

RealNetworks®

RealVideo® 10

Technical Overview

Version 1.0

Summary:

This document provides a technical summary of the RealVideo® 10 video codec. A description of the key features, performance characteristics and memory usage of the RealVideo 10 decoder is also included. Key features of RealVideo 10 include:

- Compatible with all RealVideo 9 decoders – No RealOne™ Player update is needed to play RealVideo 10 content
- **Same Quality at 30% lower bitrate than RealVideo 9**
- Same Quality at 80% lower bitrate than MPEG-2
- Same Quality at 75% lower bitrate than HDTV
- Same Quality at 45% lower bitrate than MPEG-4 (ASP)
- Same Quality at 30% lower bitrate than WMV 9
- Same Quality at 15% lower bitrate than H.264

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1 RealVideo 10 Compression

Whether used for download or streaming, RealNetworks' RealVideo 10 codec delivers unparalleled quality from narrowband to HDTV. By providing dramatically improved compression over previous generation technologies, RealVideo 10 reduces bandwidth costs while enabling high-quality, rich media experiences — at any bit rate and on any device.

1.1 KEY FEATURES OF REALVIDEO 10

Broad reach — Compatible with all RealVideo 9 decoders

- No RealOne™ Player update is needed to play RealVideo 10 content
- Same system, processor requirements for playback as the previous generation RealVideo 9
- Also plays back in RealPlayer 10

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

- **Same Quality at 30% lower bitrate than RealVideo 9**
- Same Quality at 80% lower bitrate than MPEG-2
- Same Quality at 75% lower bitrate than HDTV
- Same Quality at 45% lower bitrate than MPEG-4 (ASP)
- Same Quality at 30% lower bitrate than WMV 9
- Same Quality at 15% lower bitrate than H.264

Cross Platform — Available for playback in multiple environments:

- Microsoft Windows, Intel Processor (MMX™, SSE™, SSE2™)
- Linux, Intel Processor (MMX™, SSE™, SSE2™)
- Mac OS, PowerPC Processor (AltiVec™)
- WinCE, ARM Processor (ARMv4, StrongARM, XScale™)
- Symbian, ARM Processor (ARMv4, StrongARM, XScale™)
- MIPS Processor (NEC vr5500)

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

- HDTV Ready — supports all HD formats and resolutions including 720p and 1080i
- Interlaced Support — The RealVideo 10 bitstream can carry 60 fields per second interlaced content

1.2 THE REALVIDEO 10 COMPRESSION ALGORITHM

RealNetworks' engineers have spent many years developing the technology that goes into RealVideo 10 and have leveraged the insight and know-how gained while developing past RealVideo codecs. RealVideo 10 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

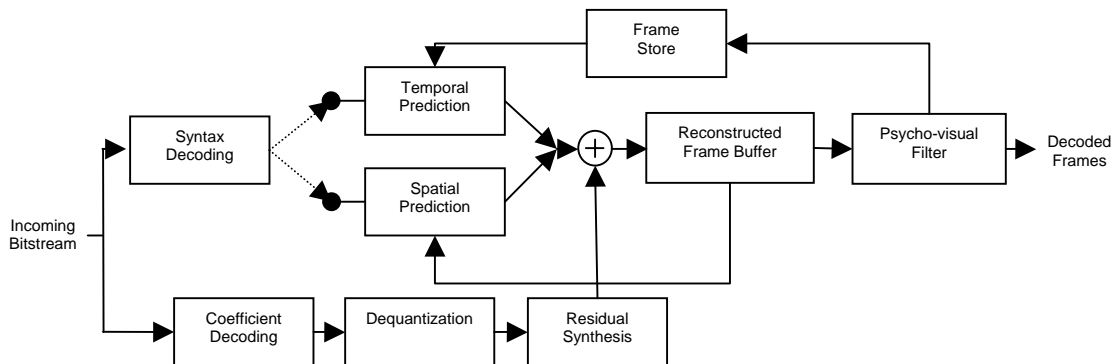


Figure 1: The RealVideo 10 Decoder

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 10 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 10 allow it to provide a higher fidelity reproduction of the video and maintain a more natural look and feel.

RealVideo 10 does no post-processing in the decoder. The core RealVideo 10 algorithms are a significant improvement over existing video codecs. Excellent video quality is achieved without it.

1.3 THE REALVIDEO 10 ENCODER

RealVideo 10 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 10 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 10 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 10 Quality

As the following section shows, RealVideo 10 achieves a superior visual quality over competing technologies. The figures below compare the bitrates required to achieve the same level of fidelity (a.k.a. Peak Signal-to-Noise Ratio, or PSNR) using RealVideo 10 and other popular video formats. However, the objective measures used below, like PSNR, do not always accurately represent perceived visual quality, and RealVideo 10 provides a good example of that. While PSNR results show roughly 15-20% reduction in bitrate, figure 2 demonstrates that RealVideo 10 provides the same, or even better, *visual* quality using a 30% lower bitrate.

For this comparison, the “Highest Quality”, “Slowest” and “Slow” encoding settings were used for Windows Media 9 Series, DivX 5.05 and VSS H.264, 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.



(a) RealVideo 10 at 175 Kbps

(b) RealVideo 9 at 250 Kbps

Figure 2: RealVideo 10 provides the same, or better, visual quality using 30% lower bitrate. (Images from the “Foreman” clip, encoded at 352x288, and then zoomed and cropped for better visual comparison.)

Comparison of Bitrates for the "Akiyo" Clip

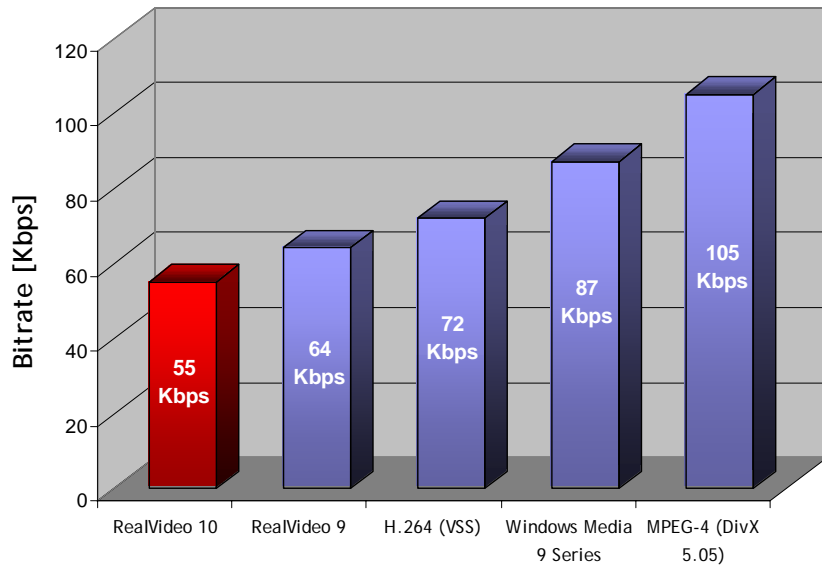


Figure 3: Bitrates needed to match visual fidelity using low action (talking head) content

Comparison of Bitrates for the "Foreman" Clip

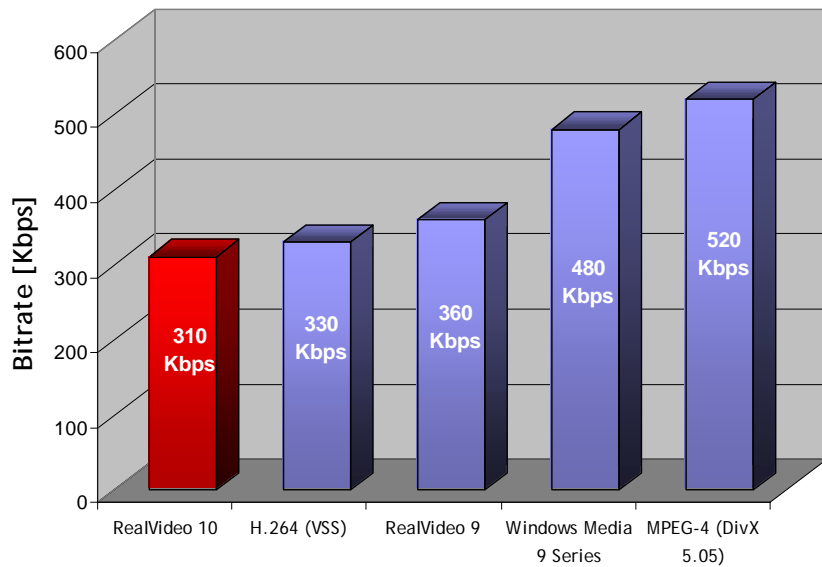


Figure 4: Bitrates needed to match visual fidelity using moderate action content

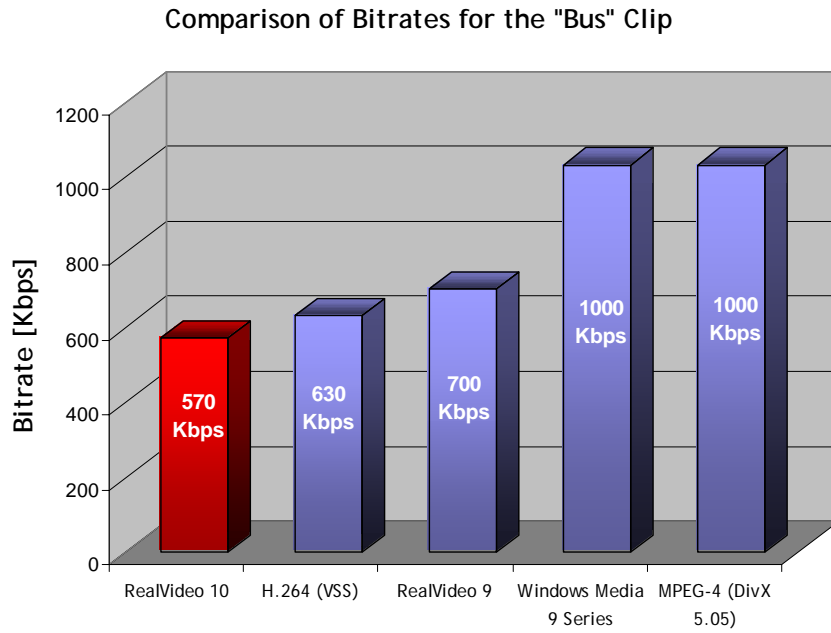


Figure 5: Bitrates needed to match visual fidelity using high action content

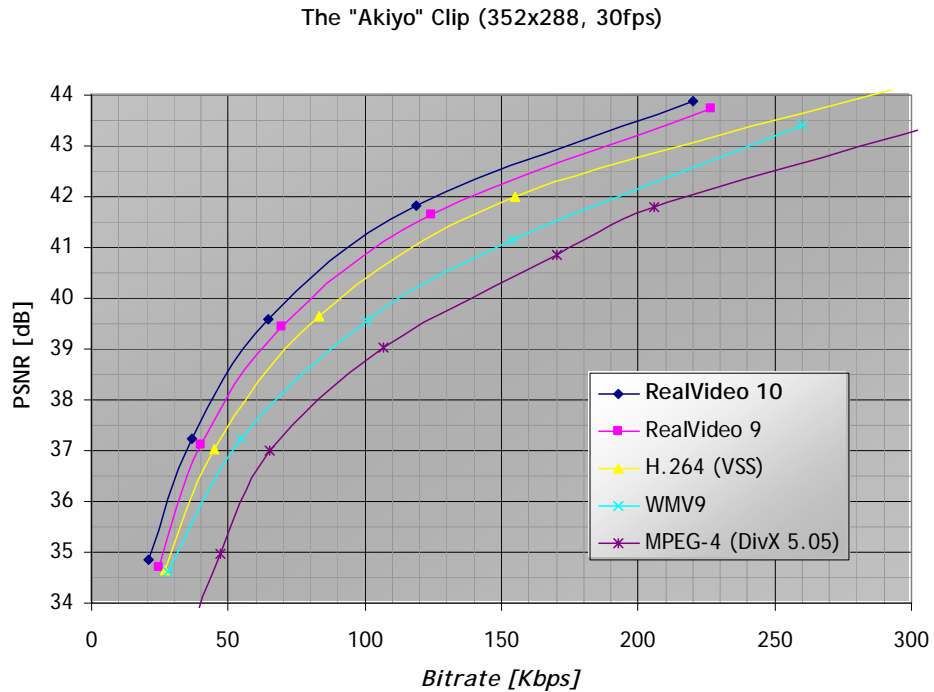


Figure 6: PSNR results for low action (talking head) content

The "Foreman" Clip (352x288, 30 fps)

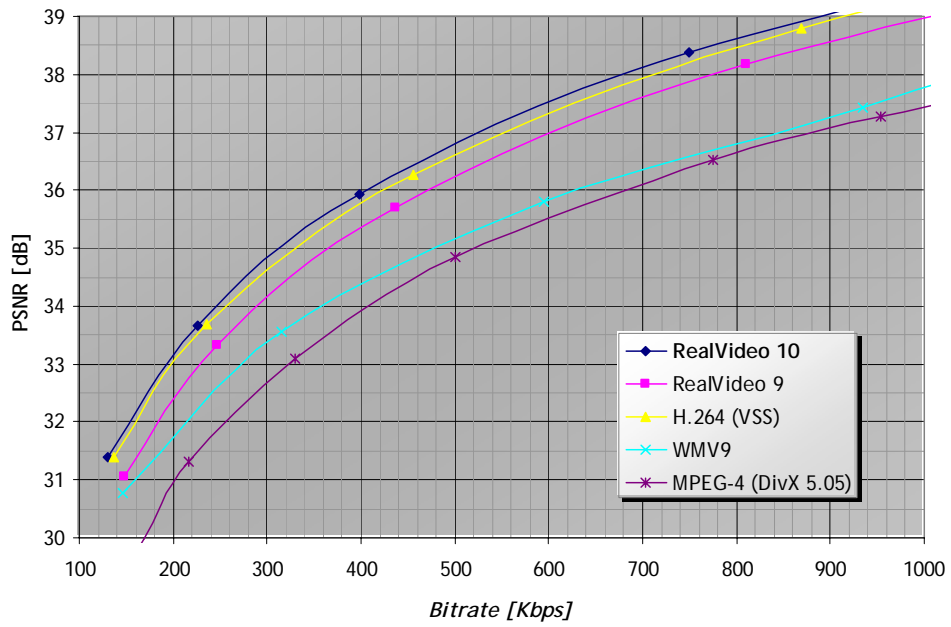


Figure 7: PSNR results for moderate action content

The "Bus" Clip (352x288, 30fps)

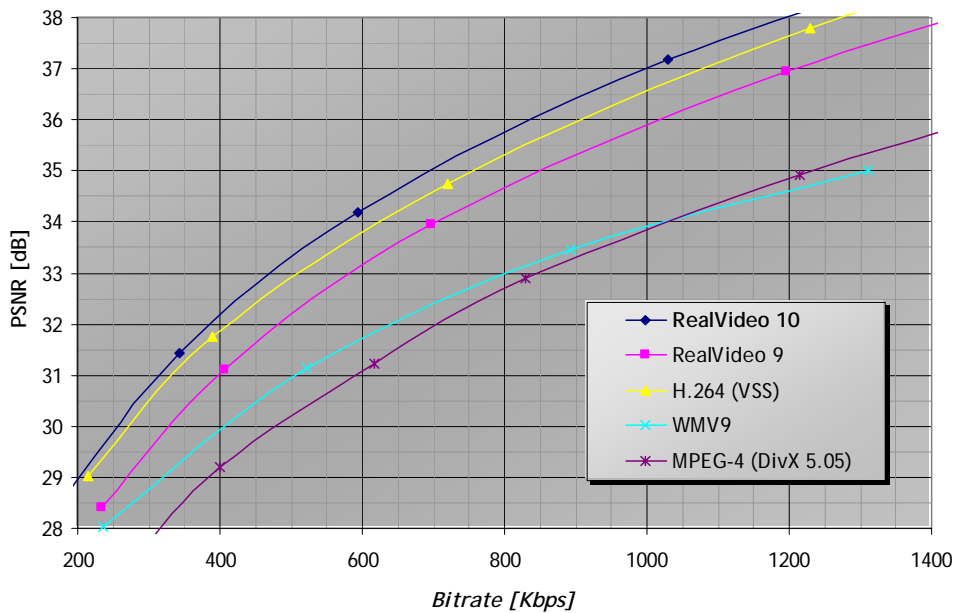


Figure 8: PSNR results for high action content

While the RealVideo 10 encoder provides superior visual quality, a significant amount of expertise was put toward fast and efficient encoding algorithms. The RealVideo 10 encoder includes optimizations developed with the help of Intel that provide remarkable performance on Intel processors. AltiVec™ optimizations for the Macintosh G4 and G5 processors are also used. Figure 9 shows the encoding speed measured encoding a 352x288 clip on a 2.2 GHz Pentium 4.

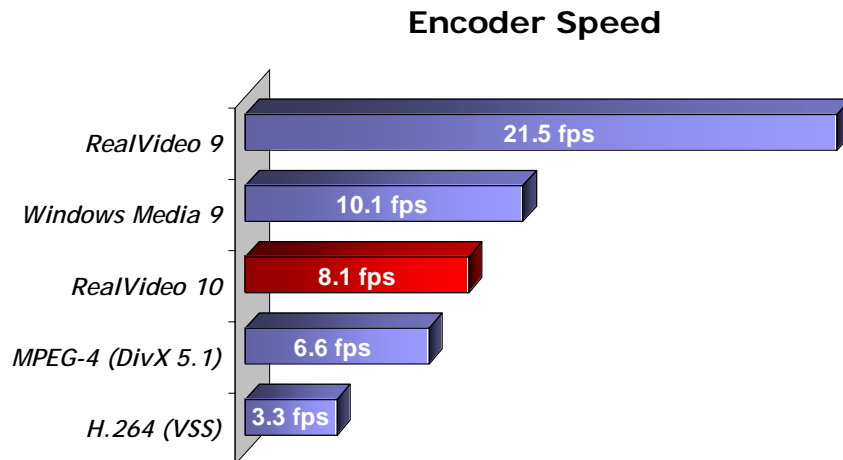


Figure 9: Speed while encoding the “Foreman” clip for a few video formats¹

3 RealVideo 10 Scalability

The Helix™ platform (Producer, Server and Client) 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.

¹ Speed measured encoding a 624x344 clip on a Dual 2.2 GHz, Pentium 4 using default quality vs. speed settings for all codecs.

4 RealVideo 10 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 10 Decoder Performance

Since RealVideo 10 is designed for use on a wide variety of clients with very different performance capabilities, RealVideo 10 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 10 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 10 running on popular device processors. In Tables 2 and 3, the performance is measured on actual devices running the RealVideo 10 decoder optimized for that platform.

TABLE 1: RealVideo 10 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	253.3 MHz	257.0 MHz

TABLE 2: RealVideo 10 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 10 CPU usage on a 1.4 GHz, Pentium™ 4

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 10 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 10 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

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.

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.

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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