RealNetworks

RealVideo 9

Technical Overview

Version 1.5

Summary:
This document provides a technical summary of the RealVideo® 9 video codec. A description of the coding algorithms, performance characteristics and memory usage of the RealVideo 9 Decoder is included. Key features of RealVideo 9 include:

- Same quality at half the bit rate of MPEG-4 and at one quarter the bit rate of MPEG-2.
- Quarter screen video starting at 34Kbps. Near DVD quality at 500 Kbps.
- Cross Platform – Windows, Linux, Macintosh, WinCE, Symbian

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1 RealVideo 9 Compression

Whether used for download or streaming, RealNetworks' RealVideo 9 codec delivers unparalleled quality from narrowband to HDTV. By providing dramatically improved compression over previous generation technologies, RealVideo 9 reduces bandwidth costs while enabling high-quality, rich media experiences — at any bit rate and on any device.

1.1 KEY FEATURES OF REALVIDEO 9

Unparalleled quality — State-of-the-art video at all bit rates:

- Same quality at half the bit rate of MPEG-4
- Same quality at quarter the bit rate of MPEG-2
- 30% improvement over previous generation RealVideo 8
- 50% improvement over RealVideo G2

Provides new capabilities — RealVideo 9 enables:

- Quarter screen video starting at 34Kbps – twice the size with better quality than current modem bitrate video
- VHS quality at everyday broadband rates (starting at 160 Kbps)
- Near DVD at 500 Kbps for download or streaming on high speed networks

Cross Platform — Available for playback in multiple environments:

- Microsoft Windows, Intel Processor (MMX™, SSE™, SSE2™)
- Linux, Intel Processor (MMX™, SSE™, SSE2™)
- MacOS, PowerPC Processor (AltiVec™)
- WinCE, ARM Processor (ARMv5, StrongARM, XScale™)
- Symbian, ARM Processor (ARMv5, StrongARM, XScale™)
- MIPS Processor (NEC vr550)

Any Device — Extends Internet media across the spectrum of devices from mobile to TV, PC, HDTV and beyond.

- The RealVideo 9 bitstream does not limit the resolution of the video. To date, RealVideo 9 has been used to encode content as small as 32x32 and as large as 1920x1080
- HDTV Ready — supports all HD formats and resolutions including 720p and 1080i
- Interlaced Support — The RealVideo 9 bitstream can carry 60 fields per second interlaced content

1.2 THE REALVIDEO 9 COMPRESSION ALGORITHM

RealNetworks' engineers have spent many years developing the technology that goes into RealVideo 9 and have leveraged the insight and know-how gained while developing past RealVideo codecs. RealVideo 9 is a motion compensated hybrid coder that employs RealNetworks patented, and patent pending, technology including:

- Highly accurate motion modeling
- Proprietary spatial pixel prediction methods
- Multi-resolution residual analysis/synthesis stage
- Context adaptive entropy coding
- Psycho-visually tuned segmentation and filtering schemes
- Rate-Distortion optimized encoding algorithms
- Two-Pass encoding

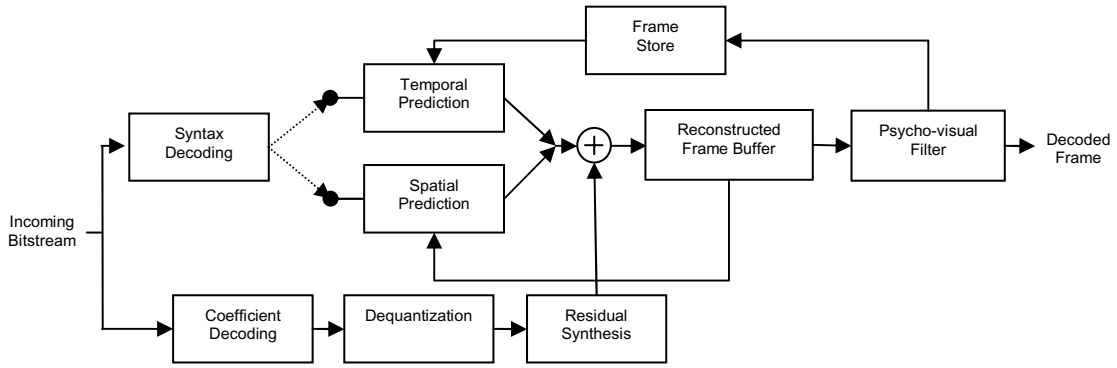

Figure 1: The RealVideo 9 Decoder

Many video codecs employ "block-based" algorithms to do compression and decompression of video. These algorithms process several pixels of video together in blocks. As the compression ratios increase, these block-based algorithms tend to represent individual blocks as simply as possible. A single block may be represented simply as a single color (e.g. the entire block is all "light-blue"). Carefully studying competing video codecs, one can easily see this visual effect (so-called visual "artifacts"). When using block-based algorithms strong discontinuities, so-called block edges, can become very pronounced.

RealVideo 9 avoids blockiness by employing sophisticated algorithms that are able to more accurately compress the video. New proprietary analysis and synthesis algorithms (transforms), more sophisticated motion analysis, content adaptive filtering technology, and other compression schemes built inside RealVideo 9 allow it to provide a higher fidelity reproduction of the video and maintain a more natural look and feel.

RealVideo 9 does no post-processing in the decoder. The core RealVideo 9 algorithms are a significant improvement over existing video codecs. Excellent video quality is achieved without it.

1.3 THE REALVIDEO 9 ENCODER

RealVideo 9 supports a wide range of video applications from real-time streaming to download and play to storage and archive. To accommodate these applications the RealVideo 9 encoder supports the following encoding modes:

- Constant Bitrate
- Variable Bitrate (with a possible maximum constrained bitrate)
- Quality-Based Encoding (with a possible maximum constrained bitrate)

In Constant Bitrate mode, the encoder maintains the target bitrate throughout the duration of the content; with a small allowed buffer for slight deviations in bit usage. The size of this buffer determines the pre-buffering time and is settable in the Helix Producer Plus using the “maximum startup latency” setting. This mode should be used for most real-time streaming applications to maximize visual quality over a constant bitrate connection.

Using the Variable Bitrate mode, the encoder attempts to meet the target bitrate over the length of the content, but makes no particular effort to maintain a constant rate throughout. Variable Bitrate encoding should be used when the overall bitrate or file size needs to be constrained, but there are no instantaneous bitrate requirements, such as for downloaded content. Using Variable Bitrate, a maximum constrained bitrate can be set to limit the instantaneous bitrate.

Quality-Based Encoding compresses content without regard for bit usage, but instead maintains a constant level of visual quality throughout. This mode should be used when there is no need to maintain bitrate or file size, but a certain level of visual quality is desired. As in Variable Bitrate mode, a maximum constrained bitrate can be set to limit the instantaneous bitrate.

Additionally, other related parameters such as frame rate, key frame rate, error protection and two-pass encoding modes are settable. Using two-pass encoding, the RealVideo 9 encoder is able to first analyze the video before compressing the content. That analysis allows the encoder to better maximize the visual quality while meeting the bit usage requirements in Constant and Variable Bitrate modes. Using Quality-Based Encoding, analysis is done to better maintain the targeted visual quality throughout the content.

2 RealVideo 9 Quality

As the following section shows, RealVideo 9 achieves a superior visual quality over competing technologies. Windows Media 9 Series video is a proprietary video codec developed by Microsoft. DivX 5.05 is an MPEG-4 Simple Profile compliant video codec developed by DivXNetworks. Figures 2-4 compare the bitrates required to achieve the same level of fidelity (a.k.a. Peak Signal-to-Noise Ratio, or PSNR) using the RealVideo 9 encoder and other popular video formats. Figures 5-7 show PSNR results comparing the RealVideo 9 encoder to others.

For this comparison, the “Highest Quality” and “Slowest” encoding settings were used for Windows Media 9 Series and DivX 5.05, respectively. To remove the effects of bitrate-control, quality-based encoding was used, and all pre- and post-processing options (smoothing, color correction) were turned off. The PSNR was calculated for the Y component of each decoded YV12 frame, and the average PSNR over all frames is reported.

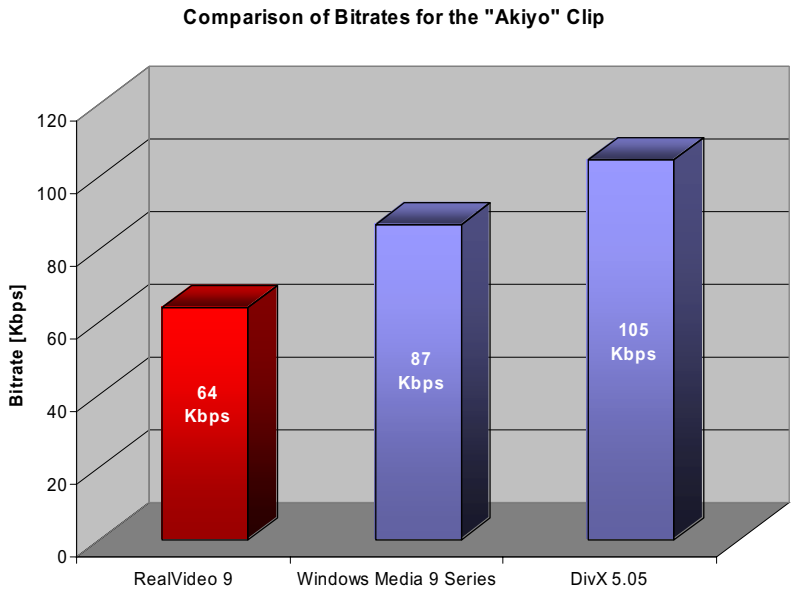

Figure 2: Bitrates needed to match visual fidelity using low action (talking head) content

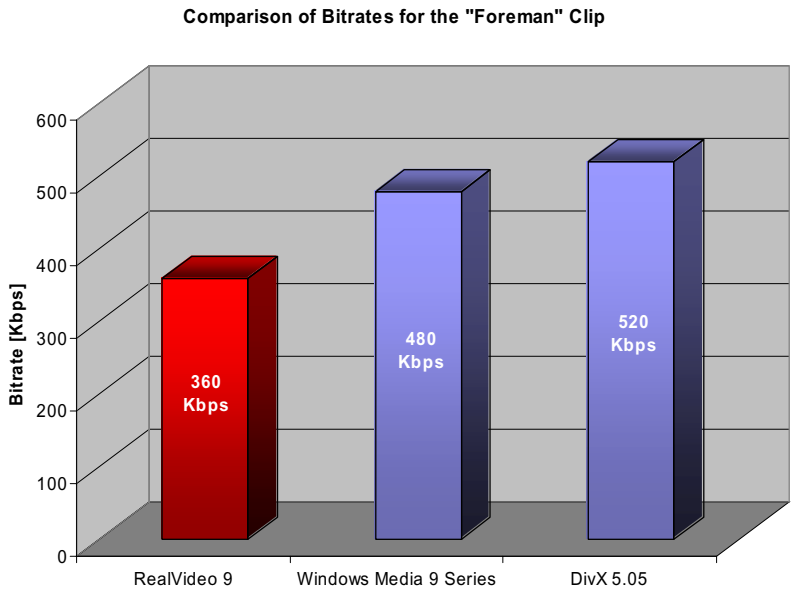

Figure 3: Bitrates needed to match visual fidelity using moderate action content

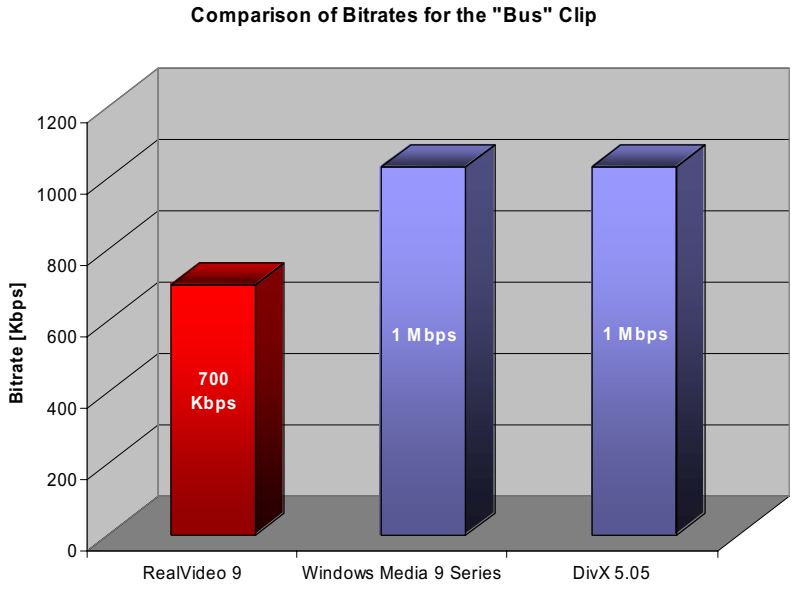

Figure 4: Bitrates needed to match visual fidelity using high action content

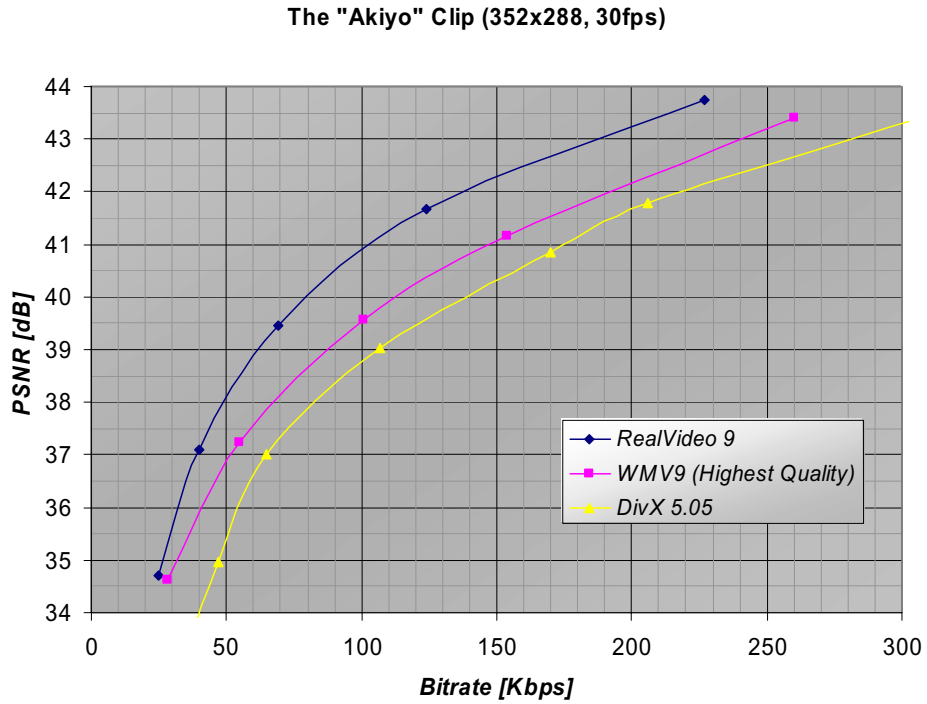

Figure 5: PSNR results for low action (talking head) content

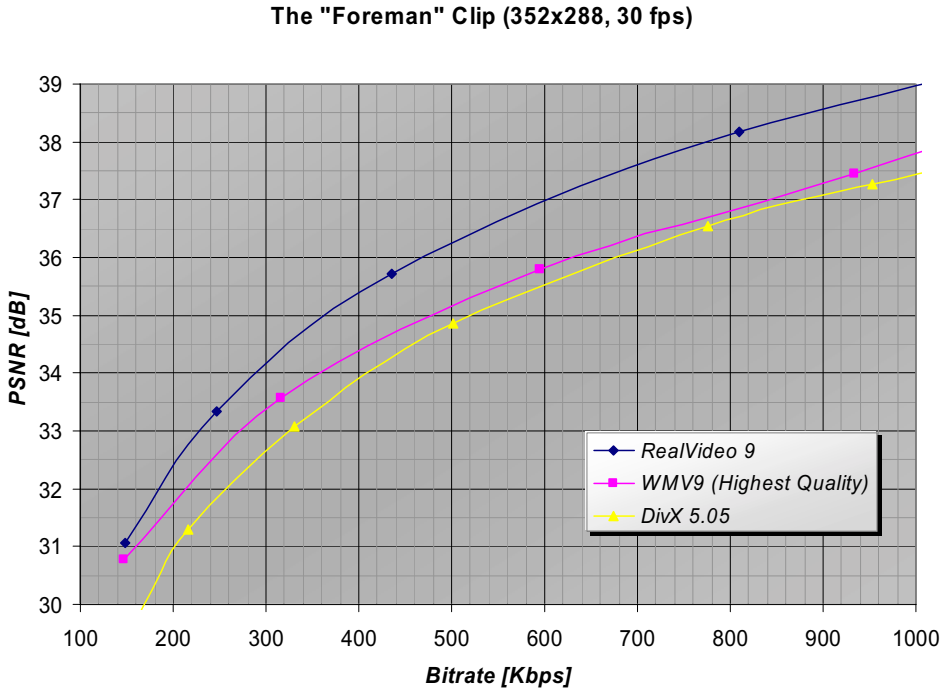

Figure 6: PSNR results for moderate action content

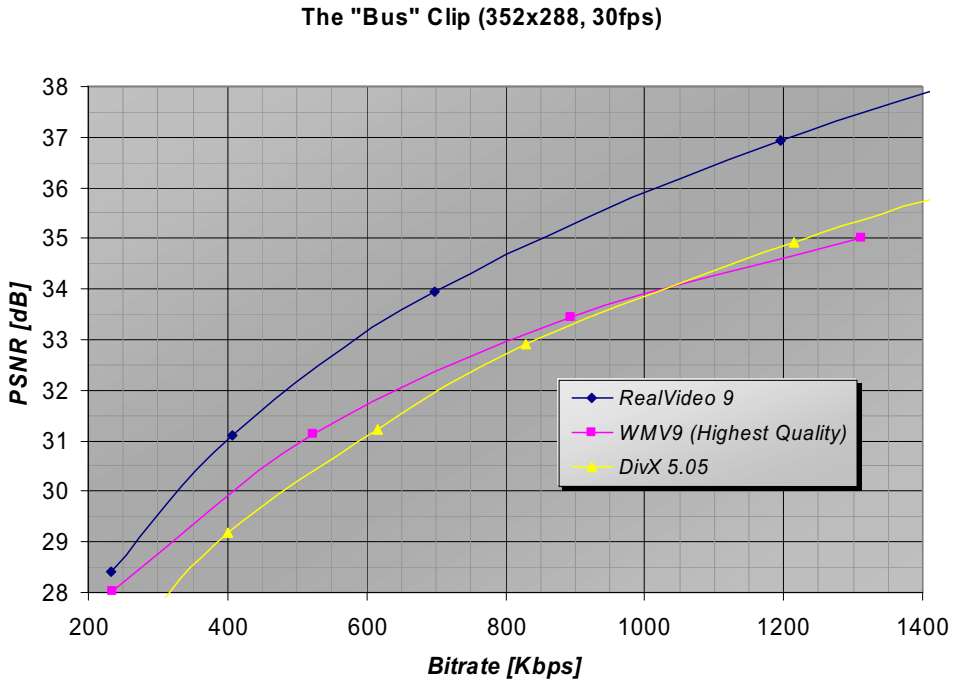

Figure 7: PSNR results for high action content

While the RealVideo 9 encoder provides superior visual quality, a significant amount of expertise was put toward fast and efficient encoding algorithms. The RealVideo 9 encoder includes optimizations developed with the help of Intel that provide remarkable performance on Intel processors, and AltiVec optimizations for the Macintosh G4 and G5 processors. Figure 8 shows the encoding speed measured encoding a 352x288 clip on a 2.2 GHz Pentium 4.

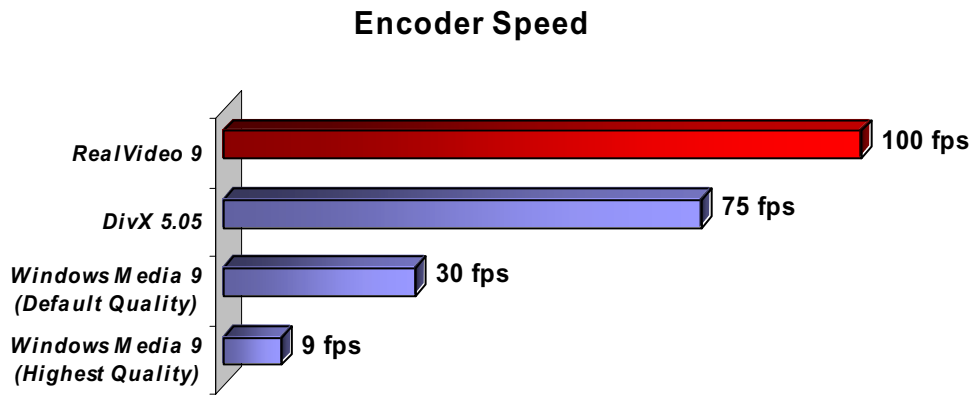

Figure 8: Speed while encoding the “Foreman” clip for a few video formats (speed measured encoding a 352x288 clip on a 2.2 GHz Pentium 4)

3 RealVideo 9 Scalability

The Helix™ platform (Producer, Server and Player) features RealNetworks' SureStream™ technology. Using SureStream, the encoder creates multiple audio and video streams tailored for various network characteristics such as bandwidth and packet loss rates. Using the Helix Producer, multiple target bitrates can be selected and audio and video streams appropriate for those target bitrates are encoded.

When streamed over a network, the RealOne™ Player and Helix Universal Server communicate the appropriate audio and video streams to be transmitted. The client and server remain in communication while monitoring dynamic network characteristics. If the available bandwidth or packet loss rates change, the server is able to switch to a more appropriate bitrate mid-stream.

All of the typical means of scalability (spatial, temporal and quality) are utilized in our SureStream technology. When selecting multiple target bitrates for the encoding of a piece of content, each bitrate selection represents an independently decodable stream. Each of these streams may be encoded at different resolutions, frame rates and image fidelities. And because there are no dependencies between streams, each stream can be encoded at a frame size, frame rate and quality level optimized for that bitrate.

4 RealVideo 9 Error Resiliency

Error resiliency is a major component of our media delivery platform. Error resiliency features implemented in our platform include:

- The ability to dynamically set FEC packet insertion rates at nearly every stage of the delivery network, from Producer to Server, Server to Server, Server to Proxies, Proxies to Clients, etc.
- Automatic retransmission requests allow clients to resend data packets that are lost.
- The ability to enable error resiliency modes in our RealVideo family of codecs. This mode, settable at encode time, adds layered error correction and error mitigation information to the RealVideo bitstream that intelligently protect more important video data.

5 RealVideo 9 Decoder Performance

Since RealVideo 9 is designed for use on a wide variety of clients with very different performance capabilities, RealVideo 9 has built-in CPU scalability in both the encoder and decoder that allows the faster processing of video if needed.

5.1 CPU USAGE

The encoder/decoder complexity is asymmetric with the difference in complexity between the encoder and decoder near a factor of 3-5 times under normal (default) encoder and decoder operation.

The following systems are recommended for high quality playback of RealVideo 9 on PCs.

- **CIF or QCIF for dial-up connections –** For playback of typical content for dial-up speeds (176 x 132), a 200 MHz Pentium II (or better) is recommended.
- **Full Screen –** For playback of 640 x 480 video at full 24 fps (for film) or 30 fps (for video), a 750 MHz Pentium III (or better) is recommended.
- **HDTV –** For playback of HD-resolution content (e.g. 720p), a 2.6 GHz Pentium 4 (or better) is recommended.

Tables 1 - 3 show the CPU performance of RealVideo 9 running on popular device processors. In Tables 2 and 3, the performance is measured on actual devices running the RealVideo 9 decoder optimized for that platform.

TABLE 1: RealVideo 9 CPU performance, with zero-wait memory

Simulation using ADS 1.2 developer tools, with zero-wait memory					
Bitrate	Image Size	Frame Rate	Content Type	Processor	
				ARM925T	XScale
30 Kbps	QCIF	15 fps	Low Action	10.8 MHz	10.7 MHz
48 Kbps	QCIF	15 fps	Moderate Action	25.4 MHz	25.6 MHz
250 Kbps	SIF	25 fps	High Action	171.7 MHz	172.9 MHz
200 Kbps	CIF	30 fps	Moderate Action	174.9 MHz	179.4 MHz
600 Kbps	CIF	30 fps	Moderate Action	235.3 MHz	257.0 MHz

TABLE 2: RealVideo 9 decoder CPU usage on XScale

Machine = ARM XScale, PXA255, iPAQ H5550, 400 MHz				
Bitrate	Image Size	Frame Rate	Content Type	CPU Usage
30 Kbps	QCIF	15 fps	Low Action	22.9 MHz
48 Kbps	QCIF	15 fps	Moderate Action	39.2 MHz
250 Kbps	SIF	25 fps	High Action	231.3 MHz
200 Kbps	CIF	30 fps	Moderate Action	260.4 MHz
600 Kbps	CIF	30 fps	Moderate Action	350.2 MHz

TABLE 3: RealVideo 9 CPU usage on a 1.4 GHz, Pentium 4 processor

Machine = Pentium 4, 1.4 GHz				
Bitrate	Image Size	Frame Rate	Content Type	CPU Usage
48 Kbps	CIF	30 fps	Low Action	81.9 MHz
100 Kbps	CIF	30 fps	Moderate Action	150.3 MHz
300 Kbps	QVGA	30 fps	Mixed Action	158.3 MHz
800 Kbps	CIF	30 fps	Moderate Action	260.0 MHz
1.5 Mbps	CIF	30 fps	Moderate Action	307.9 MHz

5.2 MEMORY USAGE

The memory usage of the RealVideo 9 decoder is dependent on the image size of the video being decoded. Table 4 presents the effective memory usage for several popular resolutions.

TABLE 4: RealVideo 9 memory usage

Image Size	**Memory Usage**		
	Code Size[1]	**RAM**[2]	**All RAM**[3]
QCIF	172 KB	147 KB	257 KB
CIF	172 KB	315 KB	868 KB

[1] *Code Size* reflects ARM-based Symbian/Series 60 platforms
[2] *RAM* usage does not include reference frame memory
[3] *All RAM* includes memory needed for reference and current frame buffers

RealNetworks has codec implementations available on a number of different processor platforms. For the most part these are available via the Helix Community but if you have a different, specific need please contact us.

6 Learn More

To learn more about RealVideo, RealAudio, and the RealSystem®, please visit our Web site at:

http://www.realnetworks.com/solutions/leadership/realvideo.html

To learn more about the Helix™ Community and the Helix DNA™ platform, please visit:

https://www.helixcommunity.org/

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