# Compression Systems for Mobile TV

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# Who is ZetaCast?

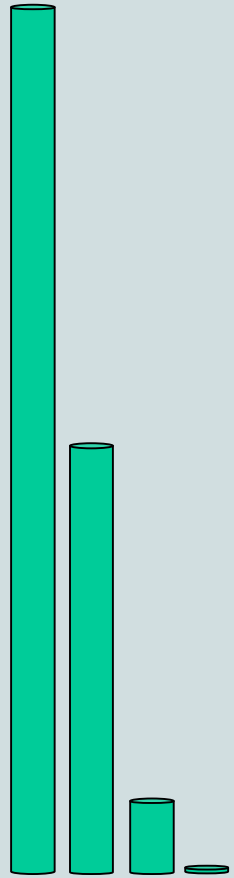
- **Independent technology consultancy company**
  - Specialising in digital broadcasting and mobile TV
- **ZetaCast directors have each over 15 years experience of digital TV, including**
  - Leading development of the world's first broadcast-quality MPEG-1 decoder
  - Leading design team for the world's first real-time MPEG-2 encoding system
  - System integration and project management for digital terrestrial, cable and satellite systems

# Overview

- **Introduction to Compression**
- **Video Compression Coding**
  - MPEG-2
  - H.264 / AVC
  - VC-1
- **Audio Compression Coding**
  - MPEG-1 Layer II
  - MPEG-4 BSAC
  - MPEG-4 HE AAC
  - MPEG-4 HE AAC v2
  - AMR Wideband Plus
- **A/V coding in Mobile TV Systems**

# Why Bother with Compression?

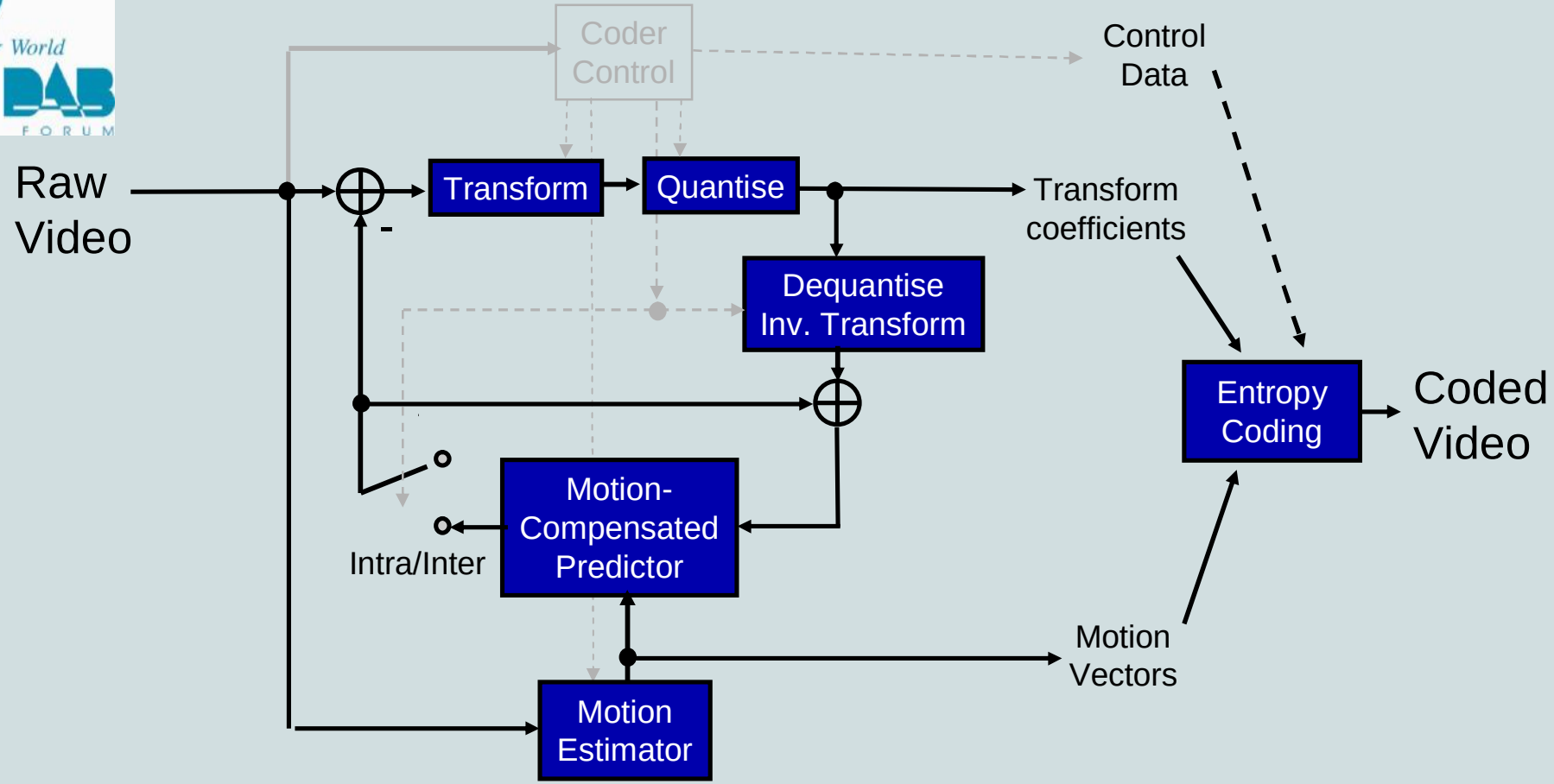
- **Typical mobile TV video clip**
  - 320 pixels x 240 lines at 25 frame/s
  - 23 Mbit/s raw video
- **After lossless data compression**
  - removes statistical redundancy
  - Compress by about a factor of 2
- **After still picture compression**
  - removes statistical and spatial redundancy
  - Compress by about an order of magnitude
- **After moving picture compression**
  - removes statistical, spatial & temporal redundancy
  - Compress by about two orders of magnitude
  - 23 Mbit/s → about 200kbit/s



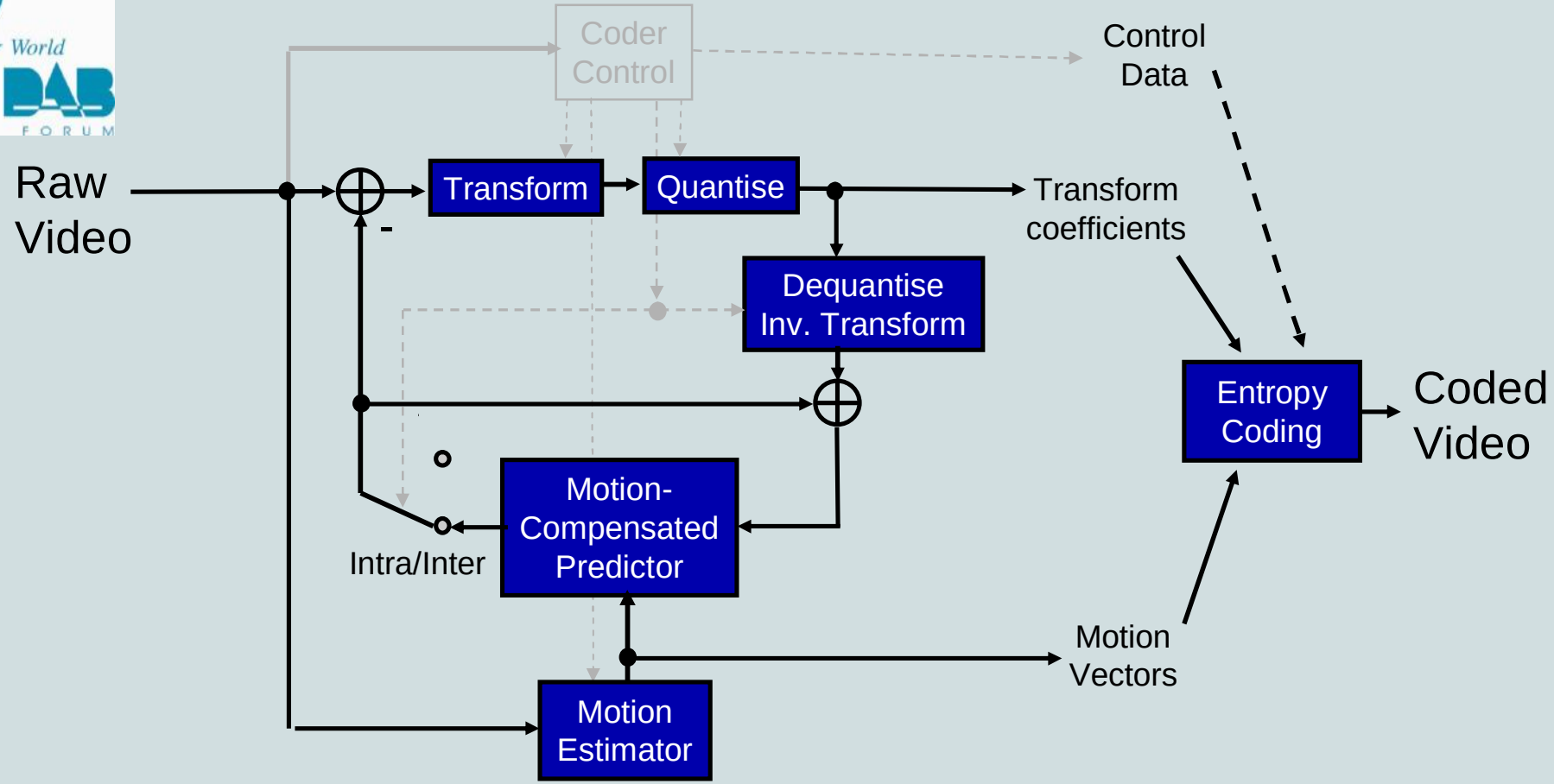
# Video Compression Coding

- **Many techniques have been tried over the years**
  - sub-band coding
  - vector quantisation
  - wavelets
  - fractals …
- **But all recent video compression algorithms use some form of motion compensated block transform**
  - MPEG-1
  - MPEG-2
  - H.263
  - MPEG-4 part 2
  - H.264/AVC
  - VC-1 …

# Intra-Frame Coding



# Inter-Frame Coding



# Video Compression Algorithms

- **MPEG-2 Video**
  - Published as ISO/IEC 13818-2 in 1995
    - MPEG-2 part 2
- **H.264 / AVC**
  - Published as ISO/IEC 14496-10 in 2003
    - MPEG-4 part 10, Advanced Video Coding (AVC)
  - Common text with ITU-T H.264
- **VC-1**
  - Published as SMPTE 421M in 2006
  - WMV9 is Microsoft's implementation of the VC-1 standard

# Key Components of a Video Coder

- **Block transform (e.g. DCT)**
  - Transform information into a “frequency-like” domain
- **Block matching motion compensation**
  - Help remove temporal redundancy by tracking moving objects
- **Quantisation**
  - Reduce data rate whilst keeping differences from original to below a “just noticeable” threshold
- **Entropy Coding**
  - Variable length coding to represent commonly occurring code words more efficiently than uncommon ones
- **De-blocking**
  - Reduce visibility of blocking artefacts

# Comparison of Key Components

| | MPEG-2 | H.264/AVC | VC-1 |
|---|---|---|---|
| **Transform** | **8x8 DCT** | **4x4 "DCT-like" Integer Transform** (or 8x8 in High Profile) | **8x8, 8x4, 4x8, 4x4 "DCT-like" Integer Transform** |
| **Motion estimation blocks** | **16x16** | **4x4, 4x8, 8x4, 8x8, 8x16, 16x8, 16x16** | **8x8 or 16x16** |
| **Quantisation** | **Scalar with "dead zone"** | **Scalar with various options** | **Scalar with or without "dead zone"** |
| **Entropy coding** | **Huffman code** | **CAVLC** (or CABAC in Main and High Profile) | **Two-layer Huffman code** |
| **De-Blocking** | **No** | **Yes, by in-the-loop de-blocking filter** | **Yes, by overlap smoothing** |

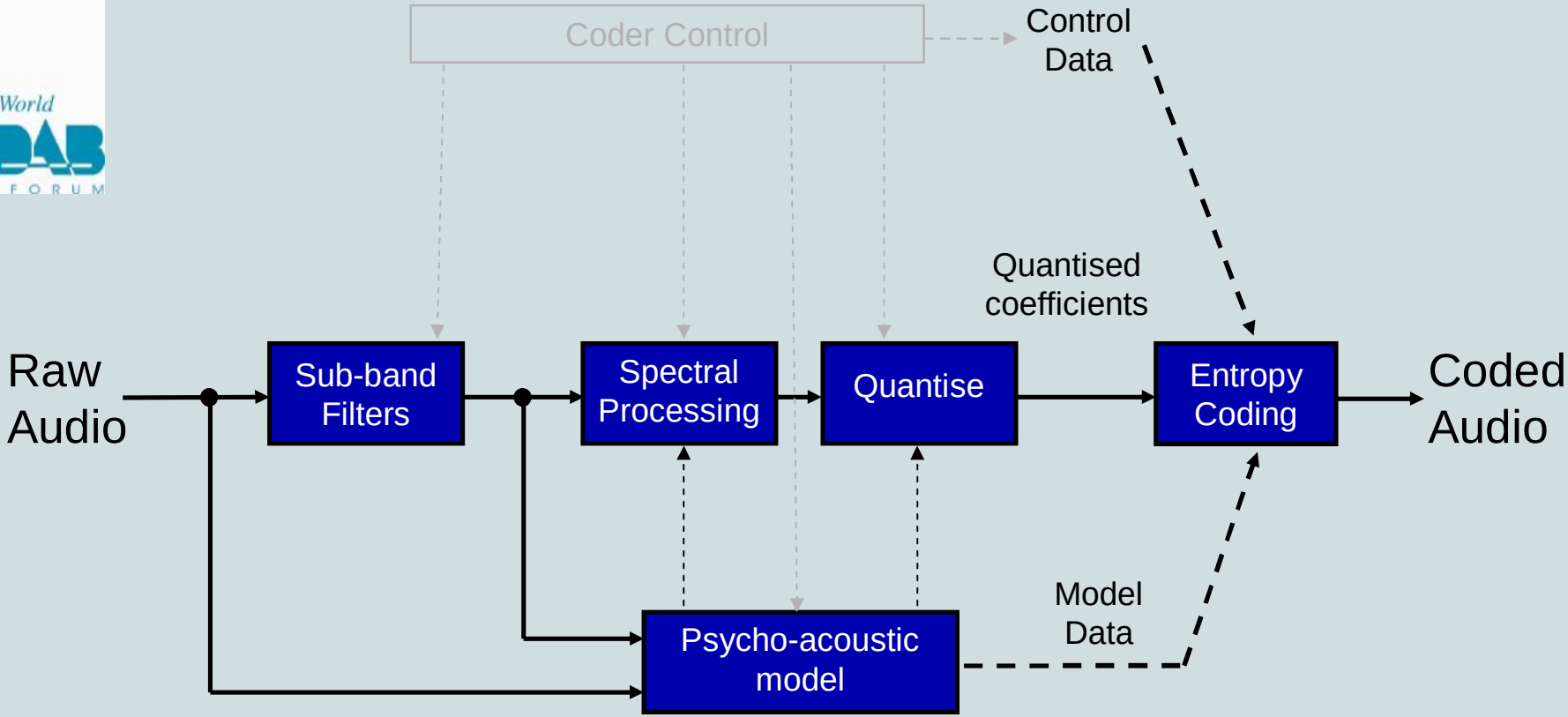
# Video Performance Comparison

- **Compression coding standards don't define the encoder**
  - Only bitstream syntax and semantics
  - More sophisticated or better tuned encoders can give significant improvements within the same algorithm
- **A rough rule of thumb is that H.264/AVC and VC-1 are about twice as efficient as MPEG-2**
  - Same quality at half the bit-rate

# Audio Compression Coding

- **Uses characteristics of human hearing**
  - Reduced sensitivity to low frequencies (< 1 kHz)
  - Reduced sensitivity to high frequencies (> 5 kHz)
- **Psycho-acoustic model exploits more complex effects**
  - Frequency Masking
    - Reduced sensitivity at frequencies close to stronger signal
  - Temporal Masking
    - Reduced sensitivity shortly after a stronger signal
- **Can exploit some statistical effects**
  - High correlation between Left and Right channel of a stereo pair
  - Correlation between signals in high and low frequency bands

# Generalised Audio Coder Architecture



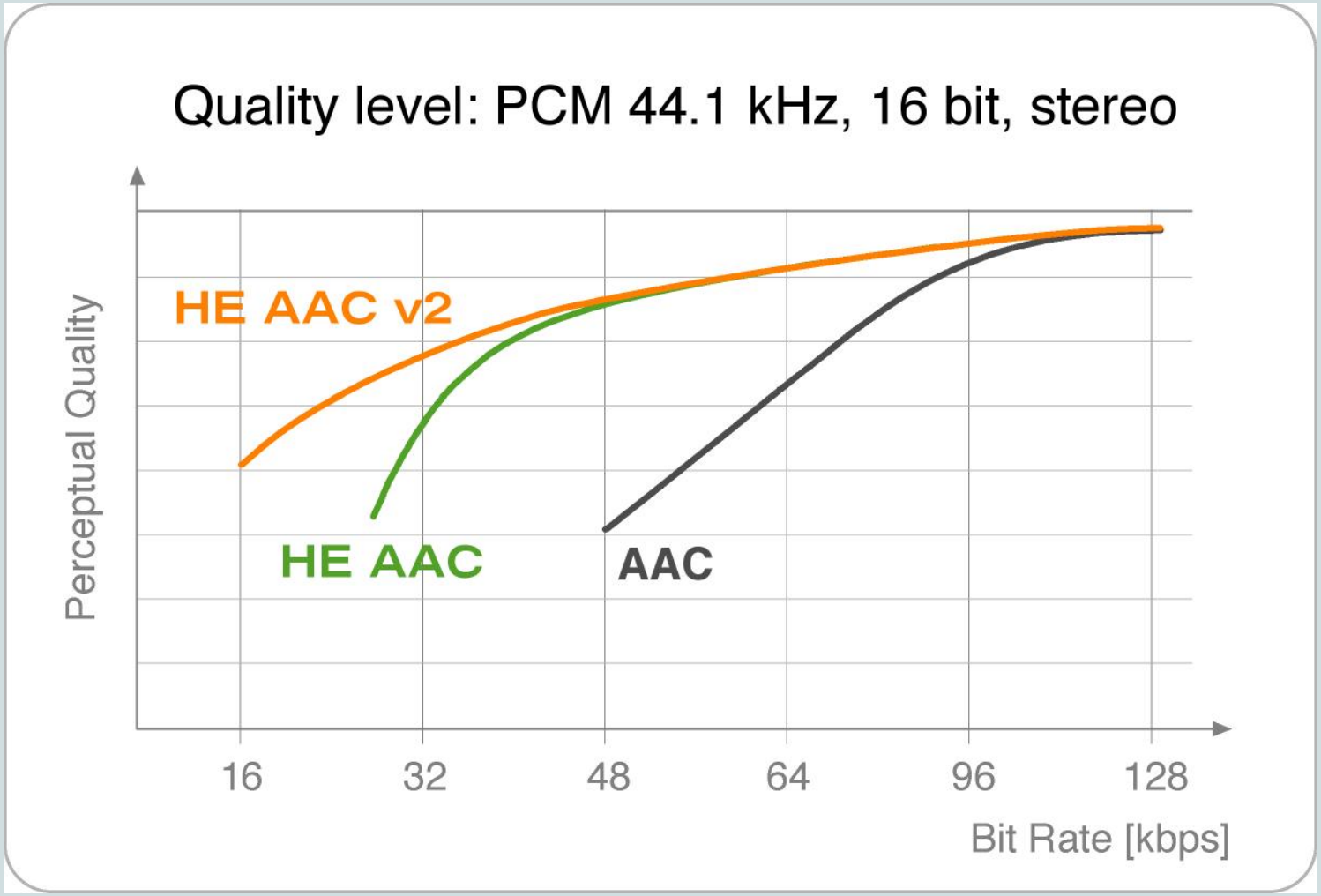
# Audio Compression Algorithms

- **MPEG-1 Audio**
  - Published as ISO/IEC 11172-3 in 1993
  - Layer I, Layer II and Layer III (MP3)
- **MPEG-2 Audio**
  - Advanced Audio Coding (AAC) added in 1997
  - Published as ISO/IEC 13818-7
- **MPEG-4 Audio**
  - Based on MPEG-2 AAC
  - Published as ISO/IEC 14496-3 in 1999
  - Complex toolbox with many variants

# Variants of MPEG-4 Audio

- **MPEG-4 Bit Sliced Arithmetic Coding (BSAC)**
  - Gives a form of scalable audio coding in 1kbit/s steps
    - Based on AAC, but with alternative noiseless coding module
  - Slight degradation relative to single-rate AAC at lower bit-rates
    - Performs best in the range 40 to 64 kbit/s
- **MPEG-4 High Efficiency AAC Profile (HE AAC)**
  - Published in 2003
  - Adds Spectral Bandwidth Replication to AAC Low Complexity
    - uses lower harmonic as reference for high-frequency information
- **MPEG-4 High Efficiency AAC Profile v2 (HE AAC v2)**
  - Published in 2004
  - Adds Parametric Stereo to HE AAC
    - Transmits stereo as mono signal plus a description of stereo image

# Performance of AAC Family




Graph of perceptual quality courtesy of Coding Technologies

# Mobile TV Systems

| | Video | Audio |
|---|---|---|
| **DMB** | **H.264/AVC** | **HE AAC v2**<br>**MPEG-4 BSAC** |
| **DAB-IP** | **Anything over IP - up to operator** | **Anything over IP - up to operator** |
| **DVB-IPDC**<br>**(IP Datacast over DVB-H)** | **H.264/AVC**<br>**VC-1** | **HE AAC v2**<br>**AMR-WB+** |
| **DVB-H**<br>**(if not DVB-IPDC)** | **Anything over IP - up to operator** | **Anything over IP - up to operator** |
| **MediaFLO** | **H.264/AVC (enhanced)** | **HE AAC v2** |
| **ISDB-T** | **H.264/AVC**<br>**MPEG-2** | **HE AAC** |

# Conclusions

- **Compression is a key enabling technology for mobile TV**
  - Different tools gives benefits under different circumstances
  - State-of-the-art compression technology is about twice as efficient as that used in most current digital TV systems
- **The various mobile TV systems allow slightly different options for audio and video compression algorithms**
  - commercial decision criteria are just as important as technical
- **Audio compression is more important for mobile TV than for SDTV or HDTV**
  - Higher percentage of total bit-rate with lower video resolution
- **Compression efficiency improves over time**
  - Future legacy issues are minimised by avoiding close coupling between compression and transport layers