ON2 TECHNOLOGIES, INC.

WHITE PAPER

Advantages of TrueMotion VP5 Technology

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On2 Technologies, Inc.
145 Hudson Street
New York, NY 10013
www.on2.com

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INTRODUCTION

This white paper explains why TrueMotion VP5 is the best video compression technology available today, particularly when compared with current MPEG-4 and H.26L profiles. This paper covers technical advances in VP5, improvements over previous versions of the TrueMotion algorithm, the performance of the VP5 decoder, and real-time VP5 encoding/decoding.

THE CASE FOR VP5

The following are just a few reasons why VP5 surpasses all other video compression technology:

- Optimized to produce the best quality video available on high resolution material (640x480 pixel resolution and higher).
- Produces output with Peak Signal-to-Noise Ratios (PSNR) that are better than H.26L on a wide range of test material at data rates ranging from dialup (28.8 Kbps) to DVD (2 to 6 Mbps).
- Can guarantee playback of a file transmitted at a constant bit rate.
- Supports both native interlaced and progressive scan output.
- Offers a “fast compress” mode that can encode at 75% D1 quality in real time on a Pentium 4 processor with minimal loss in quality.
- Decode complexity in VP5 is lower than H.26L, leading to faster decompression. This has allowed VP5 to be successfully ported to inexpensive digital signal processing (DSP) solutions running at full D1 resolution.
- Post-processing level can be determined by the decoder based on what type and speed of processor it is running on.
- Purely software-based solution that can be upgraded easily in the future.
- Carries no burdensome “patent pooling” restrictions or complicated external licensing fees.

HOW VP5 IMPROVES ON VP4

VP5 introduces several landmark improvements over VP4, among them real-time encoding, guaranteed data rate control, and significantly faster decompression (up to 50% faster at typical broadband data rates).

In addition, efficiency has been greatly improved in VP5. VP4 requires up to 50% more bits to produce the same output quality as VP5.

Technical Improvements

Below are some of the technical enhancements that On2's engineers have made in VP5.

- Sophisticated context modeling in the entropy encoder.

  The algorithm uses prior coded data in the source material to optimize how subsequent frames are encoded. The information can come from lower frequencies in the same general location, information from already coded areas in the same frame, and even information in prior coded frames.

- New block prediction modes that enable a mix of interlaced and progressive scan material.

  Each block in an image can be coded interlaced or progressive scan. All post-processing and filtering takes into account whether a block is interlaced or not.

- Proper interlacing support with the associated pre- and post-processing filters.
- Better prediction of low-order frequency coefficients to improve output quality.
- Improved quantization strategy that preserves more detail in the output.
- Improved prediction mode selection strategy that takes into account the impact of decisions on the entropy and context modeling.
- New motion estimation strategy that scales based on the cycles available, taking advantage of cost/quality trade-offs.
- Achieves any requested data rate by choosing automatically to adjust quantization levels, adjust encoded frame dimensions, or drop frames altogether.
- Pre-filtering is not required in the encoder, but different filters can be used to improve the quality of marginal source material (noise filtering, etc.)

VP5 DECODING

Decoding Speed Compared with MPEG-4 and MPEG-2

Initial testing indicates that best-quality VP5 images have roughly the same decode complexity as the fastest MPEG-4 profiles (without B-frame prediction) at roughly the same data rate.

Decoding Speed Compared with H.26L

VP5 has substantially less decoding complexity than *best-quality* H.26L profiles. Our initial testing indicates that best-quality H.26L is roughly 4-8 times more complex than VP5. "Best-quality H.26L" in this case is defined as material encoded with a profile in which the B-frame, CABAC entropy encoding, and eighth-pixel estimation options are *enabled*.

In addition, VP5 has significantly less decoding complexity than the *fastest* H.26L profiles. When compared using these profiles, H.26L is roughly twice as complex as VP5. “Fastest H.26L” in this case is defined as material encoded with a profile in which the B-frame, CABAC entropy encoding, and eighth-pixel estimation options are *disabled*.

VP5 Real-Time Encoding/Decoding

Encoding and decoding content on the same processor is often a requirement for real-time video applications. For example, you may have a video conferencing application that requires the processor to encode an outgoing stream while also decoding an incoming stream in real time. In such applications, the VP5 real-time encoder can be configured to let the application decide how much processor time to spend encoding.

Using the real-time encoder results in only a slight decrease in the quality of the compressed stream when compared with normal VP5 encoding. This is especially noticeable in cases where the source material contains high motion, complex textures, and so on. Additional lossless entropy encoding tradeoffs may be required that will impede quality slightly.

Research by On2’s engineers has found that conventional symmetric encoding/decoding is possible with VP5 (although it is not yet implemented). For more information, contact your On2 Customer Support representative.

VP5 Performance and Quality

The following table illustrates the performance of various VP5-encoded clips on the Texas Instruments TMS320-C6415 Digital Signal Processor (running at 600 MHz).

Resolution	Bit Rate	Frame Rate	Approximate CPU Utilization
352x240	270 kilobits/second	29.97	12%
640x480	800 kilobits/second	24	30%
720x480	1000 kilobits/second	24	34%
Interlaced			
640x480i	1200 kilobits/second	29.97	40%
720x480i	1500 kilobits/second	29.97	46%

Quality Comparisons with H.26L (TM9)

The test results in this section illustrate how VP5 outperforms H.26L in video quality (signal-to-noise ratio).

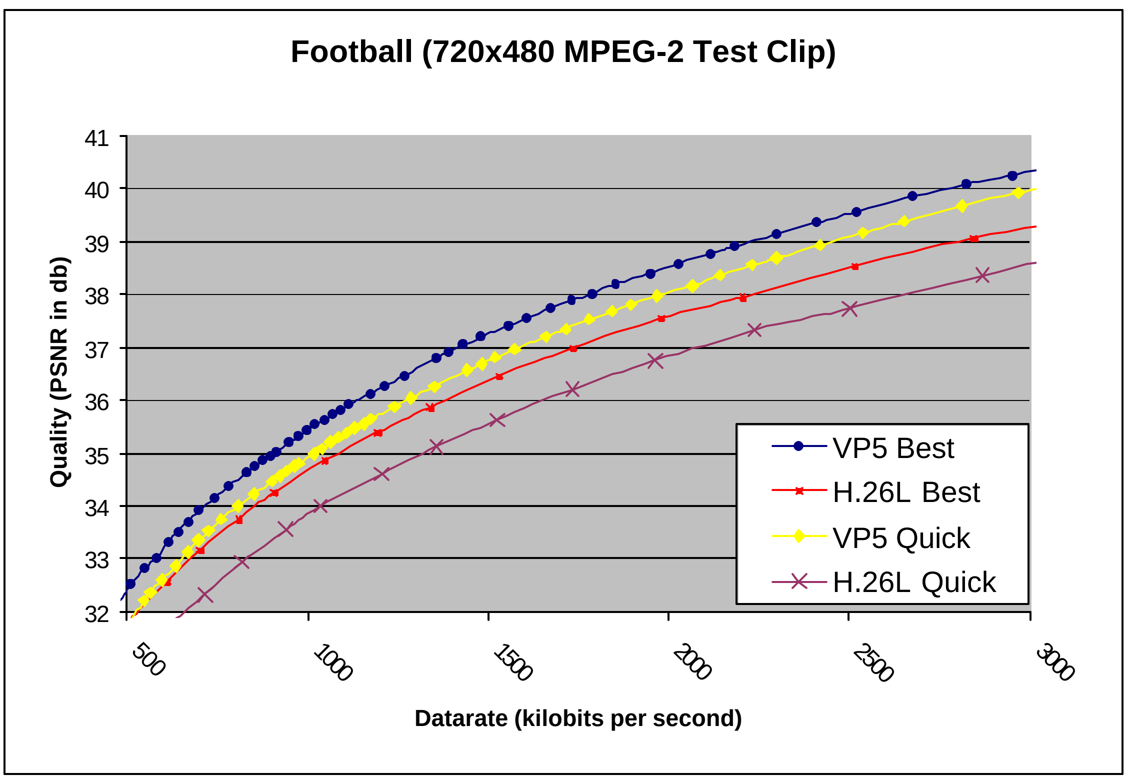
To conduct our tests, we downloaded the H.26L source code from **ftp://standard.pictel.com/video-site/h26L**. We ran the tests at all 31 fixed quantizers. The graphs in this section show the results of these runs for from one megabit to three megabits.

We used the following parameters in our profiles for comparing H.26L versus VP5.

Profile	CABAC	RdOpt	Hadamard	Motion	Search Radius	B Frames	Reference Frames
Best	on	on	on	1/8 pixel	39	2	1
Quick	off	off	off	1/4 pixel	15	0	1

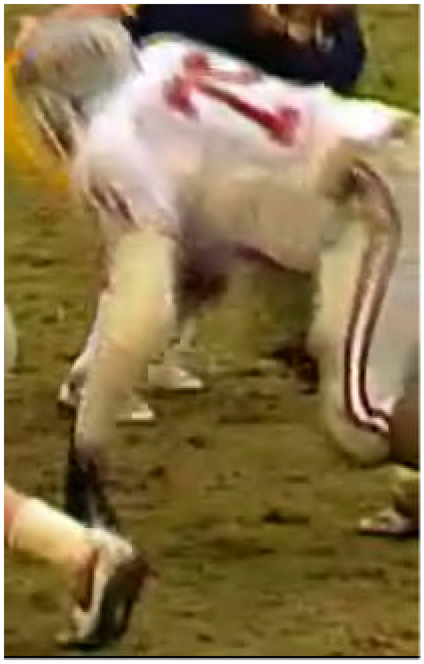
In order to perform fair calculations between the two codecs we shut off data rate control in VP5. We forced the codec to use fixed quantization.

Test Clip "Football" (non-interlaced)



The following still images from the football sample show the superiority quality of the best VP5 profile over the best H.26L profile. Note the significantly higher number of visible artifacts in the H.26L image.

VP5 Sample



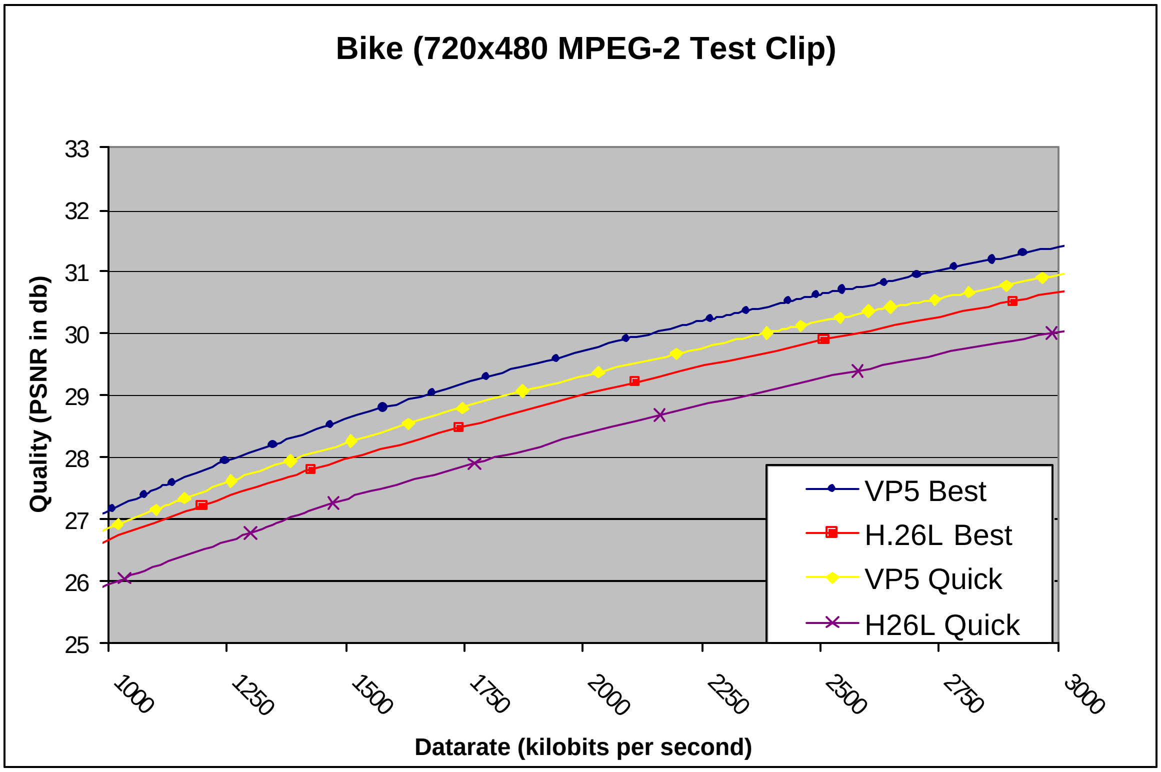
H.26L Sample

The following are selections from the still images (the arm pad of the football player), magnified by 300%.

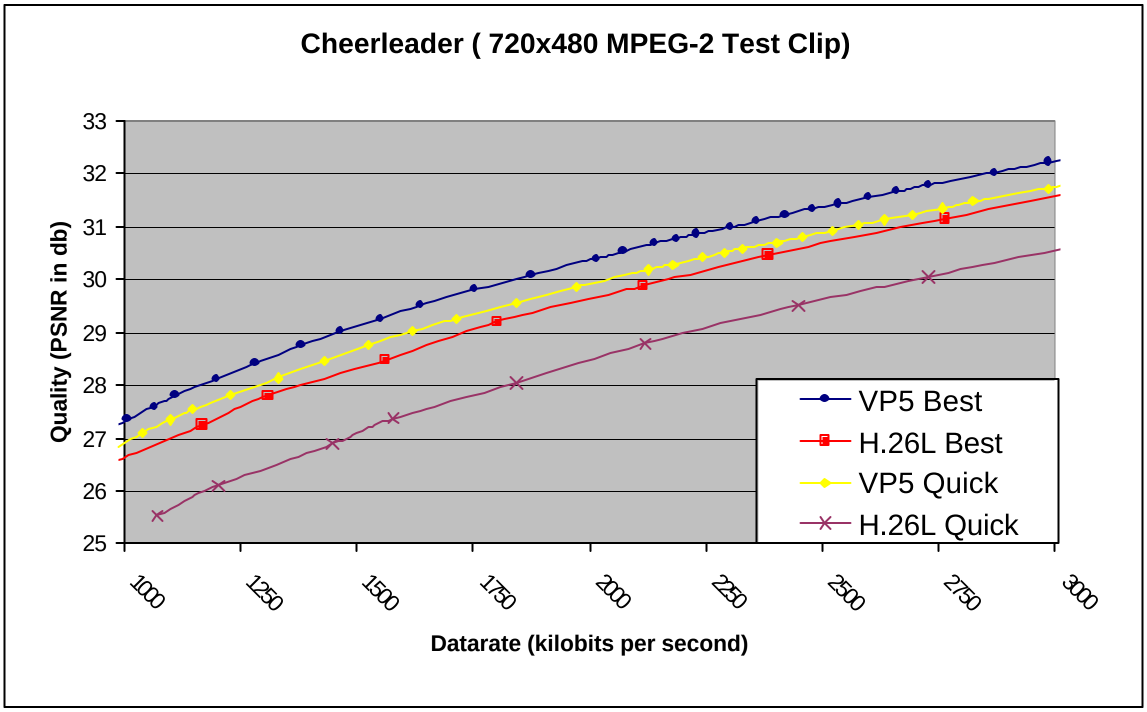
VP5 Sample

H.26L Sample

Test Clip "Bike"



Test Clip "Cheerleader"



Test Clip "Carousel"