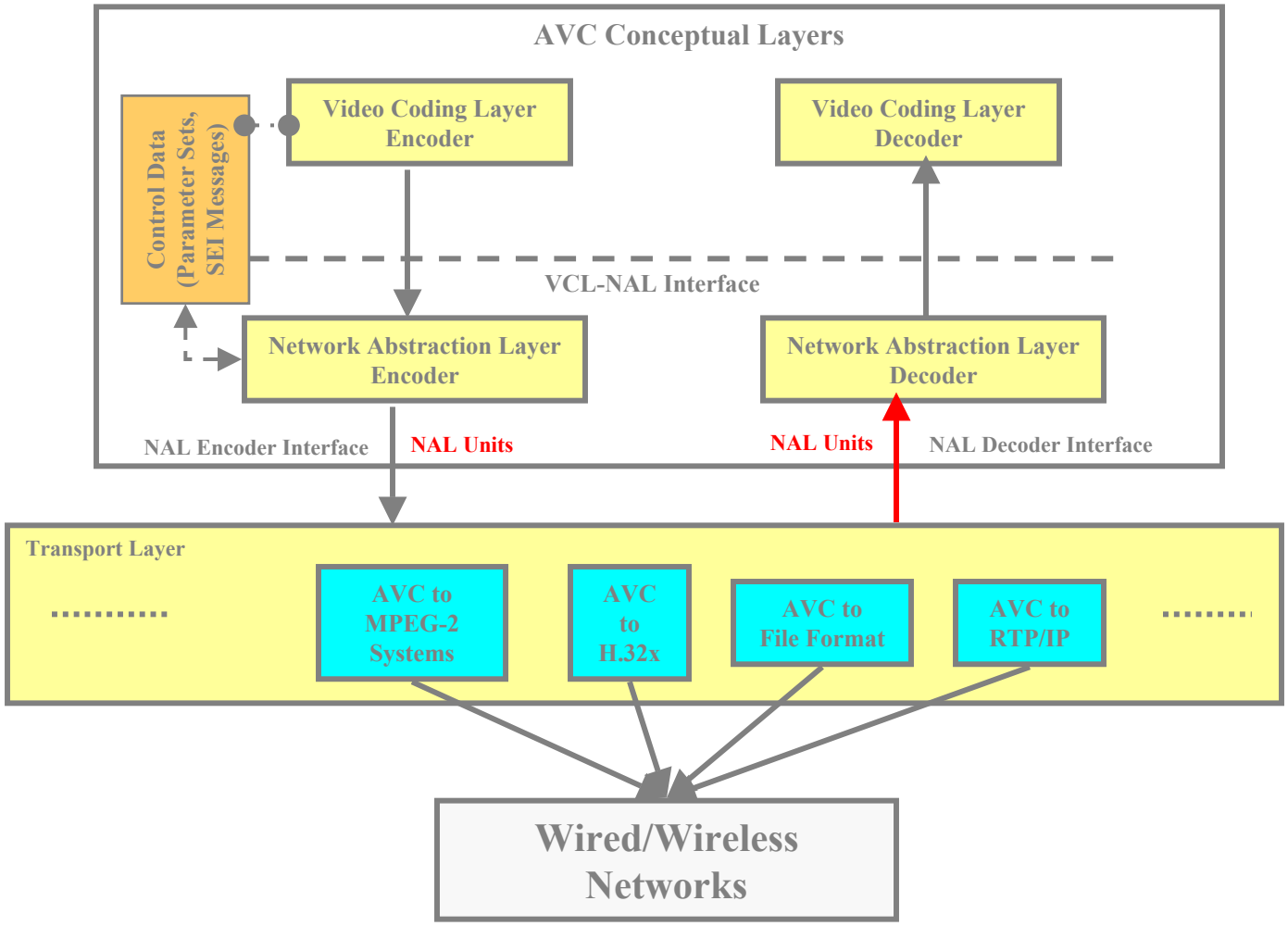
- AVC Advanced Video Codec (MPEG-4: Part10)
  - Current Status:
    - AVC/H.264 Specification:
      - AVC 3rd edition was released in July.
    - AVC Reference Software
      - The latest reference software version is JM 10.1
  - Ongoing Work:
    - Work on FR-Ext, to provide support for 14-bit depth and improve the lossless coding performance.
    - Work on investigating a new “Low Complexity Profile”

AVC/H.264 Systems/Carriage

Carriage of AVC Content

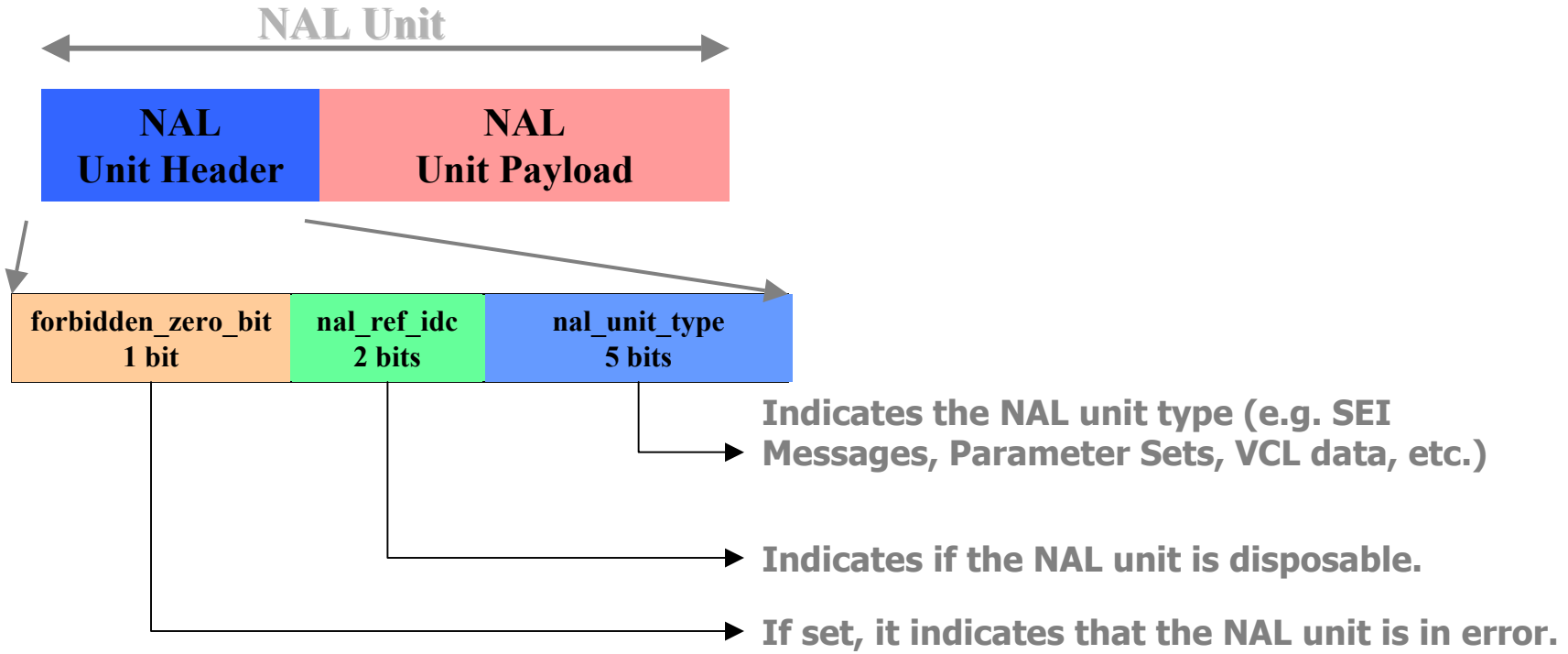
- Overview
  - AVC Conceptual layers
  - NAL Units
  - Access Units
- Carriage:
  - AVC over MPEG-2 Systems
  - AVC File Format
  - AVC over RTP

AVC Conceptual Layers



Concept of a NAL (Network Abstraction Layer) unit

- The Network Abstraction Layer (NAL) defines a network friendly interface between the Video Codec a variety of transport layers (e.g. RTP/IP, MPEG-2 Systems, File Format).



- Packet oriented systems can employ NAL units directly
- Bit and Byte stream oriented systems can employ the byte-stream version of NAL units, which are NAL units encapsulated by start codes.

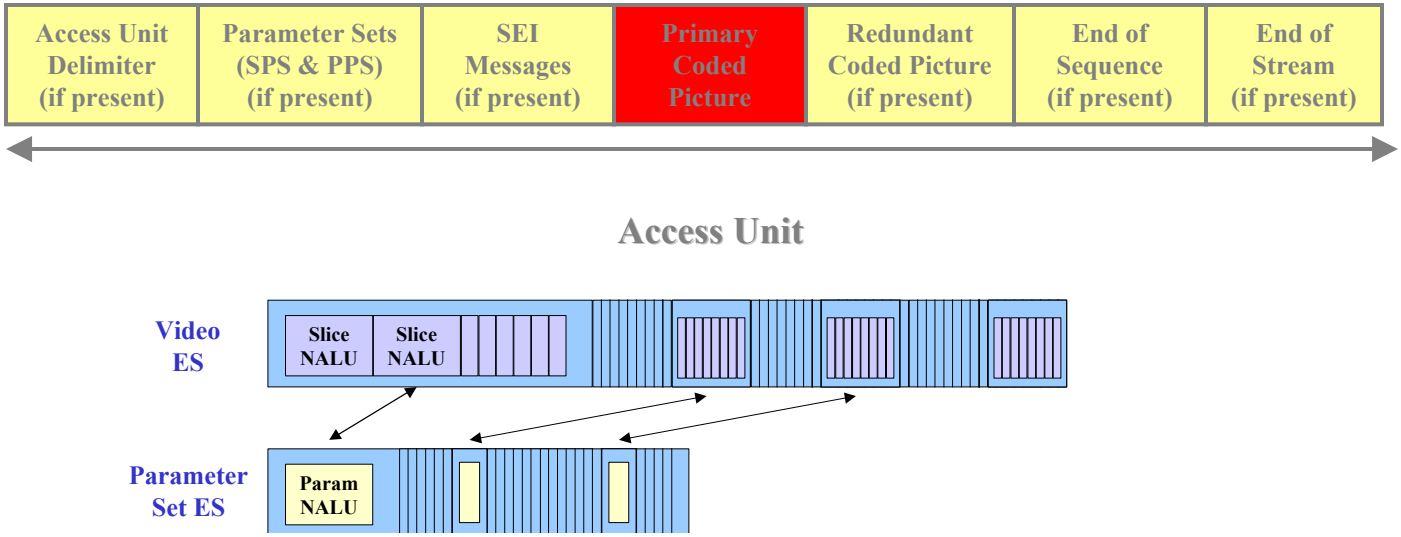
Categorization of NAL units

- NAL units can be categorized in two types:
  - VCL NAL units: These NAL units contain data that represents the values of the samples in the video pictures.
  - Non-VCL NAL units: These NAL units contain any associated additional information such as parameter sets and supplemental enhancement information.

Definition of an Access Unit in AVC

- **Access Unit:**

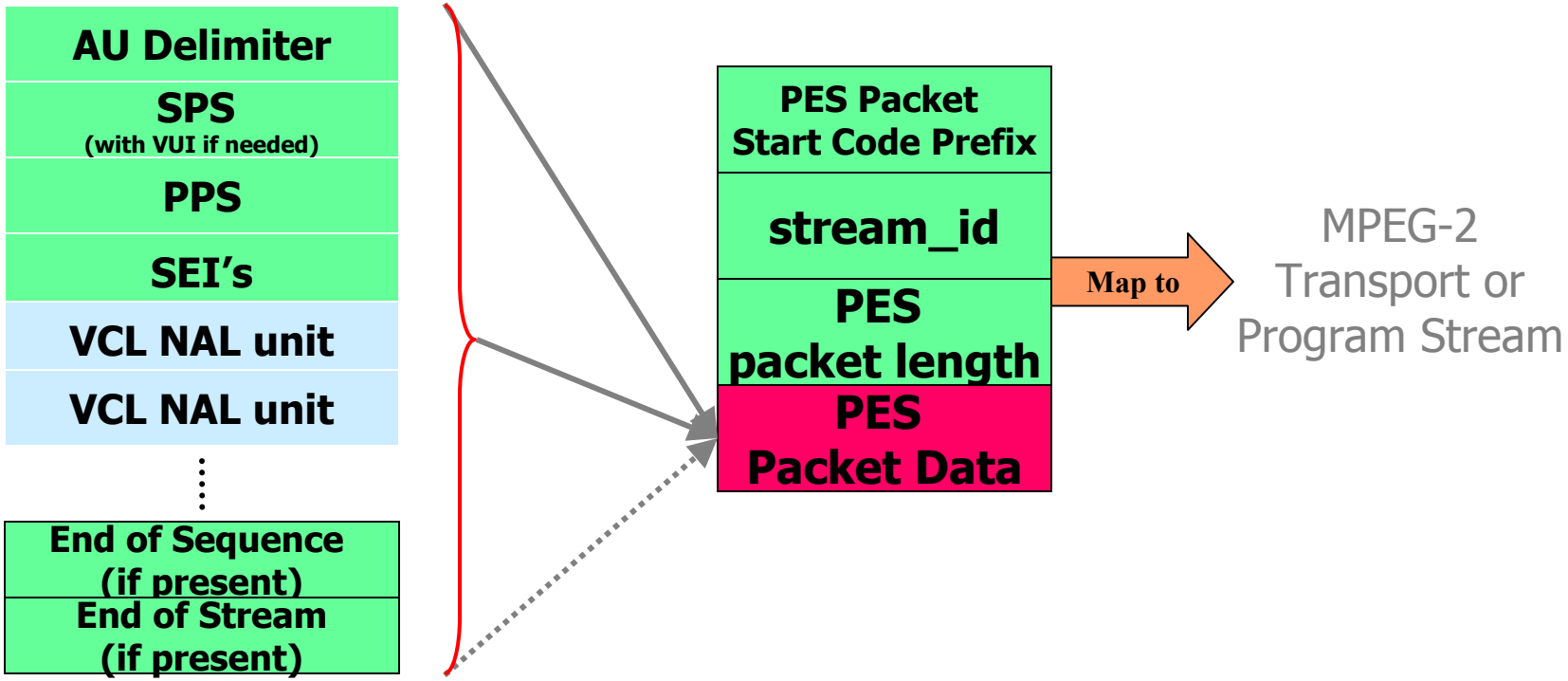
  " An access unit consists of one primary coded picture, zero or more corresponding redundant coded pictures, and zero or more non-VCL NAL units."



Carriage of AVC on MPEG-2 Systems

An Amendment to MPEG-2 Systems is being prepared so that AVC video can be carried over the existing MPEG-2 infrastructure.

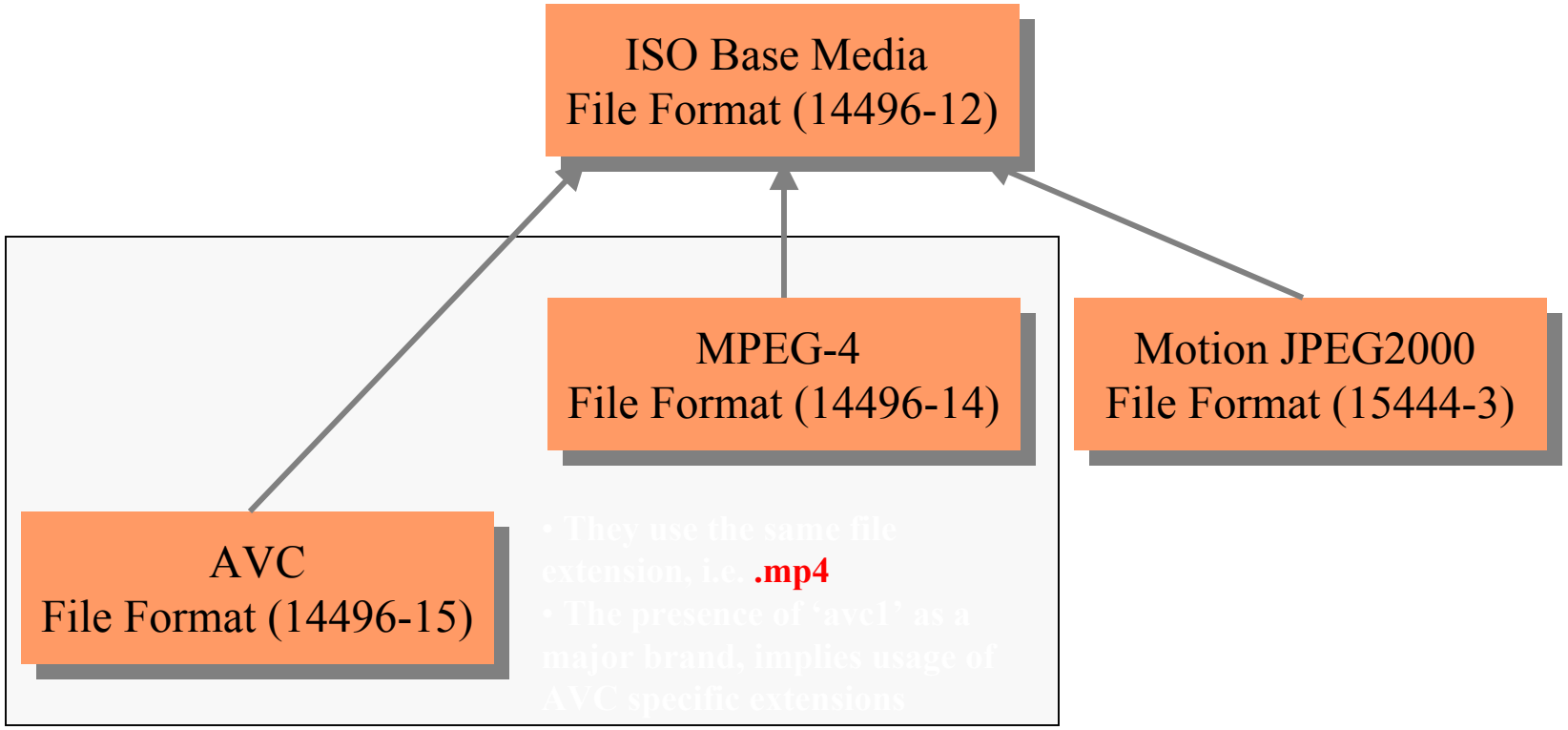
Mapping AVC Access Units into MPEG-2 PES Packets



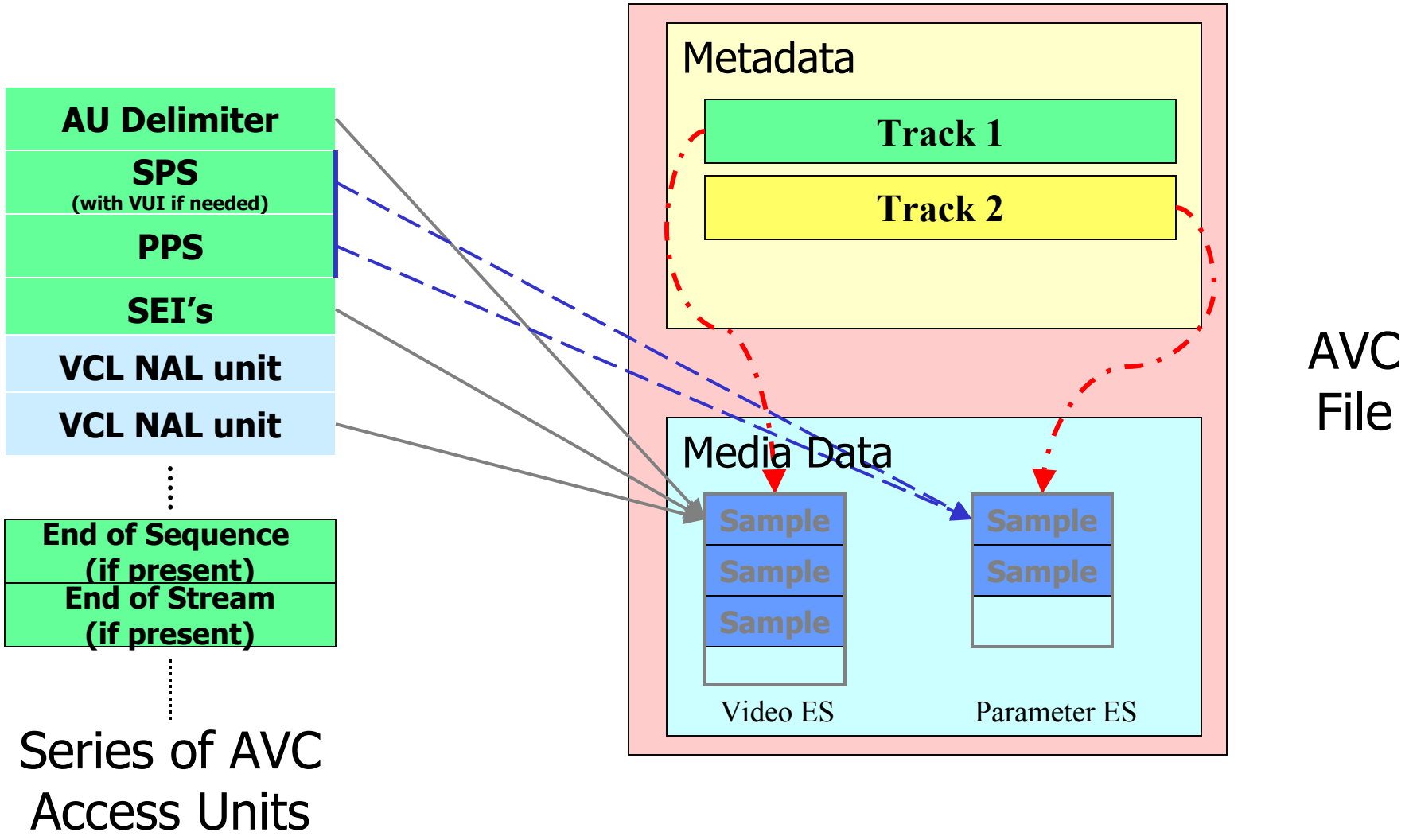
AVC Byte Stream NAL units MPEG-2 PES Packets

Storage using the AVC File Format

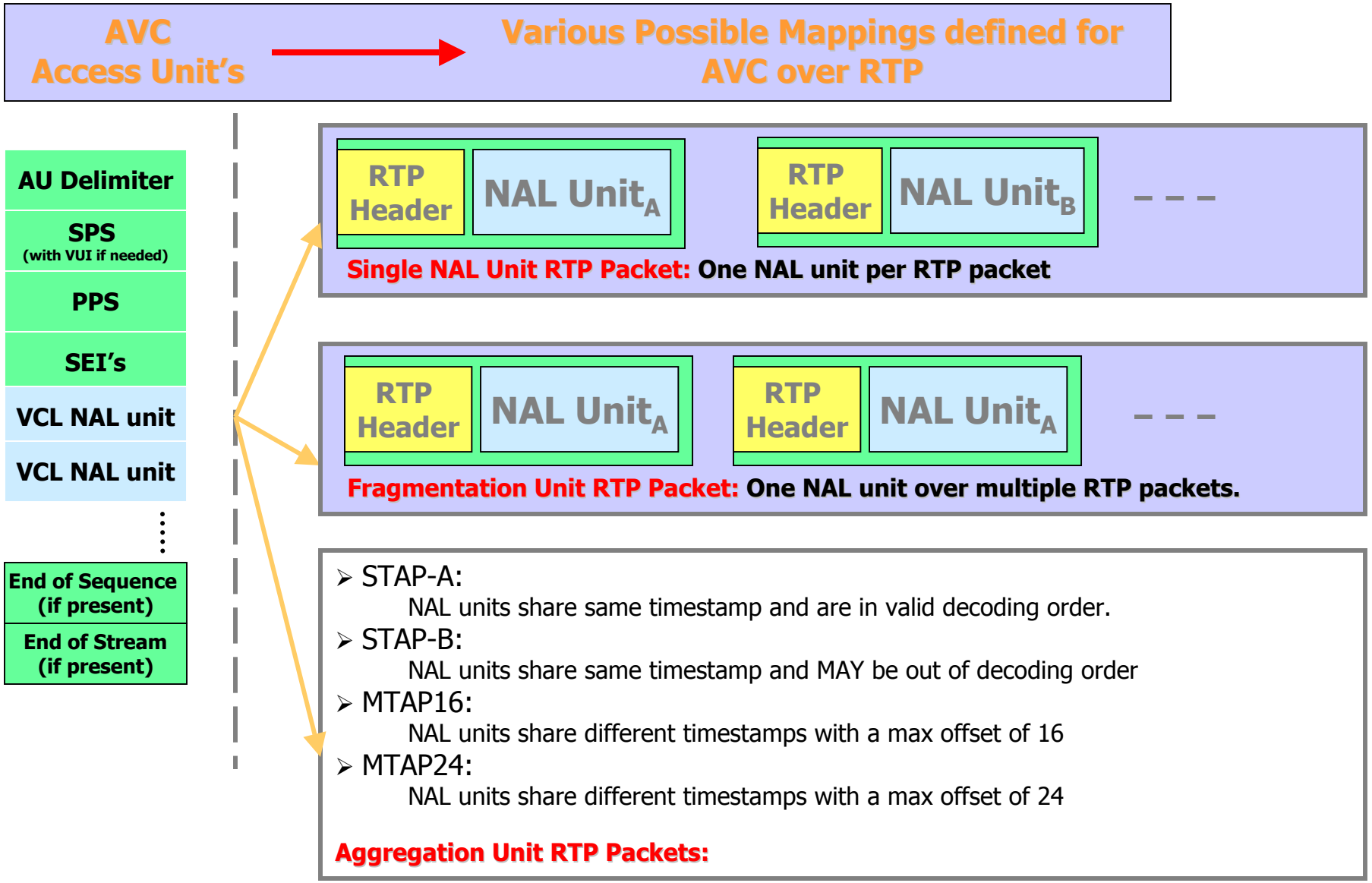
- This AVC File Format defines extensions to the ISO Base Media File format to provide support for the storage of AVC video data.



Mapping AVC Bitstream -> AVC File Format



RTP Payload Format for H.264 Video (RFC 3984)



Current MPEG & JVT Activities

ISO/IEC: MPEG

- Scalable Video Coding (SVC):
  - Goal:
    - This is being developed by the Joint Video Team (JVT) as an extension of AVC.
    - It intends to address the need for the reliable delivery of video to diverse clients over heterogeneous networks, by providing scalability (such as spatial, temporal and SNR/fidelity) with good compression efficiency.
  - Development Status:
    - Working Draft 3 as AVC/AMD1 & JSVM 3 Software released in July
  - Schedule:
    - Working Draft: WD 3 stage in July
    - CD: 2006 March
    - FCD: 2006 - July/Oct
    - FDIS: 2007 (expected)

ISO/IEC: MPEG

- Wavelet Coding Exploration:
  - Background:
    - Initially this activity was part of the SVC development effort in MPEG.
    - Later on it forked off as a separate “Exploration Activity” within MPEG
  - Status:
    - A report based on the results of the Exploration Activity will be released during early 2006.

- Multi view Video Coding (MVC)
  - Background:
    - Multi-view Video Coding (MVC) is a key technology that has been in exploration status in MPEG since the past 1 year.
    - It serves a variety of applications such as FTV (free-viewpoint television), 3DTV (3D television) and surveillance.
    - It allows the viewpoint and view direction to be interactively changed (as in FTV) or multiple viewers can see different stereoscopic views consistent with their relative locations (as in 3DTV)
  - Status:
    - Call for Proposals was issued in July ‘05.

Conclusion

- New International Video Coding Standards
  - Joint Development by MPEG Group of ISO/IEC and VCEG Group of ITU-T
- Improved Coding Efficiency & Flexibility
  - Introduction of New Coding Tools.
  - About 50% Compared to MPEG-2/4
  - Use Over a Wide Range of Networks
- Increased Complexity
- Two Patent Pools
  - MPEG LA & Via Licensing
- New Work Items
  - MPEG: Scalable Video Coding
  - Multiview Coding

Thank You for Your Attention.....